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PROCEEDINGS OF THE SECOND SERBIAN - BULGARIAN ASTRONOMICAL MEETING

June 23 – 26, 2000, Zaječar, Serbia

Edited by Milan S. Dimitrijević, Luka Č. Popović and Milcho Tsvetkov

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2000

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SEARCH FOR OPTICAL VARIABILITY IN TWO SEYFERT GALAXIES

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Abstract.. We started a program for optical VR_cI_c monitoring of variable Seyfert galaxies. First results for two Seyfert 1 type objects - Mkn 335 and Mkn 315 - are presented here. We detected significant variability in one of the objects - Mkn 335. Connections between variations in different spectral bands are found and some conclusions about the nature of the Seyferts' optical variability are given.

1. OBSERVATIONS

All observations are performed with the 0.6 m reflector of the Observatory of Belogradchik, Bulgaria, equipped with SBIG ST-8 CCD and Johnson-Cousins set of filters (Bachev et al. 1999). Aperture photometry with a diaphragm of 16 arcsec is performed using a code developed at the Observatory (Bachev et al. 1999). As comparison stars we used relatively bright, non-variable stars, close to the monitored objects. The VR_cI_c magnitudes of these stars were calibrated via observations of standards (Bachev et al. 2000). The monitoring has covered a period of about 3 years (1997 - 2000) and the objects have been observed in about 15 turns each.

2. LIGHT CURVES AND ANALYSIS

The V-band light curves of the monitored AGN are given in Fig.1a and 1b. Although both objects are reported to be variable, Mkn 315 did not show any significant variability exceeding the measurement errors (about $0.02\text{-}0.03^m$) during the period of observation. Its brightness remained almost constant (V=14.7). The second object - Mkn 335, however, showed variations of about $0.3\text{-}0.4^m$ in V-band. No intra-night variability was detected in both objects.

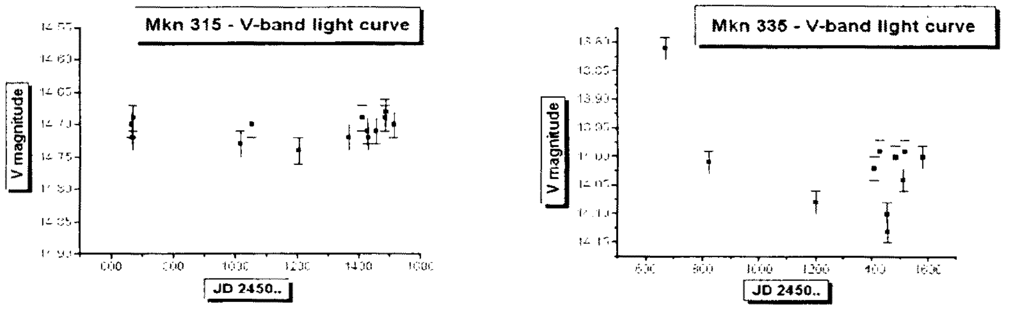

Fig. 1. Optical (V-band) behaviour of Mkn 315 and 335.

During the greater part of the monitoring, Mkn 335 showed V-band magnitude of about 14.0 (Fig. 1b). There are also dips seen in the light curve, sometimes rather sharp (lasting just a few days) as well as some signatures for flaring events. Unfortunately, the scarce sampling does not allow making any detailed analysis of the light curve. However, combining colour and intensity changes of this object some conclusions about the reasons of its variability could be drawn. In Fig. 2 we present the relation between V-I colour of Mkn 335 and its V magnitude. This colour - brightness diagram implies that the main reason for the variability is probably that one, causing decreases in brightness and leading to gradual colour changes (reddening). On the other hand, R-I colour did not change significantly with brightness.

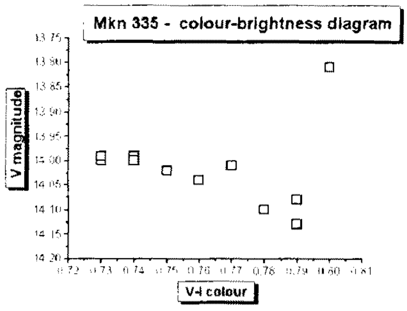

Fig. 2. Mkn 335 - "V - (V-I)" diagram.

These observations give preference to global processes like optical reprocessing of variable X-ray emission (Ulrich et al. 1997), accretion disk instabilities (Kawaguchi et al. 1998), microlensing, shadowing by outer matter (Cherni et al. 1999), changes in accretion rate, etc. However, most of these processes are inconsistent with the sharp dips observed. The flaring event, however, has probably different nature since it deviates significantly from brightness-colour dependence (Fig. 2). It could be attributed to local events like stellar explosions (Kawaguchi et al. 1998) or explosive processes in an accretion disk.

3. DISCUSSION AND CONCLUSIONS

It is important to study optical continuum variability in radio-quiet AGN since the reasons for their variability are usually connected with the instabilities in the accretion flow feeding the central massive black hole, rather than with the instabilities in relativistic jets, as in blazars case. Hence, any knowledge about that variability could shed some light onto the accretion process and the nature of the central engine. Two basic conclusions could be drawn from our study: i) Variability is not attributed to all Seyferts or at least the periods of continuum changes are often followed by a quiescent periods. The processes responsible for these variations, therefore, should not be based on the general principles of accretion or on the common properties of AGN. ii) The strict relations between the colours and brightness imply a single reason inducing variability of the continuum. Otherwise, in the case of many superimposed independent events, each characterised by different physical properties, evolving on different time scales, such tight relations could not be observed. In the case of Mkn 335, a significant role in the optical variability probably can play reprocessing, shadowing by outer clouds and explosive stellar or accretion disk processes.

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UNIVERSALITY OF PLANETARY ACCRETION

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Abstract. A recently developed model of planetary formation (Balaž et al. 1999) allows a detailed investigation of various properties of planetary systems. In this paper we focus on the results regarding the spin of condensates, and show that the spin–mass relation obeys a power law with universal exponents. The results of the model are compared with the Solar system data, as well as with the binary star system data.

1. INTRODUCTION

There is a pressing need for the detailed modeling of the planetary accretion process. This has become even more apparent in recent years due to a wealth of new data regarding extrasolar planets (Marcy and Butler 1998). So far, the prevalent theoretical approach to planet formation has been in brute-force *ab-initio* simulations of large numbers of gravitating bodies (e.g. Ida and Makino 1992). Despite the enormous advances in computer speed, even the current generation of dedicated super-computers can not deal with the huge number of initial bodies ($N \geq 10^6$) needed to simulate the formation of a planetary system as a whole.

To achieve this goal, we have recently developed an effective model of planetary accretion utilizing a set of physical assumptions that simplify the accretion process considerably (Balaž et al. 1999). This has made possible the routine investigation of large numbers of initial particles up to $N = 10^{10}$. For each value of the parameters 100 independent runs were performed, in order to accumulate statistics.

Apart from N, the only parameter entering our effective model is the condensation parameter K, which is proportional to the ratio of masses of the protoplanetary disk and star. One of the main results of our work so far has been the uncovered independence of scaling exponents characterizing certain properties of the final condensates from the initial mass distribution in the protoplanetary disk. In this paper we will focus on the properties of exponents related to the spin of the condensates.

2. SPIN

Figure 1 depicts the typical result of our simulations for the relation between the spin of a condensate, i.e. angular momentum due to the rotation about its axis, and its mass. We have investigated a large number of initial mass distributions $\rho(r)$. In all cases we find a power law of the form $s \propto K^{\epsilon} m^{\omega}$. The scaling exponents ϵ and ω are almost independent of the choice of initial mass density. We have established the existence of two distinct classes of initial mass distributions. The above scaling exponents are universal inside each of those classes. Of the two exponents ω is obviously much more interesting, as it gives the connection between two directly measurable quantities.

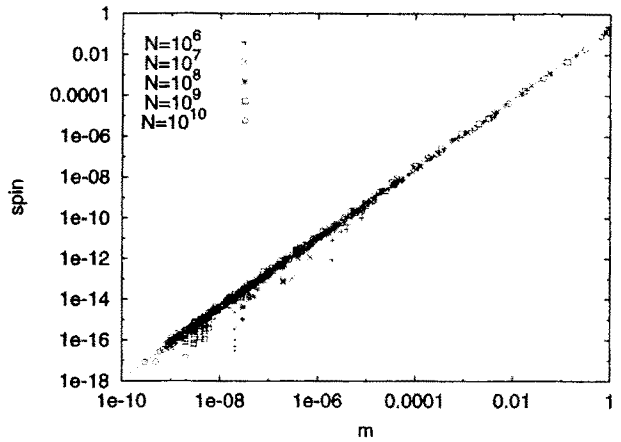

Fig. 1. Spins of condensates as a function of mass for $K = 0.1$ (best fit to Solar system) and $N = 10^6, 10^7, \ldots, 10^{10}$ initial particles. The results fit to $s \propto m^{\omega}$. Initial mass densities belonging to the first universality class all give $\omega = 1.75 \pm 0.03$, while those in the second universality class give $\omega = 1.94 \pm 0.06$.

In Fig. 2 we show several initial mass distributions belonging to the first universality class. All the distributions belonging to this class lead to the same values for the scaling exponents $\omega = 1.75 \pm 0.03$ and $\epsilon = 0.40 \pm 0.02$. Distributions belonging to the second universality class also, within error bars, lead to a single value for the scaling exponents. In particular, in this class we have $\omega = 1.94 \pm 0.06$. The simplest initial mass distribution in the second class is a generic uniform distribution from some minimal radius $r = a$ to a maximal radius $r = b$. The further analysis of these results, along with an analytic derivation of the two universality classes will be given in a future publication (Nađ–Perge et al.).

The corresponding data for the planets in the Solar system is given in Fig. 3. We see that our effective accretion model agrees quite well with phenomenology. The only two planets that do not satisfy the above spin-mass relation are Mercury and Venus. This is not surprising, as these are the two planets nearest to the Sun, where additional tidal lock effects, neglected in our simplified model, play an important role.

Let us note that our effective model represents a general model of gravitational condensation. As such it may be applied to other systems. For example, for large values of the condensation parameter K, the whole material in the protoplanetary disk condenses into a single object. This represents the scenario for the formation of a binary star system. In this limit the condensation process becomes independent of the order of condensation, making the model analytically solvable. The application of the model to binary star systems is still in progress. As a preliminary result, we used astrometric data on binary star systems (Malkov 1993) to plot the dependence of the orbital angular momentum L of a binary star system in terms of M_1 the mass of the primary. This is shown in Fig. 4.

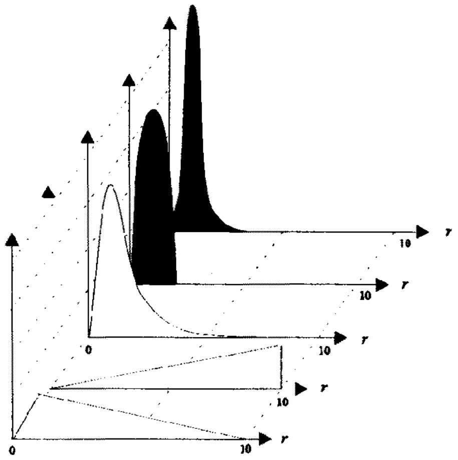

Fig. 2. Examples of initial mass distributions of the protoplanetary disk belonging to the first universality class.

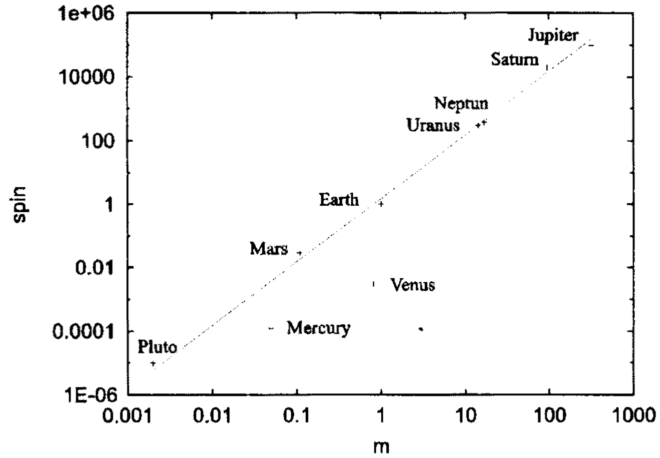

Fig. 3. Spin vs. mass for the planets of the Solar system. The planets satisfy $s \propto m^{\omega}$, where $\omega = 1.94 \pm 0.06$. As a result of tidal forces, Mercury and Venus do not lie on this curve.

From this figure we see that approximately 80% of binary star systems lie on the curve $L = 30{M_1}^{1.75}$, while a further 10% (visual binaries) lie on $L = 850{M_1}^{1.75}$. The majority of the remaining binary systems (mostly spectroscopic binaries) lie on a line of constant mass $M_1 \approx 1.16$ connecting the two curves. Under very simple assumptions it is possible to show that the spin of the secondary star is proportional to the orbital angular momentum. On the other hand, to a good approximation, binary systems satisfy $M_2 \propto M_1$, so that M_1 offers the only mass scale. Therefore, we see that binary star systems are well described by the scaling exponent $\omega = 1.75$, corresponding to the second universality class in our model. Although these results are preliminary it is interesting to see that both existing universality classes of our model are 'used' in nature: the one in the condensation of planetary systems, the other in the formation of binary stars.

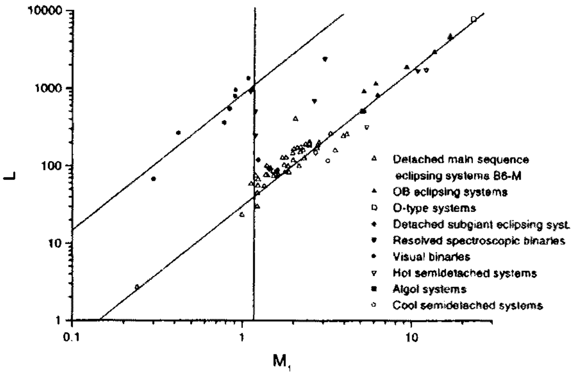

Fig. 4. Orbital angular momentum of a binary system about its center of mass as a function of the mass of the primary star.

The numerical simulations presented in this contribution have been performed on an SGI Origin 2000 super-computer. We would like to acknowledge the help of the staff of the IPCF (Institute of Physics Computing Facilities). This research was supported in part by the Serbian Ministry of Science and Technology under research projects 01M01 and 01E15.

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ISTRAŽIVANJE MODELA UTICAJA TEMPERATURE PRI ODREDJIVANJU RAZLIKA LONGITUDA IZ MERENJA ZENITNIH DALJINA ZVEZDA DANŽONOVIM ASTROLABOM

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Abstract. 1988. godine, u okviru Evropske mreže longituda, odredjivane su razlike longituda Minhen-Beč-Grac iz merenja zenitnih daljina zvezda Danžonovim astrolabom. Merenja su izravnata korišćenjem dva modela koji se razlikuju medjusobno u opisivanju uticaja temperature na merenja zenitnih daljina. Model koji su predložili autori bolje opisuje sistematski uticaj temperature.

1. UVOD

Za uspostavljanje ELN (European Longitude Network) sprovedeno je nekoliko kampanja za odredjivanje razlika longituda izmedju nacionalnih referentnih stanica u sedam evropskih zemalja (Kaniuth and Wende 1980, 1983, Wende 1992). Ova merenja su uradjena Danžonovim astrolabom, od 1977 do 1980. i 1988. godine. Primenjena je metoda jednakih zenitnih daljina, tj. vreme prolaza zvezde kroz almukantarat registrovano je na zenitnoj daljini $z \approx 30^o$.

Poslednja kampanja za odredjivanje razlika longituda u okviru ELN sprovedena je 1988. godine. Odredjivane su razlike longituda izmedju dve austrijske stanice, Beča i Graca, i referentne stanice u Minhenu. Opažanja je uradio W. Wende. Opažane su odabrane zvezde iz FK5 kataloga, sa deklinacijama izmedju 20^o i 70^o. Opis kampanje i analiza merenja dati su u Wende-ovom radu (Wende 1992).

Autori ovoga rada su neke rezultate obrade i analize ovih merenja objavili ranije (Perović and Cvetković 1998, Cvetković and Perović 1999). U ovom radu daju se rezultati dobijeni sa dva modela za izravnanje merenja. Jedan je zasnovan na Wende-ovom modelu, a drugi su predložili sami autori. Za redukciju merenja korišćeni su položaji zvezda iz Hipparcos kataloga.

Kampanja 1988. godine radjena je od 20. jula do 10. septembra. Ukupno je bilo **23 večeri opažanja.** Prvo je u Minhenu za 5 večeri opažano po dve grupe zvezda ili ukupno 10 serija, zatim u Beču za 6 večeri 15 serija, pa u Gracu za 7 večeri 17 serija i na kraju, ponovo u Minhenu za 5 večeri 10 serija zvezda.

2. PRVI MODEL IZRAVNANJA – MODEL I

Za **model I**, u suštini, korišćen je Wende-ov model izravnanja (Wende, 1992) koji obuhvata obavezne i opcione parametre, ali ne i *a priori* nepoznati broj popravki po rektascenziji.

Za svaki zvezdani prolaz postavljena je sledeća jednačina popravaka:

$$\begin{aligned} l_p + v &= b_\varphi d\varphi_i + b_\lambda d\lambda_i - dz_k \\ &\quad + \Delta T\, b_\varphi\, \Delta\varphi_G + \Delta T\, b_\lambda\, \Delta\lambda_G \\ &\quad + b_{IT}\, dIT + b_{IA}\, dIA + b_{HD_2}\, dHD_2 \\ &\quad + b_H\, dH1 + b_H^2\, dH2 + b_F\, dF \end{aligned}$$

gde su:

a) *9 obaveznih parametara*: 3 parametra $d\varphi_i$ i 3 parametra $d\lambda_i$ – za svaku stanicu po jedan; 3 parametra dz_k – za svaku grupu zvezda, (10, 11 i 12), po jedan;

b) *8 opcionih parametara*: $\Delta\varphi_G$, $\Delta\lambda_G$ – vremenska promena latituda odnosno longituda izmerenih od strane jednog posmatrača; dIT – parametar promene temperature instrumenta isti za sva merenja kampanje; dIA – parametar promene razlike temperatura instrumenta i vazduha isti za sva merenja kampanje; dHD_2, – parametar adaptacije ljudskog oka; $dH1$, $dH2$ – parametri za uticaj prividne veličine zvezde, i dF – parametar za uticaj boje zvezde.

Radi odredjivanja težina opažanja (prolaza zvezda) izvršeno je ocenjivanje komponenti disperzija korišćenjem modela:

$$\sigma_i^2 = \sigma_1^2 + \sigma_2^2 \cdot (\cos\varphi \sin A)^2 + \sigma_3^2 \cdot m_v^2 \ .$$

i metode ocenjivanja komponenti PERKDV1 (Perović 1999).

Za otkrivanje grubih grešaka u opažanjima korišćen je Popeov tau-metod (Pope 1976) sa nivoom značajnosti testa $\alpha_o = 0.05$. Broj prolaza zvezda sa kojim se ušlo u izravnanje iznosio je 1601. Po primeni testa grubih grešaka odbačeno je oko 14% prolaza i sa preostalih 1378 merenja sračunata je ocena disperzionog koeficijenta m_o^2 – Tabela 1.

Posle izravnanja, grafički su predstavljene ocene popravaka $\hat{v}$ po različitim regresorima (uticajima): serijama, večerima, azimutu, prividnoj veličini zvezda, spoljašnjoj temperaturi tokom opažanja, atmosferskom pritisku i temperaturi instrumenta. Od svih grafika, jedino je grafik po večerima ukazivao na promene popravaka (Grafik 1.a.), uzrok čega je mogla biti temperatura koja je bila različita po večerima. Radi toga je uveden drugi model kojim se temperaturni uticaji bolje opisuju.

3. DRUGI MODEL IZRAVNANJA – MODEL II

Umesto dva parametra uticaja temperature, dIT i dIA, korišćenih u modelu I za sva merenja kampanje, u **model II** uvedena su *po dva parametra*, dIT i dIA, *za merenja u pojedinoj večeri*. Zbog ovoga model II ima ukupno 46 parametara za opisivanje uticaja temperature i glasi:

$$\begin{aligned} l_p + v \; = \; & b_\varphi d\varphi_i \; + \; b_\lambda d\lambda_i \; - \; dz_k \\ & + \Delta T \; b_\varphi \; \Delta\varphi_G \; + \; \Delta T \; b_\lambda \; \Delta\lambda_G \\ & + b_{IT} \; dIT_h \; + \; b_{IA} \; dIA_h \; + \; b_{HD_2} \; dHD_2 \\ & + b_H \; dH1 \; + \; b_H^2 \; dH2 \; + \; b_F \; dF \end{aligned}$$

gde indeks h označava broj večeri, ($h = 1, ..., 23$). U ovom modelu broj obaveznih parametara je 9 – isti kao u modelu I, a opcionih 52, tako da ukupan broj parametara iznosi 61.

Težine opažanja su odredjivane istim postupkom kao kod modela I. Za testiranje grubih grešaka u opažanjima takodje je korišćena Popeova tau-metoda na isti način kao kod prvog modela. Odgovarajući rezultati dobijeni na osnovu izravnanja ovim modelom dati su u Tabeli 1.

Ocene popravaka $\hat{v}$ dobijene iz izravnanja pomoću modela II grafički su predstavljene po istim regresorima kao pri modelu I. Sada ni grafik popravaka po večerima ne pokazuje zavisnost – Grafik 1.b.

Medjutim, pravi odgovor na pitanje opravdanosti uvodjenja modela proširenog za temperaturne uticaje po večerima – model II, daje nam F-test. Statistika testa glasi:

$$F = m_{o,I}^2 / m_{o,II}^2 \; .$$

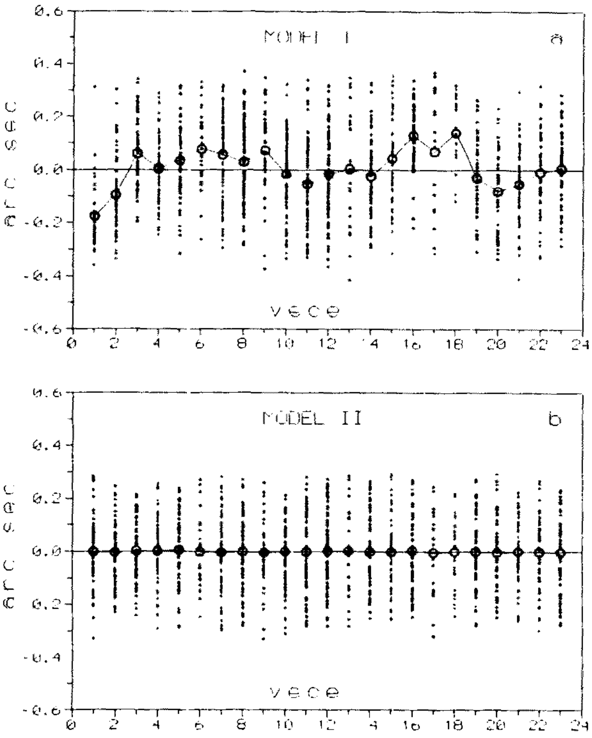
Na osnovu uporedjenja test veličine F sa kvantilom F-rasporeda:

$$F = 0.02565/0.01578 = 1.625 > 1.184 = F_{0.999}(1361; 1335)$$

zaključujemo da se modelom II značajno bolje opisuju uticaji temperature u merenjima, što se, sa druge strane, direktno odražava na tačnije odredjivanje razlika longituda.

Tabela 1. Vrednosti $R = \hat{v}^T P \hat{v}$ i m_o^2 dobijene pomoću modela I i II. (n – broj prolaza (posle eliminacije merenja sa grubim greškama); u – broj parametara; f – broj stepeni slobode.

Model	n	u	R ["]^2	m_o^2 ["]^2	f
I	1378	17	34.9085	0.02565	1361
II	1396	61	21.0608	0.01578	1335



Grafik 1. Ocene popravaka u zavisnosti od večeri dobijene: a) modelom I; b) modelom II. Kružići predstavljaju srednje vrednosti popravaka po večerima.

4. ZAKLJUČAK

Rezultati analize potvrdjuju da se temperaturni uticaji u merenjima zenitnih daljina zvezda Danžonovim astrolabom značajno bolje opisuju modelom sa dva parametra po jednoj večeri – model II, u odnosu na model uticaja temperature sa dva parametra za celu kampanju – model I.

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IS THERE AN ARROW OF TIME AFTER ALL?

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Abstract. In recent attempts at building an atemporal ("tenseless") picture of the physical world, insufficient attention is devoted to the cosmological arrow of time. According to new empirical findings, and particularly the epoch-making discovery of a large effective vacuum energy density, the existing discussions of the topic need reassessing. In particular, the necessity of a new treatment of asymmetric temporal boundary conditions in an open universe is hereby put forward. Some errors implicit in the earlier treatment of the problem of the cosmological arrow of time are briefly discussed.

1. ATEMPORAL UNIVERSE

The puzzle of apparent temporal asymmetry of the physical world arguably governed by series of simple, time-symmetrical processes has been considered by philosophers and cosmologists from the time of pre-Socratics. Only in the course of the last century, since the great discoveries of Ludwig Boltzmann, and subsequent elucidations by Eddington, Jeans, Tolman and others, it has gradually become clear that the problem of irreversibility of physical processes encountered in everyday life is inseparably linked to the global initial conditions of the world we live in; that is, to cosmology. Although this simple point has been put forward by many authors (e.g. Gold 1962; Penrose 1979; Hawking 1985; Price 1996), it has somewhat remained outside of the mainstream of cosmological thought, for at least two reasons. One is unhappy association of some attempts to deduce the thermodynamical and radiative arrows of time from the cosmological one, with the discredited steady-state theory defended mainly by Hoyle and Narlikar (i.e. Hoyle and Narlikar 1972, 1974). Another, which I shall try to highlight in this note is too narrow cosmological framework to which the idea has been applied. In other words, the problem has been set in several versions, each too special to appeal to most of cosmologists, naturally very cautious with respect to determination which **exact** cosmological model describes the empirical reality. This is understandable, particularly in the light of great difficulties encountered—even after the great cosmological controversy of the 1950-ies has left only evolutionary Friedmann models on the battlefield—by observational cosmologists in determination of the three fundamental cosmological parameters, H_0, Ω and Λ.

Hereby, I would like to defend the following thesis:

1) The recently observationally confirmed positive cosmological constant breaks any conceivable time-reversal global symmetry.

In addition, two complementary philosophical theses can be put forward, but their discussion is beyond the scope of this paper and will be the subject of a subsequent work:

2) The existence of life, and particularly intelligent observers has basically the same effect of breaking the global symmetry. Therefore, the introduction of an additional arrow of time, which we can call the anthropic arrow (or arrow of technologization) may be a useful concept.

3) A reductionist picture of continuity of cosmological, biological and anthropological evolution makes a good framework for unification of various arrows of time, and therefore presents the unique consequent approach to building a completely atemporal worldview.

2. OPEN UNIVERSE AND THE COSMOLOGICAL CONSTANT

In a recent very important study of Huw Price *Time's Arrow and the Archimedes' Point* (Price 1996), the most comprehensive discussion to this day of implications of an atemporal worldview for physics can be found. Central point of atemporal description of the initial (and possibly) the final conditions in cosmology is what Price calls the "basic dilemma":

> *...A symmetric physics seems bound to lead to the conclusion either that both ends must be smooth (giving the Gold universe), or that neither end need be, in which case the smooth big bang remains unexplained. On the face of it, then, we seem to be presented with a choice between Gold's view, on the one hand, and the conclusion that the smooth big bang is inexplicable (at least by a time-symmetric physics), on the other.*

However, smoothness or simplicity of the early universe does not seem intractable from the point of view of a general theory of nonlinear dynamics (Devlin 1991; Treumann 1993). If one could specify information content of the universe at any given epoch, it could be shown that the retrodiction to the initial state requires a very simple state. Although the prospects for giving exact laws of this complexity growth are still unclear, it seems plausible that in an atemporal view it is enough that the final state is **complex** enough to give a unique initial state. And the roads to such final state through entropy production are actively investigated in contemporary astrophysics and cosmology.[1]

In contradistinction to the spirit of the "basic dilemma", it should be noted that there have been several attempts to derive (Clutton-Brock 1977; Tegmark and Rees 1998;

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[1] In linear regimes, the entropy production has been thoroughly investigated by Weinberg (1971). For non-linear regime of the structure formation, see, for example, Valageas and Silk (1999) and references cited therein, which all follow the seminal study of Press and Schechter (1974).

Barrow 1999) the low initial entropy from anthropic constraints; even more to the point, it could well be done in each particular instance without the ontological enlargement (i.e. postulating the multiverse), if one is willing to follow in bold steps of Dyson (1979), and break the taboo by introducing a teleological discourse. This step immediately breaks the symmetry, since "known physics" which should, from the reductionist point of view, include the complexity of biological and even psychological structures, is (to say the least) ambiguous with respect to temporal orientation. This point does not seem to have been recognized in contemporary literature on the subject. However, another form of breaking of the temporal symmetry has obtained (and justly so) very much publicity during the last two years.

Recent observational confirmation of the large vacuum energy density (commonly known as "cosmological constant")[2] will undoubtedly have great impact on our way of thinking about the time, as well as on almost any aspect of physical eschatology. The three most significant consequences of a cosmological constant roughly corresponding to the cosmological density fraction $\Omega_\Lambda \sim 0.7$ are as follows:

- The universe will expand at an ever-accelerating pace; at some point in time, which has already been reached (Kardashev 1997; Ćirković and Bostrom 1999), it will enter a de Sitter (quasi-exponential) expansion phase.
- Event horizons (Rindler 1956; Harrison 1991; Ellis and Rothman 1993) form in the de Sitter space, the size of which is determined exclusively by the magnitude of Λ
- The temperature of ever-expanding universe will not go to zero as in open Friedmann cosmological models. Instead, in asymptotic limit when proper time $t \to \infty$, temperature will tend to a constant value,

$$T \to T_\Lambda = \frac{\hbar c}{k}\sqrt{\frac{\Lambda}{12\pi^2}} \approx 3.3\times 10^{-30} h \sqrt{\frac{\Lambda}{0.7}}\ \mathrm{K}, \tag{1}$$

where k is the Boltzmann constant.

The extremely low temperature in Eq. (1) will, eventually, become higher than the microwave background radiation. In addition, it will become hotter than any other form of background remaining at these distant epochs. Without going into details (see Tipler 1986; Treumann 1993) we note that in the open universe energy consumption entering the Brillouen (1962) inequality (for the maximal amount of information which can be processed by a physical system using energy E and working at the temperature T) remains finite, but the possible divergence can be obtained in the $T \to 0$ limit. Such manner of satisfying the final anthropic hypothesis (Ćirković and Bostrom 2000) seems frustrated by the realization that the temperature in Eq. (1) is the **minimal** possible temperature, and

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[2] For observational findings see Perlmutter et al. (1998, 1999), Riess et al. (1998) and Lineweaver (1998). The methodology used in searches for distant Type Ia supernovae has been elaborated on by Branch and Tamman (1992). Impact on theoretical cosmology has not yet been investigated in detail, but some important lessons have been drawn by Krauss and Turner (1999), as well as in an earlier study of structure formation by Liddle et al. (1996). For the anthropic significance of the cosmological constant see Barrow and Tipler (1986), Weinberg (1987), Efstathiou (1995) and Martel, Shapiro and Weinberg (1998).

therefore the integration of the Brillouen inequality will give a finite result in any realistic case. A hibernation-type decrease in energy consumption (Dyson 1979) probably will not help due not only to finite asymptotic temperature but also to quantum effects (Krauss and Starkman 1999). The recourses left are connected with the topological structure: transferring to another unit of the global multiverse, or **creating** another such unit (Harrison 1995). In a sense, this offers a possibility of answering the question: if the cosmological constant breaks the temporal symmetry, and the same may be said of the emergence of intelligent observers, what are the relations between the two breaks? Of course, the answer may be given only **with respect** to the entire timespan of intelligence in a universe (which can be thought of as a generalization of relationist view of time; see Schuster 1961; Newton-Smith 1980).

Parenthetically, the presence of vacuum energy as indicated by the recent cosmological supernovae experiments has some interesting consequences for the evolution of matter. For instance, it seems clear that the long-term evolution of black holes is substantially different when Λ is present (e.g. Hayward, Shiromizu & Nakao 1994; Adams, Mbonye & Laughlin 1999). If anything, the process of black hole accretion of matter and subsequent evaporation through Hawking radiation is made even *more* asymmetric than earlier (in this respect, the physical asymmetry has been emphasized by Paul Davies back in 1973). Therefore, it seems that the basic dilemma is resolved in a way which you consider less appealing, that is, through physical boundary conditions which are asymmetric completely independently of human cognizance. In a sense, the true cosmological arrow of time is established only after the existence of the cosmological constant is confirmed.

3. OTHER FORMS OF BREAKING THE TIME SYMMETRY

The discussion of the cosmologial constant sketched here points out that there is an easy way to break the symmetry of cosmological time. This solution comes, of comes, with a price. Part of the price lies in the fact that it is necessary to account for the **sign** of Λ. Preceeding considerations apply only to the positive sign, in which case the universe is ever-expanding disregarding its topological structure. However, the negative Λ will just add to the total energy density, and if its magnitude is in a wide range of interesting values, it will cause recollapsing universe in which case we are faced with the Price's basic dilemma again (see also the illuminating discussion of such models in Barrow & Dabrowski 1995). Although there are some exceptions to this, we shall not consider them further here. What is interesting is the fact that the ultimate "Theory of everything" will have to give the explanation of the sign of the cosmological constant in terms of the "first principles", in order to explain the cosmological asymmetry. Since the same ultimate theory is (naturally) expected to account for the CP violation, it is quite plausible to think that the same set of fundamental processes is responsible for both asymmetries, thus unifying micro- and macrocosmos in the most remarkable way, confirming Bronstein's (1933) farsighted intuition.

From a historical perspective, therefore, it seems that apart from the processes of unifying the various seemingly distinct empirical phenomena, we are dealing with attempts to unify the various arrows of time. While the connection of thermodynamical and cosmological arrows has been suggested by various authors, notably Gold and others during the last half century, and connection of electromagnetic arrow with the cosmological one first elucidated by Wheeler and Feynman (1945, 1949), later followed by Hogarth (1962), only with works such as Price's we get a comprehensive enough view. However, the prospect of this (inherently atemporal!) unification is somewhat marred by the explicit rejection of possibility that what is traditionally called psychological arrow of time can be explained in the same manner as the rest.

In this respect we see another instance of violating inherent symmetry of (macro)physical laws. The phenomenon of life, and particularly intelligent life, if regarded as transcedental, of course can not be analyzed in physical terms, but while such dualism permeates the modern scientific thought, from Descartes onward, and has certainly brought important fruits in natural sciences, it should not be regarded as divinely ordained truth, as most practicing physicists and philosophers tend to do. Instead, one may follow the leads of Schrödinger (1944) and Stapp (1985), or even better, Empedocles, Anaxagoras and some other pre-Socratic thinkers, that the biological, psychological, and even sociological evolution is an inherent and inseparable part of the physical, i.e. cosmological evolution (e.g. Guthrie 1969). While here is certainly impossible to go into depths of such a rich and insufficiently studied worldview (which, ultimately, includes the transition, or **translation** between syntaxical and semantical structures in epistemological sense), it is interesting to speculate whether the same sort of asymmetry creating the large cosmological constant and cosmological arrow of time is responsible for the appearance of life and intelligence in the physical world. What does seem clear is that melioristic cosmos in which complexity increases as more and more advanced form of life and intelligence arise is incompatible with the time-symmetric worldview, as personified by the Gold (1962) universe, or indeed any similar simple scheme.

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SEMICLASSICAL PLANETOLOGY: SOME RESULTS

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Abstract. In the early sixties two Yugoslav scientists, Pavle Savić and Radivoje Kašanin have started developing a theory of the behaviour of materials under high pressure. The initial work was published between 1962 and 1965. In the course of time, this theory has found applications in planetology and laboratory high pressure work. The aim of this lecture is to review the basic physical ideas and some results of the planetological applications of this theory.

1. INTRODUCTION

Planetology is defined as a branch of astronomy and physics pertaining to the study of planets. Its origins can not be traced precisely, because first purely logical and philosophical considerations on the "wandering stars" were made already in antiquity. First scientific studies of the problem of the origin of planets date back to the times of Kant and Laplace. However, studies of planetary interiors had to wait until the second half of the last century and the development of seismology. It has been shown on several occasions in the XIX century that seismic waves , originating in earthquakes, in their propagation through the interior of the Earth encounter regions of different densities (Zharkov V.N. and Trubitsin V.P. 1981). These were the first experimental proofs that the Earth's interior is stratified.

The turn of the century witnessed first attempts of laboratory studies of planetologically important materials. Water, for example, has been subdued to increased pressure, already in XVII century. It is known that an Englishman, a certain Mr.Cannon, compressed water to 0.01 GPa at room temperature, and obtained water ice (Block S. et al. 1980). This attempt is nowadays remembered just as a detail of historical interest. Laboratory experiments on the behaviour of water under high pressure started due to work by Tamman (1900) and Bridgman (1911) in the first decade of the XX century. For comparison, note that there exist at least 15 phases of ice, and that water has been studied in diamond anvil cells at values of pressure $P \leq 128 GPa$ (Hemley R.J. 1987).

Theoretical planetology started developing rapidly in this century. The usual process of modellization of planetary internal structure includes the following steps: assume some chemical composition of the body under study and some form of the equation of state of the material which makes up the planet, and then calculate the radial distribution of pressure, density and temperature (see, for example, Čelebonović V. 1983) .

The aim of this lecture is to review the main physical ideas of a theory of behaviour of materials under high pressure, proposed in the sixties by P. Savić and R. Kašanin (1962/1965) (styled the SK theory). As the theory has applications in astrophysics, as well as in laboratory high pressure studies, we shall here present only a part of the planetological results. For a previous review of the theory see Savić P. and Čelebonović V. (1994).

2. THE SK THEORY

This theory started developing after a paper by Savić which had the aim to explore the origin of planetary rotation (Savić P. 1961). It was shown in that paper that in order to draw conclusions about the origin of planetary rotation, one needed to know details about their internal structure. The mean planetary densities were fitted by a simple analytical formula

$$\rho = \frac{4}{3} 2^{\varphi} \tag{1}$$

Note that the factor 4/3 turns out to be very close to the mean solar density, and φ is an integer: $\varphi \in \{-1,0,2\}$. Choosing values of φ by trial and error, it becomes possible to reproduce the known values of the mean planetary densities. The original data presented in Savić P. (1961) are reproduced in Table I:

Table I

Object	φ	ρ_{calc} (kg/m^3)	ρ_{obs} (kg/m^3)
Saturn	-1	660	650
Sun	0	1330	1410
Jupiter	0	1330	1340
Uranus	0	1330	1360
Neptune	0	1330	1320
Earth	2	5320	5520
Mars	2	5320	3940
Venus	2	5320	5210
Mercury	2	5320	5600

The symbols ρ_{calc} and ρ_{obs} denote, respectively, the density calculated according to Eq. (1) and values derived from known planetary masses and radii.

The importance of Eq. (1) is in the fact that it helped the SK authors of to introduce a new idea in planetology - that the internal structure of a planet is influenced to a large extent by changes, produced by high pressure, of the atomic and/or molecular structure of the mixture of materials that the planet is made of, as well by changes in the lattice structure of these materials. Apart from the "quantum" nature of Eq. (1), they were pushed in that direction by two more factors: the geophysical data on the propagation of seismic waves through the Earth, which showed that the Earth's interior consisted of different layers with sharp transitions between them, and laboratory experiments on materials under high pressure (such as Bridgman P.W. 1964).

At the time, they were not aware of the fact that Enrico Fermi invoked the possibility of changes of atomic and molecular structure under high external pressure several decades before them, while testing the applicability of the then "new" Schrödinger equation. However, Savić and Kašanin were the first to use the idea of changes of atomic structure under high pressure in planetology. This phenomenon was termed "pressure excitation", and received full quantum mechanical treatement only recently (Ma D. 1988).

In four years following the publication of (Savić 1961) Savić and Kašanin developed their theory of the behaviour of materials under high pressure (Savić and Kašanin 1962/1965). It has two general aims: to develop a theoretical explanation of the origin of rotation of cold solid celestial bodies (such as planets,satellites,asteroids) and a theory of behaviour of dense matter. The result is a theoretical description of some aspects of phenomena occuring in materials under high pressure, founded on known laws of classical physics combined with some facts from quantum mechanics - hence the name semiclassical.

The considerations of SK start from a low temperature isolated cloud of gas and dust, consisting of an arbitrary number of chemical elements and their compounds. The evolution in time of such a cloud is governed by two physical processes: the mutual interactions of its constituting particles, and the loss of energy due to radiation. Because of the low temperature of the cloud, this radiation is somewhere in the red or even IR part of the spectrum.

The obvious consequence of these two factors is the increase of density, and pressure in the interior of the cloud. A further consequence is the excitation and ionisation of the atoms and molecules in the cloud. Pressure excitation and ionisation is an expectable consequence of the perturbation of the electronic energy levels by the external pressure field. The physical possibility of such a coupling can be proved even in solvable elementary quantum mechanical systems such as a finite potential well. Increasing the pressure to which a system is subdued leads to the expansion of the radial part of the electronic wave functions of the atoms and molecules that make up the system.

When the pressure has risen sufficiently so that pressure ionisation can start, a phase transition occurs in the cloud - it passes into the state of a poly-component plasma.This plasma consists of a randomly moving electron gas and neutral and ionized atoms and molecules. Such an electron gas has a non-zero magnetic field (de Groot S.R. and Suttorp L.G. 1972). Owing to a combination of high pressure and low temperature, the magnetic moments of the ionized atoms and molecules become oriented in parallel, and the resulting torque starts the rotation of the whole system. We have here given a qualitative description of the process which,according to SK, gives rise to rotation. Details, pertaining to the rotation of the Moon and the form in which the rate of rotation is expressed in SK are given in Savić P. and Kašanin R. (1962/1965), Čelebonović V. (1995).

The second line of investigations pursued by SK is the study of the behaviour of materials under high pressure. Experimental work in this domain is linked with a multitude of problems (such as filling a diamond anvil cell, or fixing the contacts on a specimen). On the theoretical side, a specimen of any material is a typical example of a many-body system, whose Hamiltonian has the form:

$$H=\sum_{i=1}^{N}-\frac{\hbar^{2}}{2m}\nabla_{i}^{2}+\sum_{i=1}^{N}V\left(\left|\vec{x}_{i}\right|\right)+\sum_{i,j=1}^{N}v\left(\left|\vec{x}_{i}-\vec{x}_{j}\right|\right) \tag{2}$$

All the symbols in Eq.(2) have their standard meanings. Instead of embarking on a calculation of the thermodynamical functions proceeding from Eq.(2) Savi} and Ka{anin have based their theory on a set of six experimentally founded premises supplemented by a selection rule.

The mean interparticle distance a is defined by the relation

$$N_{A}(2a)^{3}\rho=A \tag{3}$$

where N_A denotes Avogadro's number , A the mean atomic mass of the material and ρ is the mass density. As a next step, one introduces the "accumulated" energy per electron as

$$E_a = \frac{e^2}{a} \tag{4}$$

It can be shown (Čelebonović V. 1992) that the mean interparticle distance defined in Eq. (3) is a multiple of the Wigner-Seitz radius which contains the ionic charge Z.

The basic premises of the SK theory are (Savić P. and Kašanin R. 1962/1965, Čelebonović V. 1995):

1. The density of a material is an increasing function of the applied pressure.
2. With increasing density, a material undergoes a sequence of first order phase transitions. Phases are indexed by an integer i. The phase ending at the critical point is denoted as the zeroth phase. For an arbitrary phase,the density is delimited by :

$$\rho_i^0 \le \rho_i \le \rho_i^*$$

or

$$\frac{\rho_i^*}{\alpha_i} \le \rho_i \le \rho_i^* \qquad \alpha_i \ge 1 \tag{5}$$

3. Assuming in Eq. (1) that $\varphi_{i+1} - \varphi_i = 1$ one gets that the maximal densities in two sucessive phases are related by

$$\rho_{i+1}^* = 2\rho_i^* \tag{6}$$

4. It is assumed that

$$\frac{E_i^*}{E_i^0} = \frac{E_{i+1}^0}{E_i^*} \tag{7}$$

A relationship between the accumulated energies in sucessive phases was needed so as to render the calculations possible, and Eq.(7) was adopted because of its simplicity. It can be shown that $\alpha_i \alpha_{i+1} = 2$ and that

$$\alpha_i = \begin{cases} 6/5, i=1,3,5,... \\ 5/3, i=2,4,6,... \end{cases} \tag{8}$$

5. The final density of the phase $i = 0$ is given by

$$\rho_0^* = \frac{A}{3V} \tag{9}$$

where $\overline{V}$ is the molar volume of the material under standard conditions (Čelebonović V. 1992).

6. It follows from the assumption 3 that

$$\frac{1}{\overline{\rho}} = \frac{1}{2}\left(\frac{1}{\rho_2^0} + \frac{1}{\rho_2^*}\right) \tag{10}$$

where the symbol $\overline{\rho} = \frac{A}{\overline{V}}$ is the density of a material at the zero point.

These assumptions enable the calculation of the value of pressure at which a first order phase transition can be expected in a material. Mathematically,the idea of this calculation is to compare the work performed by the external pressure on the material with the corresponding change of the accumulated energy. Details concerning this algorithm, as well as its applications to 20 materials chosen at random, and an analysis of the possible causes of the discrepancies can be found in the literature (Čelebonović V. 1992, 1995, 1999).

The algorithm proposed in the SK theory provides the mathematical rule for calculating the phase transition pressure. However, SK have devised a selection rule for determining those phase transitions which are physically possible (Savić P. and Kašanin R. 1962-1965). A transition $i \to i+1$ is possible if

$$E_0^* + E_I = E_i^* \tag{11}$$

where E_I denotes the ionisation and/or excitation potential.

3. APPLICATIONS IN PLANETOLOGY

In planetology, the SK theory offers the possibility of modelling the internal structure of planets,satellites and asteroids.It can not be applied to stellar structure studies simply because it does not take into account the fact that nuclear reactions take place in stars.

The input data needed for a planetological application of this theory are the mass and the radius of the object under study. SK have developed algorithms which, starting from this pair of values, allow the determination of the number and thickness of layers which exist in the interior of the object, the distribution of pressure density and temperature with depth,the strength of the magnetic field and the allowed interval in which the rate of rotation of the object can be expected.This theory also gives the mean atomic mass of the chemical mixture that the object under study contains.

The SK theory has been applied to the Sun and all the planets except Saturn and Pluto, the Moon, the Galileian satellites, the 5 big satellites of Uranus and the asteroids 1 Ceres and 10 Hygiea. It was known to SK that the model of the solar interior within their theory can not be realistic. Interestingly, the central temperature obtained is of the correct order ($T_c \approx 10^7 K$).

The form of the results is illustrated in the following Tables, which contain the models of the Earth and Moon calculated according to the SK theory. The maximal values of the temperature in various layers were calculated according to Čelebonović V. (1991).

Table II Interior of the Earth

Depth (km)	0-39	39-2900	2900-4980	4980-6371
$\rho_{\max}(kg/m^3)$	3000	6000	12000	19740
$P_{\max}(Mbar)$	0.25	1.29	2.89	3.7
$T_{\max}(K)$	1300	2700	4100	7000

<A> = 26.56

Table III Interior of the Moon.

Depth (km)	0-338	338-1738
$\rho_{\max}(kg/m^3)$	3320	6640
$P_{\max}(Mbar)$	0.015	0.089
$T_{\max}(K)$	529	793

<A> = 71

Parameters of the models of the Earth and the Moon, and similar models of other objects calculated within the SK theory, can not be compared to in situ experimental data, but only to observable consequences on the surfaces of these objects of conditions in their interiors. However, the mean atomic mass <A> and combinations of chemical elements and/or compounds which fit it can be compared to experimental data obtained by remote spectroscopy from the Earth and/or space probes. A table of values of <A> is avaliable in Čelebonović V. (1995), and a distribution of <A> with radial distance from the Sun is represented in Fig.1

The radial distribution of <A> is of considerable interest for cosmogony, because it is a consequence of composition gradients and transport processes which existed and operated in the accretion disk from which the Solar system condensed. Namely, values represented in Fig.1 were derived within the SK theory, whose predictions have been compared with laboratory results (Čelebonović V. 1992) and astronomical observation. On the other hand, direct experimental verification of cosmogonical calculations is nearly impossible.

The most sucessful example of the determination of the value of <A> for an object is the case of the Galileian satellites. Their values of <A> were determined in Čelebonović V. (1987) back in 1987. First in-situ data on their chemical composition were obtained by the "Galileo" space probe in 1996. It turned out that predictions made by the SK theory in 1987., are in excellent agreement with experimental data collected nearly 10 years afterwards (Čelebonović V. 1998). At the time of publication, Čelebonović V. (1998) has aroused considerable interest.

Another interesting case of the determination of <A> has been the asteroid 10 Hygiea (Čelebonović V. 1988). It is known from observation that asteroids 1 Ceres and 10 Hygiea are spectroscopically similar.Using the known values of the mass and radius of

Ceres, its value of <A> was calculated. Combining this result with the value of R for 10 Hygiea as determined by IRAS, it became possible to calculate the mass of this asteroid.

4. CONCLUSIONS

In this lecture we have reviewed some planetological applications of a semiclassical theory of dense matter proposed by Savić and Kašanin in the sixties, and later applied and developed by various authors. Naturally, no details of the calculations are given on the text, but they can be found in the references .

The SK theory is mathematically simple. It has been developed with the aim of describing extremely diverse and complicated phenomena, but this complexity has been bypased by a set of basic postulates and a selection rule. This is a great advantage of this theory over better known models of phase transitions. However, there is also a hidden disadvantage - namely, the simplification of the physical assumptions of necessity renders the calculation cruder, and increases the discrepancies between the calculated and experimental results.

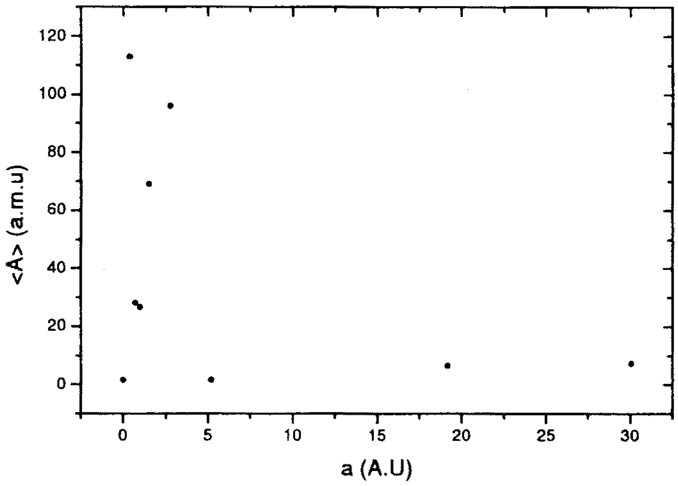

Fig. 1. Distribution of <A> with radial distance from the Sun.

We have discussed in this contribution some of the planetological results of the SK theory, and the obvious question is "What lies ahead?". This theory has a wide For instance, it would be very useful to improve its basic postulates. Eq. (1) should be rederived from modern data, and it is very probable that a new set of values of the exponent φ would emerge from this. The point here is that this equation is later used in calculation of the phase transition pressure, because it gives the ratio of densities in two sucessive phases. In the same domain, it would be important to develop a microscopic explanation of Eq.(1) and,in particular of the physical meaning of φ. On the laboratory side, it would be useful to repeat the analysis presented in Čelebonović V. (1992), but for a larger set of materials. It would be interesting to try to include nuclear reactions in the theory and thus render it applicable to stellar structure studies.

On the planetological side, there remain two planets which have not been modelled: Saturn and Pluto. But more interesting than that could be the modellization of the asteroids. Using similarities, as has been done for Hygiea and Ceres, this could be a useful method for determining masses of some asteroids.

In cosmogony, the SK theory could also be useful. Just one example is its possibility to determine the value of <A> .This implies that one can, proceeding from observed data, gain knowledge about the distribution of chemical elements within the planetary system, and thus constrain cosmogonical models. Such studies have already been performed on the Jovian and Uranian satellite systems (Čelebonović V. 1987, 1989). It has also been shown that Triton and Neptune are widely different in their chemical composition (Čelebonović V. 1986), which is in perfect agreement with the result known in celestial mechanics that Triton is a captured body.

To conclude, we can say that this simple theory of complicated phenomena has achieved interesting planetological and laboratory results and that it offers possibilites for future work both in astronomy and physics.

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СВОЂЕЊЕ БОШКОВИЋЕВИХ АСТРОГЕОДЕТСКИХ ОДРЕЂИВАЊА НА СИСТЕМ FK5

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Абстракт. Почетком двадесетог века С. П. Бошковић је на територији Србије вршио астрогеодетска одређивања ради добијања скретања вертикала. За обраду резултата посматрања узимани су положаји звезда из фундаменталног каталога NFK. Коришћењем података из FK5 у поновној обради посматрања, добијају се резултати ових одређивања у систему FK5. Овде се разматрају грешке *a priori* Бошковићевих резултата у односу на систем FK5, односно, свођење резултата Бошковићевих астрогеодетских одређивања на систем FK5.

1. УВОД

У периоду од 1900. до 1911. године, Стеван П. Бошковић је на тридесет тачака територије ондашње краљевине Србије обављао астрогеодетска одређивања (стање часовника, географска ширина и азимут правца) да би на њима добио скретање вертикале. Средња епоха Бошковићевих посматрања била је приближно 1906.0 . Резултати су приказани у књизи "СКРЕТАЊЕ ВЕРТИКАЛА У СРБИЈИ" (Бошковић 1952). Стање часовника је одређивано Цингеровом методом, ширина Пјевцовљевом, а азимут је одређиван из посматрања Северњаче. За обраду посматрања служили су положаји звезда из каталога NFK (Peters 1907) који је у то време (после првог светског рата) представљао референтну основу и, заједно са Њукомбовим системом астрономских константи, референтни систем.

Уколико желимо да резултате Бошковићевих одређивања сведемо на неки други систем, потребно је узети податке из тог другог система и са њима рачунати привидне положаје звезда за одговарајуће тренутке посматрања. У овом раду користимо податке из каталога FK5 (Fricke и др. 1988). Треба напоменути да се важећа референтна основа коју у оптичком делу представља HIPPARCOS каталог поклапа са FK5 каталогом у границама грешака FK5.

С једне стране, истражујући грешке NFK у односу на систем FK5, можемо да одредимо систематске разлике положаја звезда (FK5 – NFK), а такође су нам интересантне и просечне средње квадратне грешке положаја у ова два система. С друге стране, за примењене методе, имајући у виду њихове основне карактеристике и формуле за рачунање које су приказане у неком од уџбеника практичне астрономије (Блажко 1979), могу се извести *диференцијални обрасци* у којима ће фигурисати грешке координата звезда. Ови обрасци омогућавају да a priori одредимо утицај грешака координата звезда на резултате поменутих астрогеодетских одређивања. Другим речима, добијене вредности грешака координата звезда и изведене диференцијалне обрасце користимо за свођење резултата одређивања на систем FK5.

Иначе, израчунато свођење на систем FK5 a priori приказано у овом раду и резултати добијени a posteriori директним уношењем положаја FK5 у редукционе листове показују задовољавајуће слагање.

2. СВОЂЕЊЕ СТАЊА ЧАСОВНИКА НА СИСТЕМ FK5

Размотримо утицај грешака положаја звезда (грешке координата α и δ) на одређивање стања часовника, под претпоставком да су звезде у Цингеровим паровима имале деклинације које се крећу између $+20^o$ и $+50^o$ и да је већина њих опажана близу првог вертикала, на удаљењу од 10 до 15 степени по азимуту. Полазећи од ове чињенице и користећи диференцијални образац изведен за Цингерову методу

$$\begin{aligned}\Delta u = &- \frac{\cos A_e - \cos A_w}{\cos\varphi(\sin A_e - \sin A_w)}\,\Delta\varphi + \\ &+ \frac{\sin A_e}{\sin A_e - \sin A_w}\,\Delta\alpha_e - \frac{\sin A_w}{\sin A_e - \sin A_w}\,\Delta\alpha_w + \\ &+ \frac{\cos q_e}{\cos\varphi(\sin A_e - \sin A_w)}\,\Delta\delta_e - \frac{\cos q_w}{\cos\varphi(\sin A_e - \sin A_w)}\,\Delta\delta_w \ ,\end{aligned} \tag{1}$$

могу се израчунати грешке a priori стања часовника као последица утицаја систематских и случајних грешака координата звезда.

За неки фиктивни Цингеров пар на средњој ширини $\varphi = +45^o$ узећемо звезде са деклинацијом $\delta_e = \delta_w \approx 35^o$. При зенитној даљини $z \approx 40^o$ нека азимут буде $-A_e = A_w \approx 80^o$ за звезде јужно од првог вертикала, односно, $-A_e = A_w \approx 100^o$ за звезде северно од првог вертикала. Нека је при томе паралактички угао $q_e = q_w \approx 60^o$.

Заменом претпостављених вредности азимута, паралактичких углова и ширине у обрасцу (1), добија се

$$\Delta u \approx \frac{1}{2}\,(\Delta\alpha_e + \Delta\alpha_w) - \frac{1}{3}\,(\Delta\delta_e - \Delta\delta_w)\ . \tag{2}$$

Уопштено гледано, звезде на истим деклинацијама имају једнаке систематске грешке: $\Delta\alpha_e = \Delta\alpha_w = \Delta\alpha$ и $\Delta\delta_e = \Delta\delta_w = \Delta\delta$. Из тога произилази да је систематска грешка стања часовника приближно једнака систематској грешки ректасцензија за дату деклинацију пара

$$\Delta u \approx \Delta\alpha$$

Према вредностима разлика FK5 – NFK звезданих координата, за деклинацију $+35^{o}$ налазимо да је $\Delta\alpha = -0\overset{\mathrm{s}}{.}070$, одакле следи

$$\Delta u \approx -0\overset{\mathrm{s}}{.}070 .$$

Значи, свођењем на систем FK5 положаја звезда које користи С.П. Бошковић за одређивања Цингеровом методом и који су дати у систему NFK, стање часовника се мења приближно за $-0\overset{\mathrm{s}}{.}070$.

Што се тиче случајне грешке стања часовника, уз поједностављење, имамо

$$\varepsilon_u{}^2 \approx \frac{1}{2}\, E_\alpha^2 + \frac{1}{4}\, E_\delta^2 \, . \tag{3}$$

Овде је E_α грешка ректасцензије за $\delta = 35^{o}$, док је грешка деклинације E_δ дата у часовној мери.

Према подацима у релевантним каталозима налазимо вредности

– за систем FK5: $E_\alpha = \pm 0\overset{\mathrm{s}}{.}004$ и $E_\delta = \pm 0\overset{\mathrm{s}}{.}002$;
– за систем NFK: $E_\alpha = \pm 0\overset{\mathrm{s}}{.}018$ и $E_\delta = \pm 0\overset{\mathrm{s}}{.}013$.

На основи тога се добија случајна грешка стања часовника која је последица случајних грешака координата звезда у датом пару:

– за систем FK5: $\varepsilon_u \approx \pm 0\overset{\mathrm{s}}{.}003$;
– за систем NFK: $\varepsilon_u \approx \pm 0\overset{\mathrm{s}}{.}014$.

Преласком са система NFK, у коме је радио Бошковић, на систем FK5, у укупном буџету случајних грешака стања часовника, део који припада координатама звезда значајно је смањен.

3. СВОЂЕЊЕ ШИРИНЕ НА СИСТЕМ FK5

У одређивањима ширине Пјевцовљевом методом појављују се парови звезда које су опажане у близини меридијана, симетрично у односу на први вертикал. Растојања од меридијана се крећу од 10^{o} до 30^{o} по азимуту. Јужна звезда у пару обично буде близу екватора, док северна звезда може да има деклинацију $+60^{o}$ до $+80^{o}$. Полазећи од ових података и диференцијалног обрасца изведеног за Пјевцовљеву методу

$$\begin{aligned}\Delta\varphi = &- \frac{\cos\varphi(\sin A_s - \sin A_n)}{\cos A_s - \cos A_n}\,\Delta u \, + \\ &+ \frac{\cos\varphi \sin A_s}{\cos A_s - \cos A_n}\,\Delta\alpha_s - \frac{\cos\varphi \sin A_n}{\cos A_s - \cos A_n}\,\Delta\alpha_n + \\ &+ \frac{\cos q_s}{\cos A_s - \cos A_n}\,\Delta\delta_s - \frac{\cos q_n}{\cos A_s - \cos A_n}\,\Delta\delta_n \, ,\end{aligned} \tag{4}$$

израчунаћемо грешке ширине као последицу грешака положаја звезда.

За фиктиван Пјевцовљев пар на ширини $\varphi = +45^{o}$ узећемо јужну звезду са деклинацијом $\delta_s \approx +20^{o}$ и северну звезду са деклинацијом $\delta_n \approx +70^{o}$, око горњег пролаза. Нека је азимут $A_s \approx 20^o$ и $A_n \approx 160^o$, а паралактички угао $q_s \approx 15^o$ и $q_n \approx 105^o$.

Замењујући у обрасцу (4) назначене вредности азимута, паралактичких углова и ширине добија се

$$\Delta\varphi \approx \mp\frac{1}{8}\,(\Delta\alpha_s - \Delta\alpha_n) + \frac{1}{2}\,\Delta\delta_s + \frac{1}{7}\,\Delta\delta_n\ . \tag{5}$$

Горњи знак испред заграде важи за пар који је опажан на источној страни неба (IV и III квадрант), а доњи знак за пар на западној страни неба (I и II квадрант).

Израчунавамо вредности $\Delta\alpha$ на деклинацијама $\delta_s = +20^o$ и $\delta_n = +70^o$ и добијамо $\Delta\alpha_s = -0''.95$ и $\Delta\alpha_n = -3''.15$, респективно. Одговарајуће разлике деклинација FK5 и NFK износе $\Delta\delta_s = +0''.12$ и $\Delta\delta_n = +0''.06$.

Тако налазимо грешку $\Delta\varphi$ која је последица систематских разлика каталога NFK и FK5. Свођењем NFK на систем FK5 добија се, дакле, поправка ширине

– за пар на истоку: $\Delta\varphi \approx -0''.21$;
– за пар на западу: $\Delta\varphi \approx +0''.35$;

– у средњем је: $\Delta\varphi \approx +0''.07$

Формулу по којој се процењује утицај случајних грешака координата звезда на одређивања ширине добијамо слично као и за Цингерову методу. Нека грешка ректасцензије за северну звезду износи $3E_\alpha$, где је E_α грешка екваторске звезде. Ако се вредност E_α узме као приближна грешка јужне звезде, онда је

$$\varepsilon_\varphi{}^2 \approx \left(\frac{1}{8}\,E_\alpha\right)^2 + \left(\frac{3}{8}\,E_\alpha\right)^2 + \left(\frac{1}{2}\,E_\delta\right)^2 + \left(\frac{1}{7}\,E_\delta\right)^2$$

После упрошћавања је

$$\varepsilon_\varphi{}^2 \approx \frac{1}{6}\,E_\alpha^2 + \frac{1}{4}\,E_\delta^2\ . \tag{6}$$

Како је

– за систем FK5: $E_\alpha = \pm 0''.05$ и $E_\delta = \pm 0''.03$;
– за систем NFK: $E_\alpha = \pm 0''.23$ и $E_\delta = \pm 0''.20$,

добија се случајна грешка ширине као последица случајних грешака координата звезда у датом пару:

– за систем FK5: $\varepsilon_\varphi \approx \pm 0''.02$;
– за систем NFK: $\varepsilon_\varphi \approx \pm 0''.14$.

Преласком на систем FK5, у укупном буџету случајних грешака ширине, део који припада координатама звезда вишеструко се смањује.

4. СВОЂЕЊЕ АЗИМУТА НА СИСТЕМ FK5

За рачунање грешке азимута поћи ћемо од следећих података: деклинација Северњаче је приближно 89^o; за географску ширину од 45^o њена зенитна даљина износи око 45^o; азимут је приближно $178 - 179^o$; паралактички угао нека се креће у границама од 45^o до 135^o. Ако са наведеним вредностима уђемо у диференцијални образац

$$\Delta A = +\frac{\cos\delta}{\sin z}\cos q\Delta u - \sin A \mathrm{ctg}\ z\Delta\varphi - \frac{\cos\delta}{\sin z}\cos q\Delta\alpha + \frac{\sin q}{\sin z}\Delta\delta \qquad (7)\ ,$$

добијамо следећи изрази за западну половину неба:

$$\Delta A \approx \mp\frac{1}{60}\ \Delta\alpha + \Delta\delta \pm \frac{1}{60}\ \Delta u - \frac{1}{60}\ \Delta\varphi\ .$$

Горњи знак важи за $q \approx 45^o$, а доњи за $q \approx 135^o$. За источну половину неба, ако ставимо $q_e = -q_w$, имамо:

$$\Delta A \approx \mp\frac{1}{60}\ \Delta\alpha - \Delta\delta \pm \frac{1}{60}\ \Delta u + \frac{1}{60}\ \Delta\varphi\ .$$

Занемарујући последња два члана у овим изразима, имамо упрошћену формулу

$$\Delta A \approx \mp\frac{1}{60}\ \Delta\alpha \mp \Delta\delta\ . \qquad (8)$$

Горњи знак испред $\Delta\alpha$ важи ако је q мање од 90^o. Горњи знак испред $\Delta\delta$ важи ако је Северњача на источној хемисфери.

С обзиром да $\Delta\alpha$ иде приближно до $+1^s$ и $\Delta\delta$ приближно до $-0''.40$ (из упоређења са вредностима у Бошковићевим редукционим листовима), налазимо поправку азимута:

$$-0''.65 < \Delta A < +0''.65.$$

Оваква вредност се добија као последица разлика положаја Северњаче у систему FK5 и систему NFK.

У разматрању утицаја грешака положаја звезда, случајну грешку азимута одређујемо према формули:

$$E_A{}^2 \approx \left(\frac{1}{60}\ E_\alpha\right)^2 + E_\delta{}^2 + \left(\frac{1}{60}\ E_u\right)^2 + \left(\frac{1}{60}\ E_\varphi\right)^2\ .$$

С обзиром да су последња два члана у овој формули практично занемарљиви у односу на случајне грешке ректасцензије и деклинације, она може да се пише једноставније:

$$\varepsilon_A{}^2 \approx \left(\frac{1}{60}\ E_\alpha\right)^2 + E_\delta{}^2 \qquad (9)$$

Случајна грешка положаја Северњаче у систему FK5 за епоху 1906.0 износи

$$E_\alpha = \pm\, 0\overset{s}{.}130 = \pm\, 1\overset{''}{.}95 \quad , \quad E_\delta = \pm\, 0\overset{''}{.}02 \quad ,$$

па се за азимут добија

$$\varepsilon_A \approx \pm\, 0\overset{''}{.}04 \quad .$$

Случајна грешка положаја Северњаче у систему NFK за поменуту епоху је

$$E_\alpha = \pm\, 0\overset{s}{.}509 = \pm\, 7\overset{''}{.}64 \quad , \quad E_\delta = \pm\, 0\overset{''}{.}13 \quad ,$$

па је случајна грешка за азимут

$$\varepsilon_A \approx \pm\, 0\overset{''}{.}18 \quad .$$

Преласком на систем FK5, дакле, случајна грешка азимута као последица случајне грешке координата Северњаче такође се видно смањује.

5. ЗАКЉУЧАК

После рачунања утицаја систематских грешака *a priori* може се закључити да у резултате одређивања стања часовника у целости улази поправка равнодневице NFK каталога ($-0\overset{s}{.}050$).

Резултати одређивања ширине су знатно мењају увођењем ове поправке (око три десета лучне секунде по апсолутној вредности). Опажањем једнаког броја Пјевцовљевих парова на источној и на западној половини неба њен утицај се анулира и остаје само утицај систематских разлика деклинација, првенствено јужних звезда.

Утицај на резултате одређивања азимута зависи од тога на којој се половини неба налази Севрњача и од тога да ли се опажа пре или после највеће дигресије.

Што се тиче случајних грешака, видимо да се део који потиче од грешака координата звезда вишеструко смањује свођењем Бошковићевих астрогеодетских одређивања на FK5 систем.

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THE BELGRADE Z-TERM FOR THE PERIOD 1949-1985 AFTER NEW REDUCTION OF BLZ LATITUDE DATA

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Abstract. The values of the parameters (the amplitude, the period and the phase) of the annual and semiannual wobbles and the secular movement of the Z - term were computed from the homogenised series of the Belgrade latitudes in the interval 1949 - 1985. The Belgrade latitude observations were made according to the Talcott method with ASKANIA zenith - telescope (D=11 cm; F=128.7 cm).

The annual wobble of the Z - term is conspicuous, with the amplitude $0''.041$ found by the Fourier transforms (DFT), but the semiannual one is with the amplitude $0''.009$ (DFT also) and the secular movement is $0''.0004$ per year found by the least – square (LSQ) method. These results are in good agreement with the results of the former analysis of the Belgrade latitude data (Grujić, Djokić, Jovanović 1989) and with the new ones obtained by independent analysis of BLZ data (Vondrák, Pešek, Ron, Čepek, 1998).

1. INTRODUCTION

The Belgrade latitude data were denoted by BLZ in the list of Bureau International de l'Heure (BIH) and they were obtained by of two observation programs in the period 1949 - 1985 : the old one - OP (Djurković, Ševarlić, Brkić 1951), until the end of 1960, and the new one - NP (Ševarlić and Teleki 1960), from the beginning of 1960 and onwards.

The BLZ data were reduced to the FK5 reference frame during the new reduction (Damljanović, Pejović 1995) by using the PPM Star Catalogue (Röser and Bastian 1991) and in line with MERIT standards (Melbourne et al. 1983). The analysis of the BLZ latitudes was necessary because of some systematic instrumental, personal, refraction and star position errors. Then, the systematic errors were removed from the data if they were confidently determined (Damljanović 1994, 1995).

The raw Belgrade latitudes were averaged by using the "normal points" (the average values of 49-58 Talcott pair latitudes) to get approximately equal weights points suitable for interpolation by the cubic spline method to obtain the equidistant data (the lag was 0.1 yr and the total number $N = 369$ of the latitude data φ).

2. CALCULATION OF THE Z - TERM

The values of Z - term were calculated by using the relation (Kulikov 1962)

$$\varphi = \varphi_o + \Delta\varphi + Z$$

where: φ are the equidistant Belgrade latitude values with the lag 0.1 yr,

φ_o are the values of the mean Belgrade latitude, with the lag 0.1 yr, obtained by applying Vondrák (V) method of smoothing the values φ with the parameter of smoothing (Vondrák 1969, 1977) $\varepsilon = 10^{-12}$,

$\Delta\varphi$ are the values of the latitude changes, for the BLZ point and with the lag 0.1 yr, from the international data by using Kostinski formula (Kulikov 1962) $\Delta\varphi = x\cos\lambda_{BLZ} + y\sin\lambda_{BLZ}$, with the BLZ longitude $\lambda_{BLZ} = 339.^{o}5$ (in W direction from the zero - meridian) and the coordinates of the instant pole (x, y) of the Earth's rotation (ILS and BIH, in this case).

The linear trend was removed from φ_o.

The necessary changes of x - coordinate in ILS data were introduced in line with BIH (1978) to bring (x, y) into the quasi 1979 BIH system of the coordinates of the pole. We used (x, y) from the ILS series (Yumi and Yokoyama 1980) for the period 1949.0 - 1962.0 and from the BIH or IERS (1993) for the period 1962.0 - 1986.0. The IERS (1993) series of (x, y) are in the system which is close to those of the 1979 BIH one and the BIH Terrestrial System - BTS (BIH 1984).

3. THE SECULAR CHANGES OF THE Z - TERM

The LSQ method was used. The equation of condition was

$$Z = a + b(T - 67.5)$$

where a, b were unknown, and T was the year minus 1900 . The linear trend of the Z - term was

$$b = +0\overset{''}{.}0004/yr \pm 0\overset{''}{.}0007/yr$$

meaning that b is in accordance with the value $0\overset{''}{.}041$/cy (which is the secular trend of BLZ latitude due to tectonic EURA plate motion) calculated from NUVEL – 1 NNR geophysical model (Vondrák et al. 1998). This linear trend was removed from the Z - term values to prepare the data in applying the DFT for the spectral analysis.

4. THE ANNUAL AND SEMIANNUAL VARIATIONS OF THE Z - TERM

In Fig. 1. the curves of the BLZ latitude variation during the year is presented. It is evident that Z - term contains the seasonal component. There are some discrepancies between the OP and NP curves, also.

An analogous curve in the paper of Grujić (1975) displays an amplitude about three times grater than this one.

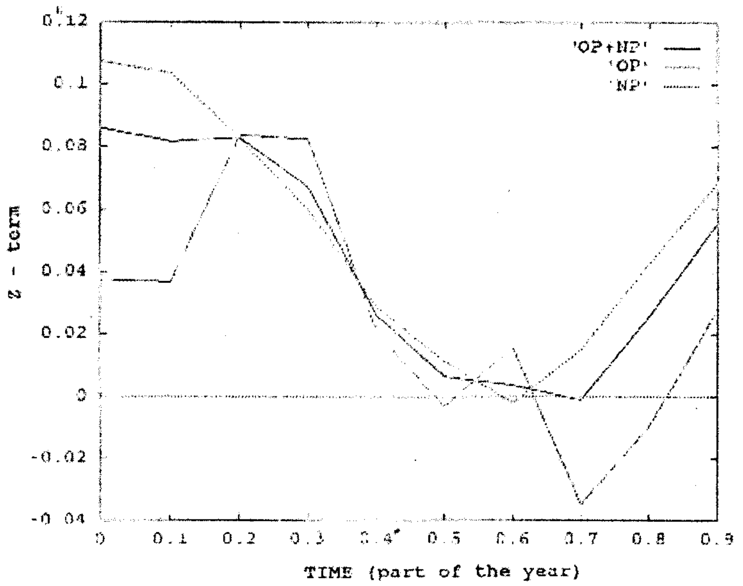

Fig. 1. The seasonal variations of the Z - term

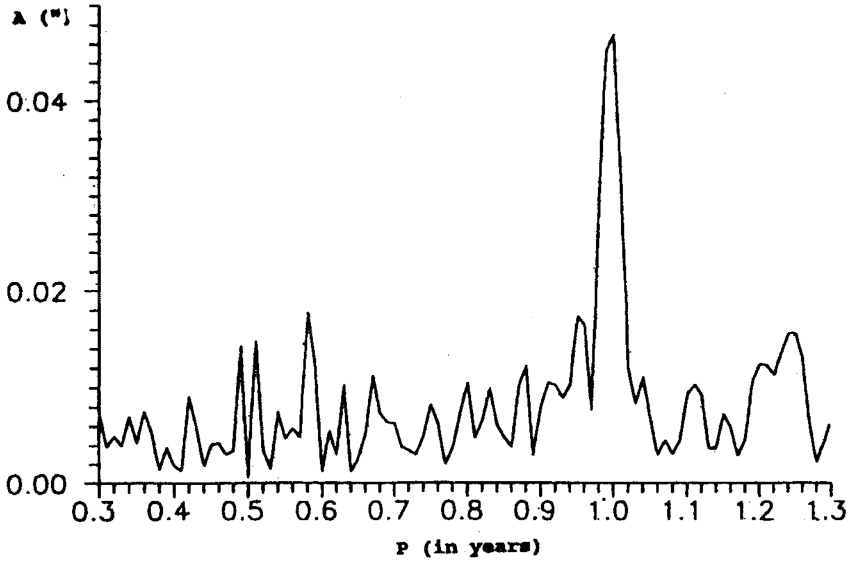

Fig. 2. The amplitude periodogram of the Z - term

After applying DFT method to the values of the Z - term the amplitude periodogram of the Z - term was derived (see Fig. 2.) the form of the harmonic expression being

$$Z = +0''.043 + 0''.041 \cos(t - 41.^{\circ}3) + 0''.009 \cos(2t - 190.^{\circ}1),$$

where t is the time (in degrees, $1yr = 360^{\circ}$), for the annual wobble ($Pa = 1.00yr$) and semiannual one ($Ps = 0.51yr$). The epoch of the phases was 1949.1 yr, and the white noise correction ΔA was removed from the amplitudes A (but in Fig. 2. ΔA was not removed from A).

The standard deviation of the residuals (the Z - term minus the secular term and two mentioned periodicities) was $\sigma_0 = 0''.07$. The amplitude standard deviation, the phase and the white noise correction to the amplitude were computed as follows:

$$\sigma_A = \sigma_0 \sqrt{\frac{4-\pi}{N}} = 0''.003$$

$$\sigma_F \approx 57.^{\circ}296 \frac{\sigma_0}{A} \sqrt{\frac{2}{N}}$$

$$\Delta A = \sigma_0 \sqrt{\frac{\pi}{N}} = 0''.006,$$

where the values of σ_F of the annual and the semiannual terms were $5.^{\circ}8$ and $18.^{\circ}5$ respectively.

From Fig. 2. evident is the annual peak of the Z - term of BLZ data but the semiannual one is neglected. The value of the amplitude of this annual wobble ($0''.041$) is in line with the values of the coefficients b and c ($b = 0''.038$, $c = -0''.014$) of the BIH function $S(T)$ for BLZ data (T is in years) from the paper of Vondrák et al. (1998). It is the same for the semiannual wobble ($0''.009$) and the BLZ coefficients d and e ($d = 0''.002$, $e = -0''.020$) of the $S(T)$. In the paper of Vondrák et al. (1998) the BLZ data are re–calculated into the Hipparcos system and the Earth orientation parameters are done in the ICRS based on the HIPPARCOS reference frame. Our own new reduction of the BLZ data (Damljanović 1994, 1995) is in the FK5 reference frame and the MERIT Standards, using the PPM Star Catalogue, and in our case the $S(T)$ describes the systematic discrepancies (Feissel 1972) between our BLZ series and the quasi system 1979 BIH (we calculated $b = 0''.04$, $c = 0''.03$, $d = 0''.01$ and $e = -0''.01$). Our values of the coefficients b, d and e are in accordance with the ones from the paper (Vondrák et al. 1998), the exception is the value of the coefficient c.

These results are in accordance with that ones from the paper (Grujić, Djokić, Jovanović 1989) where the former analysis of the BLZ data was done.

The results of the amplitudes and the phases of the annual (A_a and F_a) and the semiannual (A_s and F_s) periodicities (of the Z - term) obtained by applying LSQ method on the independent three years subintervals of the BLZ data are presented in Table 1.

Table 1. The values of the amplitudes and the phases of the annual (A_a and F_a) and the semiannual (A_s and F_s) wobbles obtained by LSQ on the independent BLZ three years subintervals

	subint. (1900+)	A_a ('')	F_a (^{o})	A_s ('')	F_s (^{o})
1	49.1-52.0	0.0270	90.3	0.0477	167.1
2	52.1-55.0	0.0467	55.3	0.0145	208.9
3	55.1-58.0	0.0699	81.8	0.0214	13.6
4	58.1-61.0	0.0449	44.2	0.0290	324.7
5	61.1-64.0	0.0778	24.5	0.0457	12.9
6	64.1-67.0	0.0385	2.4	0.0082	359.5
7	67.1-70.0	0.0343	20.6	0.0133	203.9
8	70.1-73.0	0.0761	43.3	0.0238	168.7
9	73.1-76.0	0.0575	34.6	0.0093	230.2
10	76.1-79.0	0.0481	18.5	0.0028	223.6
11	79.1-82.0	0.0506	46.5	0.0074	3.2
12	82.1-85.0	0.0387	38.0	0.0059	22.7
mean value		0.0508 ± 0.0047	41.7 ± 7.3	0.0191 ± 0.0043	161.6 ± 35.6

The epoch of the phases is 1949.0 yr.

It is evident that A_a increases during OP, mostly stable during NP (exempt during the subintervals 1961.1 - 1964.0 and 1970.1 - 1973.0), and successively decreases after 1970.1 . At the other hand, F_a is mostly stable. The semiannual amplitude A_s mostly decreases (exempt for the subintervals 1961.1 - 1964.0 and 1970.1 - 1973.0, as in the case of A_a), and the values of A_s are small after 1973.1 . The semiannual phase F_s is very changeable.

The LSQ results are in good agreement with the DFT ones.

The same method (LSQ) on the independent BLZ six years subintervals gives the results presented in Table 2. The epoch of the phases is 1949.0 yr, also. The LSQ results presented in Table 2. are in good agreement with the DFT ones, too.

Table 2. The values of the amplitudes and the phases of the annual (A_a and F_a) and the semiannual (A_s and F_s) wobbles obtained by LSQ on the independent BLZ six years subintervals

	subint. (1900+)	A_a ('')	F_a (^{o})	A_s ('')	F_s (^{o})
1	49.1-55.0	0.0353	68.0	0.0297	176.5
2	55.1-61.0	0.0545	67.2	0.0230	345.2
3	61.1-67.0	0.0572	17.2	0.0269	10.9
4	67.1-73.0	0.0543	36.3	0.0178	181.1
5	73.1-79.0	0.0523	27.3	0.0061	228.7
6	79.1-85.0	0.0446	42.8	0.0066	11.8
mean value		0.0497 ± 0.0034	43.1 ± 8.5	0.0184 ± 0.0041	159.0 ± 52.9

5. CONCLUSION

The more detailed discussion will be given elsewhere (Damjanović and Pejović, 2000)

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MILUTIN MILANKOVIĆ I ASTRONOMIJA

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1. RAD MILUTINA MILANKOVIĆA U ASTRONOMIJI

Milutin Milanković (Dalj, 28.V.1879 - Beograd, 12.XII.1958) je u istoriju nauke ušao kao čovek koji je objasnio pojavu ledenih doba, sporim promenama u osunčavanju Zemlje usled različitih uticaja usled kojih se menja nagib Zemljine ose i karakteristike njenog kretanja oko Sunca. Milanković je rastumačio i istoriju klime na Zemlji i drugim planetama i tvorac je matematičke teorije klime i teorije o pomeranju Zemljinih polova. Unapredio je nebesku mehaniku u koju je uveo vektorski račun a dao je i nekoliko originalnih doprinosa rešavanju problema tri tela, što je detaljno analizirano u radovima Popovića (1979ab). Bavio se i pitanjem reforme kalendara, predloživši njegovo poboljšanje. Milanković od 1909. godine predaje astronomske sadržaje na Beogradskom Univerzitetu (vidi na primer Dimitrijević, 1997b). Napisao je udžbenike za fakultet *Nebeska mehanika* (Milanković, 1935), *Istorija astronomske nauke od njenih početaka do 1727.* (Milanković, 1948a) i *Astronomska teorija klimatskih promena i njena primena u geofizici* (Milanković, 1948b), pri čemu je zadnji namenjen postdiplomcima i doktorantima. Milanković je dao značajan doprinos i popularizaciji astronomije i njegova knjiga *Kroz vasionu i vekove* doživela je više izdanja (Milanković, 1926a, 1927, 1928ab, 1936, 1939a, 1943, 1944, 1952, 1979c, 1997c).

Milanković je dao veliki doprinos organizaciji astronomije u našoj zemlji. Godine 1925., on je u grupi profesora Filozofskog fakulteta u Beogradu predvodjenoj Miškovićem, koja je 30. aprila (Indjić, 1997) povela akciju za izgradnju nove Astronomske opservatorije u Beogradu. Od 1933. do 1940. godine, Milanković je član ispitne komisije za polaganje državnog ispita za osoblje Astronomske opservatorije u Beogradu za predmet - Nebeska mehanika. Od 1936. do 1939. godine on je predsednik prvog Nacionalnog komiteta za astronomiju, uz pomoć koga je Jugoslavija postala član Medjunarodne astronomske unije. Na godišnjoj skupštini Jugoslovenskog astronomskog društva (Danas Astronomsko društvo "Rudjer Bošković"), održanoj 21. januara 1940. izabran je za počasnog člana na predlog Stjepana Mohorovičića i Vojislava Grujića. Za počasnog člana Astronomskog društva "Rudjer Bošković, ponovo je izabran 22. februara 1953. Na Kongresu Medjunarodne astronomske unije 1948. u Cirihu, izabran je za člana Komisije 7 za Nebesku mehaniku, koja je tada obnovljena posle ukidanja 1932. godine. Kada je maja 1948. godine prihvaćena ostavka Vojislava Miškovića na položaj direktora, za direktora Opservatorije biva imenovan akademik

Milutin Milanković. On je honorarni direktor Opservatorije do 27. januara 1951. kada postaje direktor sa punim radnim vremenom i na ovom položaju ostaje do 26. juna 1951. Predsednik Naučnog saveta Opservatorije ostaje do marta 1954. godine. Rad Milutina Milankovića kao direktora Astronomske opservatorije, detaljno je analiziran u radu Popovića i Dimitrijevića (1999). Godine 1949., 26. oktobra izabran je za člana naučnog saveta Astronomsko - Numeričkog instituta Srpske akademije nauka.

2. KANON OSUNČAVANJA ZEMLJE

Astronomskim uzrocima klimatskih promena i matematičkom teorijom klime Milanković počinje da se bavi u Beogradu pa 1912. objavljuje *Prilog teoriji matematičke klime* (Milanković, 1912b), 1913. *O primeni matematičke teorije sprovodjenja toplote na probleme kosmičke fizike* (Milanković, 1913), a 1916. *Ispitivanja o klimi planete Mars* (Milanković, 1916). U *Théorie mathématique des phénomènes thérmiques produits par la radiation solaire* (Matematička teorija toplotnih pojava izazvanih Sunčevim zračenjem) (Milanković, 1920), Milanković razvija teoriju zasnovanu na principima Nebeske mehanike i Teorijske fizike, koja objašnjava raspodelu Sunčevog zračenja u medjuplanetarnom prostoru i na površinama planeta. On takodje pokazuje vezu izmedju osunčavanja i temperature planetarnih slojeva i pokazuje dnevnu, godišnju i vekovnu promenu osunčavanja.

Godine 1926. objavljuje naučni rad *Ispitivanje o termičkoj konstituciji planetskih atmosfera* (Milanković, 1926). U ovim radovima on je posebnu pažnju posvetio klimi planete Mars i utvrdio da je na ovoj planeti srednja godišnja temperatura minus 17 Celzijusovih stepeni. Njegova istraživanja klime Marsa kao i predvidjanja da na ovoj planeti nema visokorazvijenog života, potvrdila su moderna kosmička istraživanja. U vezi sa istraživanjem Marsa, naučni radovi Milankovića su korišćeni u naučnim istraživanjima i raspravama o tečnoj vodi na Marsu (Hoffert *et al.*, 1981), o kori i atmosferi Marsa (Miyamoto, 1966), o površinskoj temperaturi i klimi na Marsu (Gifford, 1956), kao i o astronomskoj teoriji o klimatskim promenama na Marsu (Toon *et al.*, 1980).

U Kanonu Milanković je objedinio rezultate svojih dugogodišnjih istraživanja u kojima je pokazao da su dugoperiodične ciklične promene klime na Zemlji i pojava ledenih doba, posledica sledeća tri uzroka:

(a) Promene nagiba Zemljine ose izmedju 22^o i 24.5^o sa periodom od 41,000 godinu, usled čega se menjaju uslovi osunčavanja na nekoj izabranoj tački na Zemlji.

(b) Promena ekscentričnosti Zemljine putanje oko Sunca sa periodom od 100,000 godina usled čega se menja udaljenost Zemlje od Sunca što ima uticaj i na trajanje godišnjih doba.

(c) Precesija usled koje se tačka zimskog solsticija pomera duž prividne godišnje Sunčeve putanje, što utiče na dužinu trajanja godišnjih doba sa periodom od 22,000 godina.

Da bi razrešio problem pojave ledenih doba u kvartaru, Milanković 1932. godine dolazi do svoje čuvene diferencijalne jednačine kretanja Zemljinih polova. On nalazi da se pre oko 300 miliona godina Severni pol nalazio u Tihom okeanu na geografskoj širini od 20^o i dužini od 168^o. I danas Severni pol se kreće prema svom ravnotežnom krajnjem položaju u Sibiru, blizu mesta gde reka Pečora utiče u Severni ledeni okean (Milanković, 1933a-d; 1934ab).

Najznačajnije delo Milutina Milankovića je *Kanon der Erdbestrahlung und seine Anwendung auf das Eiszeitenproblem* (Kanon osunčavanja Zemlje i njegovog uticaja na problem ledenih doba) (Milanković, 1941). To je njegovo kapitalno naučno delo, monografija koja uključuje rezultate istraživanja, koji su prethodno bili publikovani u 28 naučnih radova. U ovoj monografiji ti rezultati su sakupljeni u celinu, zajedno sa novim analizama i dodacima i sa brojnim primerima i primenama njegove teorije. U ovom kapitalnom delu Milanković daje matematičku teoriju klime Zemlje (koja se može primeniti i na druge planete), objašnjava poreklo ledenih doba i daje svoju teoriju pomeranja Zemljinih polova. Kanon je Milanković počeo da piše 30. marta 1939. a završio ga je u prvoj polovini februara 1941. (Indjić, 1997).

Dimitrijević (1997a) daje rezultat istraživanja prisustva Milankovićevog Kanona u Indeksu citata u periodu 1946. - 1996. U ovom periodu nadjeno je 253 referenci koje citiraju Kanon. Analizom raspodele citiranja Kanona po godinama, izveden je zaključak da je ovo jedinstveno delo, čija citiranost ne opada sa godinama nego raste ili ostaje konstantna. Tako se u periodu od 1945. do 1960. Kanon citira 5 puta. U periodu od 1961. do 1975. godine jedan do dva puta godišnje s tim što 1964. i 1971. nije zabeležen u Indeksu citata, 1961. se citira tri puta, a 1966. šest puta. Prvi skok u citiranosti je verovatno povezan sa završetkom Američkog CLIMAP (Climate Long Range Investigation, Mapping and Prediction) projekta 1976. godine (Hays, Imbrie i Shackleton, 1976). Povećanju citiranosti u to vreme svakako je doprinela i pojava engleskog izdanja Kanona (Milanković, 1969). Posle blagog porasta (1976. pet puta, 1977. tri puta), 1978. nastaje skok na osam citata i u periodu od 1978. do 1990. Kanon se citira od šest do 12 puta godišnje. Godine 1991., dolazi opet do skoka, Kanon je citiran 19 puta; 1992., 17 puta; 1993., 19 puta; 1994., 13 puta; 1995., 14 puta i 1996., 14 puta. Ovaj drugi skok u citiranosti verovatno je povezan sa radjanjem nove naučne discipline - ciklostratigrafije, koja je zasnovana na Milankovićevoj krivoj osunčavanja. Prvi medjunarodni kongres posvećen novoj naučnoj oblasti bio je u Perudji 1988. godine.

U Indeksu naučnih citata objavljenom u periodu 1946 - 1996, Dimitrijević (1997a) je pronašao 522 citata Milutina Milankovića. Oni se odnose na 17 članaka i knjiga a u tri slučaja citiranje je indirektno. Osim kanona za koji je nadjeno 253 citata, naučni radovi Milanković (1920), Milanković (1930ab) i Milanković (1938ab; 1939d) imaju 46, 135 i 37 citata. Ovi članci su blisko povezani sa matematičkom teorijom klime i njihovi rezultati su uključeni u Kanon, kao i rezultati drugih radova (Milanković, 1923; Milanković, 1931; Milanković, 1933d) citiranih (prema SCI) u neposrednoj vezi sa astronomskim problemima. Astronomski problemi u vezi sa kojima se koristi ova grupa radova su na primer: promene klime u kosmičkoj perspektivi (Opik, 1965, 1966; van den Heuve, 1966), masena spektrometrija u kosmohemiji (Delaeter, 1990), sekularne promene u zvezdanoj strukturi i ledena doba (Opik, 1950), Sunčevi neutrini i promene sjaja Sunca (Ulrich, 1975), fundamentalni astronomski sistem (Fleckenstein, 1953), stabilnost Sunčevog sistema (Kopal, 1980)...

Napominjem da se pojavom Indeksa citata (Science Citation Index - SCI), koji danas naročito u prirodnim naukama obuhvata najznačajniju literaturu koja izlazi u svetu, razvio Metod indeksa citata za istraživanje naučnog stvaralaštva i njegovog značaja. U mnogobrojnim analizama, pokazano je (Hajtun, 1993), da je broj citata indikator *kvaliteta* naučnog rada, njegove *vrednosti*, *značaja*, *koristi* i *važnosti*. Metod Indeksa citata interesantan je i za istoričare nauke, da bi identifikovali najznačajnije autore, dela, kao i različite formalne i neformalne grupe. On je takodje indikator *individualnog doprinosa nauci* pojedinog naučnika i njegovog *prestiža*. Osim toga, podaci o citiranosti ukazuju na radove, koje smatraju važnim oni naučnici koji su upravo aktivni u datoj naučnoj oblasti (Garfield, Welljams-Dorof, 1992).

Broj od 253 citata u razmatranom periodu (1946 - 1996), identifikuje Kanon kao najcitiranije (u bazi podataka Indeksa citata) pojedinačno delo iz astronomije, kod Srba (Dimitrijević, 1996). Osim toga utvrdjeno da su su značajna dela starijih naučnika manje citirana od savremenih dela iste takve važnosti, s obzirom da se broj citata jednog dela u proseku smanjuje sa godinama a nauka se tako razvija da sa vremenom broj naučnika pa samim tim i verovatnoća citiranja raste. Ako uzmemo u obzir činjenicu da je Kanon napisan i objavljen pre drugog svetskog rata, možemo zaključiti i da je to najcitiranije u medjunarodnoj naučnoj javnosti pojedinačno delo (prema Indeksu citata), koje je do početka perioda obuhvaćenog Indeksom citata (1946.) objavljeno kod Srba i od strane Srba u nauci u celini. Godine 1997, Kanon je objavljen na srpskom jeziku (Milanković, 1997a).

3. NEBESKA MEHANIKA

Ministar prosvete i crkvenih poslova Ljub. Stojanović potpisuje 9 septembra 1909. godine ukaz o postavljenju Milutina Milankovića, koji je radio kao viši inženjer u preduzeću Betonbau - Unternehmung Pittel und Brausewetter u Beču, za vanrednog profesora primenjene matematike, koju su činile racionalna mehanika, nebeska mehanika i teorijska fizika. Tako Milanković dolazi u Srbiju u Beograd i započinje univerzitetsku karijeru. Predavanja drži u ciklusima od šest semestara pri čemu je nebeskoj mehanici pripadao nepun semestar. On se bavi i naučnim istraživanjem u oblasti nebeske mehanike a dobijene rezultate objavljuje u radovima *Osobine kretanja u jednom specijaliziranom problemu triju tela* (Milanković, 1910), *O opštim integralima problema n tela* (Milanković, 1911), *O kinematičkoj simetriji i njenoj primeni na kvalitativna rešenja problema dinamike* (Milanković, 1912a). Za redovnog profesora primenjene matematike izabran je 29 septembra 1919. godine a od školske 1920/21. godine predaje samo teorijsku fiziku i nebesku mehaniku, a racionalnu mehaniku prepušta Antonu Bilimoviću, bivšem profesoru Univerziteta u Odesi. Zahvaljujući uvodjenju vektorskih metoda, ova predavanja bila su modernija nego na nekim zapadnim univerzitetima. Posle okupacije naše zemlje, ostaje na Univerzitetu do poslednje sednice fakultetskog odbora 19. oktobra 1941., posle koje zajedno sa celokupnim osobljem Univerziteta biva stavljen na raspolaganje. Od 6 marta 1942. postavljen je za redovnog profesora Filosofskog fakulteta Univerziteta u Beogradu na katedri za teorijsku i primenjenu matematiku za predmete astronomija i nebeska mehanika. Posle drugog svetskog rata nastavlja da predaje nebesku mehaniku na Beogradskom fakultetu kao poseban predmet sa fondom časova 2 + 0. Osim toga, jedan semestar kursa nebeske mehanike koristio je za obradu istorije astronomije, tako da su studenti ove dve naučne discipline polagali kao jedan predmet (Andjelić, 1977).

Nebesku mehaniku, koja je predstavljala udžbenik za ovaj predmet (Milanković, 1935), je započeo prema pedantnim beleškama koje je vodio, 20 jula 1934. godine a završio je 14 januara 1935 (Indjić, 1993). Zahvaljujući tome što je medju prvima u svetu za izlaganje nebeske mehanike koristio metode vektorskog računa on je "u najmanju ruku tri puta sažeo , skratio, uprostio i učinio očiglednijom, za šta je dobio i inostrana priznanja" (Ševarlić, 1979; B. Š. (Ševarlić), 1980; Popović, 1979ab). Umesto šest brojčanih elemenata koji su do tada služili za odredjivanje eliptičkih putanja nebeskih tela u Sunčevom sistemu, on uvodi dva vektora "čime je znatno uprostio i učinio elegantnijim sva rešenja u ovoj oblasti" (Ševarlić, 1979).

Predratno izdanje Nebeske mehanike Milanković je sažeo i pod naslovom *Osnovi nebeske mehanike* objavio 1947. godine kao udžbenik za taj predmet (Milanković, 1947). U ovom skraćenom izdanju iznet je deo nebeske mehanike koji se bavi kretanjem planeta i njegovim sekularnim poremećajima. Osim toga, koristeći rezultate svoga rada *O upotrebi vektorskih elemenata u računu planetskih poremećaja* (Milanković, 1939bc) i Kanona (Milanković, 1941) dolazi do "glavnih stavova izložene teorije kraćim i preglednijim putem nego što je to drugde učinjeno" (Milanković, 1947, predgovor). Ovaj njegov rad našao je široku primenu u astronomiji i citiran je više puta (Musen, 1947, 1948, 1961, 1966; Fleckenstein, 1952; Allan i Ward, 1963; Deprit, 1975; Hestenes, 1983; Bartnik *et al.* 1988) u vezi sa problemom tri tela u slučaju planeta i zvezda, ispitivanjem planetarnih putanja i istraživanjem kretanja veštačkih satelita. Drugo izdanje objavljeno je 1955. godine (Milanković, 1955a), treće 1980. godine (Milanković, 1980), povodom stogodišnjice njegovog rodjenja, 1978. godine a četvrto 1988. (Milanković, 1988). Pored toga godine 1977. objavljeno je kompletno predratno izdanje (Milanković, 1997b).

4. ISTORIJA I POPULARIZACIJA ASTRONOMIJE

Interes za istoriju nauke pojavio se kod Milankovića još za vreme njegovog boravka u Beču. U svojim *Uspomenama, doživljajima i saznanjima* (Milanković, 1979b) on ističe "da se svaka nauka može samo onda u potpunosti shvatiti kada se upozna njen postanak i postepeni razvitak" i opisuje kako se u njemu "začela misao da je istorija nauka najveličanstveniji deo cele istorije čovečanstva" (Mužijević, 1979), kao i ljubav prema takvoj istoriji. Milanković je čitao, proučavao i sakupljao dela iz istorije nauke i tehnike i to sistematski sa strašću kolekcionara. Kao profesor univerziteta pobrinuo se da biblioteka seminara za matematiku a i biblioteka Astronomske opservatorije "pruži jasan pregled istorijskog razvitka tih nauka" (Milanković, 1979b). U svojoj knjizi Tehnika u toku davnih vekova (Milanković, 1955b) on sa žaljenjem konstatuje da "dok bi dela svetske istorije napunila veliku biblioteku, najvažnija dela istorije matematike, astronomije i fizike mogu se smestiti u ma kojoj ličnoj biblioteci". Za razliku od svetske istorije, prema Milankoviću u istoriji nauke umesto naslednih vladara, glavnu ulogu igraju oni koji su svoje mesto u istoriji osvojili snagom svoga duha i napominje da se "vredelo upoznati izbliže sa njima! Zato se moja lična biblioteka iz godine u godinu obogaćivala delima iz istorije egzaktnih nauka i njihovih primena" (Milanković, 1953 uvod).

Istorija astronomije objavljena je 1948. godine (Milanković, 1948a) njeno drugo izdanje 1954. (Milanković, 1954) a treće 1979., takodje povodom stogodišnjice rodjenja

1978. godine (Milanković, 1979a). Osim toga, ova knjiga je prevedena i na slovenački jezik i objavljena u Ljubljani 1951. godine. (Milanković, 1951), a objavlena je i 1997. godine (Milanković, 1997b).

Knjigu Istorija astronomske nauke od njenih početaka do 1727., koja je bila udžbenik za istoriju astronomije, počinje da piše krajem novembra 1946., rukopis je pripremljen za štampu 19 septembra 1947. godine a knjiga je štampana 1948. godine. U ovoj zanimljivoj i veoma lepo dokumentovanoj knjizi, obuhvatio je period od prvih početaka astronomske nauke pa do Njutnove smrti 1727. godine. Pri tome, on u ovome delu daje i svoj originalni naučni doprinos, "kao što je na primer raščišćavanje uloge Aristarha u razvoju heliocentrične misli ili dokaz da je Apolonije stvorio svoju znamenitu teoriju epicikala polazeći od heliocentrizma, a ne od geocentrizma, kao što se pre njega smatralo" (Ševarlić, 1979). U svome prikazu B. Ševarlić (1980a) kaže: "Knjiga po svojim kvalitetima, predstavlja malo remek-delo, pravi spomenik Milankovićevog nastavnog i naučnog rada koje studenti sa velikim interesovanjem proradjuju. No knjiga daleko prevazilazi udžbeničke okvire i predstavlja pravu poslasticu za sve ljubitelje astronomije." Njegova želja izražena u predgovoru "da jednim kasnijim delom, obuhvati u širem obimu celokupnu istoriju astronomije", ostala je na žalost neostvarena.

Svoje remek delo u oblasti popularizacije astronomske nauke, knjigu *Kroz vasionu i vekove* (Milanković, 1928b), Milanković je počeo da piše u leto 1925. godine u Austriji. U periodu od 1926. do 1928. godine objavljivao ga je u nastavcima u Letopisu Matice srpske (Milanković, 1926a, 1927, 1928a) a kao knjigu je objavio 1928. (Milanković, 1928b). Godine 1936. knjigu je preveo na nemački pri čemu je preradio i znatno proširio tekst (Milanković, 1936), a drugo nemačko izdanje izašlo je u Lajpcigu 1939. (Milanković, 1939a). Znatno prošireno srpsko izdanje izlazi 1943. (Milanković, 1943), a ova knjiga je ponovo izdavana još četiri puta (Milanković, 1944, 1952, 1979c, 1997c). Pojedina pisma iz knjige *Kroz vasionu i vekove* Milanković je objavljivao u Politici (19. XII 1928), Deutsche Algemeine Zeitung (2. XII 1936), Aachener Anzeiger u. Politisches Tageblatt (20. X 1936), Wolfenbütteler Zeitung (9. X 1936), Das Weltall (1936, Vol. 37, No 4), Berwardsblatt (1937, No 22), Kasseler Post (1. VI 1937), Mitteldeutsche National Zeitung (23. V 1937), Osteroder Zeitung (25. V 1937), Saarbrücker Landes Zeitung (21. V 1937) Scwerter Zeitung (7. VI 1937), Sonntagsbeilage der Nordhäuser Zeitung (5. VI 1937), Der Westen (13. VI 1937), Altonaer Nachrichten (17. III 1937), kao i u časopisima Saturn (1938, Vol. IV, Nos. 1, 2 i 3), Proteus (Ljubljana, 1940, VII, Nos. 2/3, 4/5, 1941, VIII, No 9) i u almanahu naučne fantastike Andromeda (1978, No 3). Ova zanimljivo pisana knjiga u obliku pisama sa obiljem podataka o istoriji astronomije i problemima ove nauke, verovatno je naša najviše objavljivana knjiga iz oblasti popularizacije nauke.

5. KALENDAR

Jedan od najvažnijih zadataka astronomije u prošlosti bio je praćenje perioda izmene godišnjih doba, zbog njegove izuzetne važnosti za čovekovu delatnost. Ciklus izmene godišnjih doba definisan jednim obrtajem Zemlje oko Sunca (precizno rečeno period izmedju dva prolaska prividnog lika Sunca kroz prolećnu ili gama tačku za vreme uzastopnih prolećnih ravnodnevica) naziva se tropska godina i iznosi 365,2422 dana. Kalendar je sistem po kome se tropska godina deli na dane, nedelje i mesece. Glavna teškoća je u tome što kalendar mora imati ceo broj dana, a tropska godina ih nema. Zato se nastoji da pravila za kalendar dovedu do toga da u dužem nizu godina kalendarska godina bude u proseku što bliža tropskoj.

Još stari Egipćani su zapazili da je godina od 365 dana, koja je primenjivana u Mesopotamiji suviše kratka. Svake četiri godine razlika poraste za gotovo jedan dan. Ova neusaglašenost ispravljena je Kanopskim ediktom 238. godine pre n.e. tako što je svaka četvrta godina odredjena kao prestupna pa ima jedan dan više t.j. 366 dana. Prema savetu astronoma Sozigena ovaj kalendar je u Rimu uveo Julije Cezar 46. godine pre n.e., pa se po njemu takav kalendar naziva Julijanski. Prestupne godine su definisane jednostavnim matematičkim pravilom, to su one koje su deljive sa 4. Po julijanskom kalendaru, godina u četvorogodišnjem proseku traje 365,25 dana t.j. nešto je duža od tropske, pa kasni za promenom godišnjih doba. Ona se od tropske razlikuje za 0.0078 dana. Razlika od 1 dan nakupi se za 128 godina. Zato se početak kalendarske godine morao s vremena na vreme podešavati, kao što je to uradjeno na koncilu u Nikeji 325. godine.

Papa Grgur XIII uveo je 1582. godine kalendar prilagodjeniji tropskoj godini na savet astronoma Lilioa. Ovaj kalendar dobio je ime gregorijanski. Lilio je predložio da se u roku od 400. godina tri prestupne godine pretvore u obične. Tako je postavio pravilo da nisu prestupne godine kojima se završavaju stoleća a koje imaju dve nule na kraju, osim ako su deljive sa 400. To znači da na primer u prvih 400 godina jednog milenijuma nisu prestupne godine koje se završavaju na 100, 200 i 300. Sada kalendarska godina traje 365,2425 dana pa je od tropske duža za 0.0003 dana. Ta će razlika narasti na jedan dan tek nakon 3000 godina.

Na saboru pravoslavne crkve u Carigradu, 1923. godine, dat je predlog koji je srpski astronom Milutin Milanković (Milanković, 1997d) razradio zajedno sa profesorom Trpkovićem, još tačniji nego šo je to gregorijanski kalendar. Umesto 3 dana u 4 stoleća, treba oduzeti 7 dana u 9 stoleća ili 0.0077 dana po godini. To znači da bi samo 2 od 9 godina kojima se završavaju stoleća bile prestupne. Pravilo je da su prestupne godine koje se završavaju sa dve nule samo ako broj vekova koji sadrže podeljen sa 9 daje ostatak 2 ili 6. Na primer 2000. godina kojom se završava XX vek je prestupna pošto je 20:9=18 i ostatak je 2. Milankovićev predlog se u srednjem razlikuje od prave tropske godine za 0.000002 dana. Dalja usavršavanja što se tiče približavanja trajanju tropske godine nisu potrebna, jer se i ona u dužim periodima menja. Eventualna dalja usavršavanja ako ih bude, pre će težiti pogodnijoj raspodeli dana unutar meseci zbog različitih prednosti koje bi iz toga mogle da proizadju.

Milutin Milanković je najznamenitiji srpski astronom. Treba takodje istaći da je za razliku od Nikole Tesle i Mihajla Pupina koji su do svojih otkrića došli u inostranstvu, Milanković svetsku slavu stekao radeći u Beogradu, u svojoj skromnoj sobi u Kapetan Mišinom zdanju. U čast njegovih naučnih dostignuća na polju astronomije, na XIV Kongresu Medjunarodne astronomske unije u Brajtonu, jedan krater na nevidljivoj strani Meseca (sa koordinatama $+170^o$ $+77^o$) dobio je njegovo ime. Na XV Kongresu Medjunarodne astronomske unije u Sidneju, njegovo ime je dobio i jedan krater na Marsu (sa koordinatama $+147^o$, $+55^o$), a 1982. je mala planeta sa privremenom oznakon 1936 GA, koju su 1936. otkrili Milorad Protić i Pero Djurković, dobila ime 1605 Milanković.

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MEASURED, CALCULATED AND ESTIMATED STARK WIDTHS OF SEVERAL Ar IV SPECTRAL LINES

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Abstract. Comparison between existing measured, calculated and estimated Stark width values was performed for the most researched Ar IV spectral lines belonging to the 4s-4p and $4s' - 4p'$ transitions. On the basis of the found agreement between these values four spectral lines have been recommended as lines with convenient Stark width data needed in plasma spectroscopy.

1. INTRODUCTION

Knowledge of the triply ionized argon (Ar IV) spectral lines characteristics is important for the determination of chemical abundances of elements and, also, for the estimation of the radiative transfer through stellar plasmas, as well as for opacity calculations (Inglesias et al. 1990). Thus, the necessity of knowledge of Stark widths of these lines was imposed. On the basis of Stark width values it is possible to obtain other basic plasma parameters e.g. electron temperature (T) and electron density (N), important in the modeling of various plasmas. The aim of this work is the comparison between existing measured, calculated and estimated Stark width values of most investigated Ar IV spectral lines (264.03, 275.79, 278.89, 280.94 and 292.63 nm) in the 4s-4p and $4s' - 4p'$ transitions. Namely, from the eventual agreement between them, their recommendation for the plasma diagnostics purpose can follow as spectral lines with convenient Stark width data. These comparisons give, also, possibility of the critical analyzing of the experimental results.

2. MEASUREMENTS

Five experiments deal with Stark FWHM (full-width at half intensity maximum, W) investigation of mentioned spectral lines (Platiša et al. 1975; Purić et al. 1988 a; Kobilarov & Konjević 1990; Hey et al. 1990 and Djeniže et al. 1999, 2000). Measurements were realized in the electron temperature range between 21 000 K and 110 000 K (see Lesage & Fuhr 1998 and references therein).

3. CALCULATIONS

Theoretical W values (G,GM,SEM, SE) are calculated on the basis of various approximations initiated by Dimitrijević & Konjević (1981). Thus, SE and SEM denote the results of semiempirical and modified semiempirical predictions using equations (4), (5) and equations (7) - (10), respectively, from Dimitrijević & Konjević (1981). G and GM denote w values obtained on the basis of the semiclassical approximation (Griem 1974 and references therein) with 1.4 instead of 5-(4.5/z) on the right-hand side of equation (12) in Dimitrijević & Konjević (1980) for the GM values. Mentioned calculations are performed only for four multiplets. Besides, in Hey et al. (1990) theoretical Stark width values, calculated on the basis of the impact and classical-path approximations (Hey & Breger 1982), are also presented, but only for the plasma parameters observed in experiments: Platiša et al. (1975), Purić et al. (1988a) and Hey et al. (1990).

4. ESTIMATIONS

The simplest way to estimate the value of a Stark FWHM is to use established regularities of W along the isonuclear or isoelectronic sequences for given type of quantum transition. It was found (Djeniže & Srećković 1998; Purić et al. 1988a,b) that a simple analytical relationship may, for same transition, exist between W and the corresponding upper-level ionization potential (I) of a particular spectral line. The found relationship, normalized to a $N = 10^{23}$ m^{-3} electron density, is of the form:

$$W(\text{rad/s}) = az^2T^{-1/2}I^{-b}. \qquad (1)$$

The upper level ionization potential I (in eV) and net core charge $z(z = 1, 2, 3, 4, ...$for neutral, singly, doubly, triply,... ionized atoms, respectively) specify the emitting ion, while the electron temperature T (in K) characterizes the assembly. The coefficients a and b are independent of I and T. In the case of the argon isonuclear (INS) sequence (Ar I - Ar VIII) for the 4s - 4p transition this dependence is expressed (Purić et al. 1988a,b; Djeniže & Srećković 1998) as:

$$W(\text{rad/s}) = 1.18\ 10^{14}z^2T^{-1/2}I^{-1.27}. \qquad (2)$$

In the case of the $4s'-4p'$ transition the following form was found (Djeniže & Srećković 1998; Purić et al. 1988a)

$$W(\text{rad/s}) = 1.12\ 10^{14}z^2T^{-1/2}I^{-1.32}. \qquad (3)$$

Eqs. (2-3) allow to predict the Stark width values for: $z = 1, 2, 3, 4, 5, 6, 7$ at various electron temperatures. The estimated Stark FWHM values of the mentioned Ar IV spectral lines (for $z = 4$) are presented in Table 1. The necessary atomic data were taken from Wiese at al. (1969).

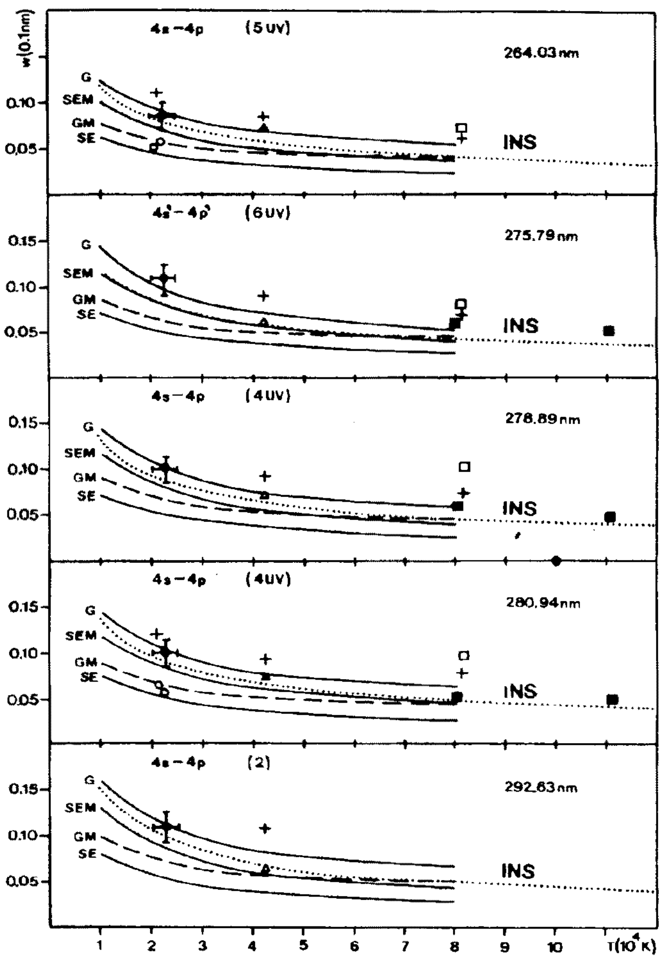

Fig. 1. Stark FWHM (W) dependence on the electron temperature for the most investigated Ar IV lines belonging to the 4s-4p and 4s′–4p′ transitions at 10^{23} m^{-3} electron density. •, Djeniže et al. (1999, 2000); ○, Platiša et al. (1975); △, Purić et al. (1988a); , Hey et al. (1990) and , Kobilarov & Konjević (1990). G and GM denote values obtained on the basis of the semiclassical (Griem 1974) approximation, both SEM and SE denote values obtained on the basis of the modified semiempirical and semiempirical approximations, respectively. All these calculations were performed by Dimitrijević & Konjević (1981). +, theoretical predictions by Hey et al. (1990) calculated plasma parameters obtained by Platiša et al. (1975), Purić et al. (1988a) and Hey et al. (1990). INS represent our estimated values taken from Table 1.

Table 1. Estimated (INS) Stark FWHM values dependence on the electron temperature (T in K) at $N = 1 \cdot 10^{23}$ m^{-3} electron density, calculated using Eq. (2) and (3).

λ (nm)	$W\ T^{1/2}$ (nm K$^{1/2}$)	Eq.
264.03	1.243	2
275.79	1.217	3
278.89	1.360	2
280.94	1.387	2
292.63	1.532	2

5. DISCUSSION

In order to allow easy comparison among measured, calculated and estimated Stark width values, in Fig.1 the dependence of Stark FWHM values on the electron temperatures is given at $N = 10^{23}$ m^{-3} electron density.

6. CONCLUSION

In general, we noticed a good matching between measured, calculated and estimated Stark width values of the 264.03 nm, 275.74 nm, 278.89 nm and 280.94 nm Ar IV spectral lines. This allows us to recommend their use for plasma spectroscopy. Existing Stark width values of these spectral lines: INS values in Table 1, in this work, and theoretical values G and SEM in Dimitrijević & Konjević (1981), within 20% uncertainties present convenient atomic data in the plasma diagnostic up to 120 000 K electron temperature (Djeniže et al. 2000). It should be pointed out that Hey's (1990) experimental W values at 80 000 K electron temperature lie about all existing measured, calculated and estimated values, especially in the case of the 278.89 nm and 280.94 nm lines. New measurements in these plasma conditions would be helpful.

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TRANSITION PROBABILITIES IN THE 4s′ – 4p′ AND 4p′ – 4d′ TRANSITIONS IN Ar III SPECTRUM

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Abstract. Using the relative line intensity ratios method between three strongest Ar III spectral lines in $4s' - 4p'(^3D^0 - ^3F)$ transition with $\Delta J = -1$, their existing transition probability values (A) have been controlled. These A values, within ±10% accuracy, have been confirmed in the case of the 333.61 nm ($\Delta J = 3 - 4$) and 334.47 nm ($\Delta J = 2 - 3$) spectral lines. Conversely, by transition with 335.85 nm ($\Delta J = 1 - 2$) a necessity for correcting the A value appeared. This correction is about +47% and transform the earlier A value ($1.6\ 10^8 s^{-1}$) up to $2.35\ 10^8 s^{-1}$ within ±15% accuracy.Besides, the A values, not known before, are determined for the 248.89 nm and 250.44 nm Ar III spectral lines belonging to the $4p' - 4d'$ transition.

1. INTRODUCTION

Transition probability of spontaneous emission (A) plays an important role in plasma and laser investigation and, also, in astrophysics. Namely, various kinetic processes appearing in plasma modeling need reliable knowledge of A values (Griem 1964, 1974, 1997). However, the existing A values (Wiese et al. 1966, 1969; Lide 1994), for number of emitters, are given with high uncertainties. These values are calculated on the basis of the Coulomb approximation (Allen 1973) or by using the Self-Consistent Field (SCF) method (Hartree 1956). In the case of ionized emitters (doubly or triply ionized, as example) the expected uncertainties are 50% or larger (Wiese et al. 1969). On the other hand, known experimental techniques involve various difficulties (Wiese et al. 1966, Rompe & Stenbeeck 1967) which limit accuracy of the measured A values.

In this work the transition probabilities of spontaneous emission of five transitions in Ar III spectrum have been obtained using the relative line intensity ratios method. Three among them (333.61, 334.47 and 335.85 nm) are strongest in the Ar III spectrum and they are frequently applied in different sort of investigations. As a source of radiation plasma of optically thin linear pulsed arc has been used. The total line intensities (I) were calculated from line profiles measured with high accuracy using the step-by-step technique. Three researched transitions belong to the $^3D^0 - ^3F$ multiplet with upper energy levels (E) within narrow energy interval, therefore correction to the electron temperature (T) of the measured line intensity ratio is not necessary. This fact allows us to establish a simple relation between measured line intensity ratios and ratios of the products of the spontaneous emission probabilities and the corresponding statistical weights (g) of the upper levels of the lines. This relation is expressed as:

$$(I_1/I_2)_{exp} = g_1 A_1 / g_2 A_2 \tag{1}$$

and gives us possibility to check the existing A values.

2. EXPERIMENT AND RESULTS

The modified version of the linear low pressure pulsed arc (Djeniže et al. 1991, 1998, 2000ab) has been used as a plasma source. A pulsed discharge was driven in a quartz discharge tube of 5 mm inner diameter and effective plasma length of 7.2 cm (Fig. 1 in Djeniže et al. (1991,1998)). The tube has end-on quartz windows. The working gas was argon-helium mixture (72% Ar +28%He) at 130 Pa filling pressure in constant flux flowing regime. Spectroscopic observation of isolated spectral lines were made end-on along the axis of the discharge tube. The line profiles were recorded using a step-by-step technique with a photomultiplier and a grating spectrograph system. The system was calibrated by using the standard lamp (EOA-101). The spectrograph exit slit (10 μm) with the calibrated photomultiplier was micrometrically traversed along the spectral plane in small wavelength steps (0.0073 nm). The averaged photomultiplier signal (five shots at each position) was digitized using an oscilloscope interfaced to a computer. A sample spectrum is shown in Fig 1.

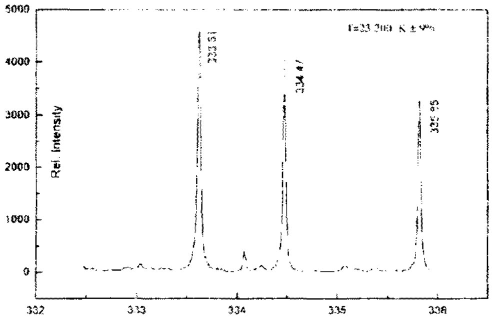

Fig.1. Recorded Ar III spectrum with researched spectral lines.

Plasma reproducibility was monitored by the Ar III and Ar IV lines radiation and, also, by the discharge current (it was found to be within ± 4%). Recorded line profiles can be fitted to the Voigt function as a superposition of the Gauss (instrumental and Doppler broadening) and Lorentz (Stark broadening) functions. The standard deconvolution procedure (Davies & Vaughan 1963) was computerized using the least square algorithm. Total line intensity (I) represents the area under the line profile. On the basis of the recorded Ar III spectrum (as can be see in Fig.1) there follows that these lines are well isolated from the other Ar I, Ar II, Ar III and Ar IV lines and, practically lie on the continuum which is equal to zero. These facts are important by determination in the total line intensity and these conveniences lead to the increase of their reliability.

The plasma parameters were determined using standard diagnostic methods (Rompe & Steenbeck 1967). Thus, the electron temperature was determined from the Boltzman-slope on seven Ar III lines with a corresponding upper-level energy interval of 8.32 eV with an estimated error of ± 9%, assuming the existence of LTE, according to criterion from Griem (1974). All necessary atomic data were taken from Wiese et al. (1969) and Striganov & Sventickii (1966).The electron density decay was measured using a well known single laser interferometry technique for the 632.8 nm He-Ne laser wavelength with an estimated error of ±7%. The electron density and temperature decays are presented in Fig. 4 in Djeniže et al. (2000b) (T_{max} = 23 200 K, N_{max} = 1.9 10^{23} m^{-3}).

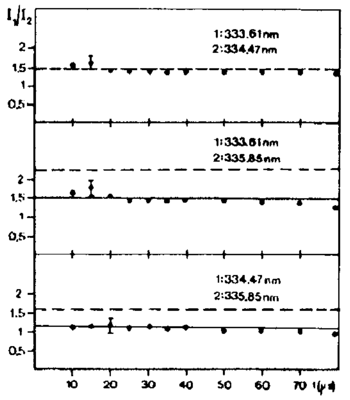

Fig. 2. Relative line intensity ratios (I_1/I_2) during the plasma decay. •, our experimental values within 12% accuracy. - - -, theoretical ratios by using the existing transition probability values from Wiese (1969) and Lide (1994) within estimated uncertainties of 50%. Solid lines represent theoretical intensity ratios after the correction of the transition probabilities. All three lines belong to the same multiplet.

In order to make direct estimation of the influence of the self-absorption on the line intensity, method of the relative line intensity ratios has been applied. Ratios $(I_1/I_2)_{exp}$ were monitored in a wide range of the decaying plasma up to 80th μs after beginning of the discharge when the line intensity maximum dropped down to 10% of its maximal value. Experimental points are presented in Fig.2. These experimental ratios are constant within ±6%, during the plasma decay. From this fact it follows that for employed experimental conditions (spatial distribution, discharge characteristics, gas pressure etc.) our plasma can be treated as optically thin. On the other hand, Stark width values of these lines measured by Djeniže et al. (2000 a) in the same plasma conditions agree well with existing experimental and theoretical Stark width values testifying, also, to the absence of the self-absorption. This suggests that the comparison between measured and calculated relative line intensity ratios can be employed as a method for estimation of the transition probabilities relatively to the selected referent A values.

Therefore, we suppose that there is at least one pair of lines, belonging to the same multiplet, for which measured and calculated relative line intensity ratios are in agreement during the whole plasma decay period. If such agreement really exists one can accept these lines with corresponding transition probabilities as the referent A values. Among the lines that we have investigated, see Fig.2., described behavior is found for the 333.61 nm and 334.47 nm transitions, while existing A value of the 335.85 nm transition has to be corrected in accordance with the experimental I_1/I_3 and I_2/I_3 values. The corrected value is presented in Table 1.

On the basis of the known transition probabilities it is possible to determine unknown A values by using the relative line intensity ratio dependence on the electron temperature (Griem 1964, 1974, 1997):

$$I_1/I_2 = (g_1 A_1 \lambda_2 / g_2 A_2 \lambda_1) exp(\Delta E_{21}/kT) \qquad (2)$$

This relation allows the mutual comparison between the relative intensities of the spectral lines that origin from the much different parent energy levels. Using Eq. (2) A values for the 248.89 nm and 250.44 nm transitions have been obtained relatively to the 333.61 nm and 334.47 nm transitions.

Table 1. Atomic data for the five researched Ar III spectral lines. E and g denote the upper level energy and the corresponded statistical weights. A_w is the existing transition probability (Wiese et al. 1969) and A_{exp} is the new value obtained by us.

Transit.	Multipl.	λ(nm)	E(eV)	g	$A_w(10^8 s^{-1})$	$A_{exp}(10^8 s^{-1})$
$4s' - 4p'$	$^3D^0 - ^3F$	333.61	28.10	9	2.0	2.00±10%
		334.47	28.08	7	1.8	1.80±10%
		335.85	28.06	5	1.6	2.35±15%
$4p' - 4d'$	$^3P^0 - ^3P^0$	248.89	33.66	5	—	1.30±20%
	$^3P - ^3P^0$	250.44	33.68	3	—	0.45±20%

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STARK BROADENING IN THE Ne II 3s ^{4}P–3p ^{4}D^0 MULTIPLET

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Abstract. Stark widths of three Ne II spectral lines (336.063, 333.487 and 332.716 nm) belonging to the $3s^4P - 3p^4D^0$ transition have been measured in the linear, low pressure, pulsed arc plasma at 31 000 K and 34 500 K electron temperatures and corresponding electron densities of 0.95 10^{23} m^{-3} and 1.83 10^{23} m^{-3}, respectively. Our experimental Stark widths data have been compared to the existing experimental and theoretical Stark width values.

1. INTRODUCTION

In the paper published by Uzelac et al. (1993) evident discrepancies between existing calculated Stark width values were found in the case of the Ne II $3s^4P - 3p^4D^0$ transition. Thus, the results of the classical-path approximation (HB) (Hey & Breger 1980; Uzelac et al. 1993) provide very small dependence on the electron temperature (T). In contrast to this, predictions made by modified semiempirical method (SEM) (Dimitrijević & Konjević 1980; Uzelac et al. 1993) show perceptible dependence on the electron temperature. Griem's (1974) (G) values calculated on the basis of the semiclassical theory lie above both other group of the mentioned theoretical predictions. Existing experimental Stark width data between 27 000 K and 40 000 K electron temperatures show acceptable agreement with G and HB values, but the latest measurements (Uzelac et al. 1993) give Stark widths which at about 80 000 K electron temperature agree well with SEM values.

The aim of this work is contribution to the clarification of the above explained problem. In this order Stark FWHM (full-width at half intensity maximum, W) have been measured in two discharge conditions in neon plasma. Beside, for the first time, estimations of the researched W values (based on the Stark width regularities) have been included, also, in the comparison between measured and calculated Stark width values.

2. EXPERIMENT AND RESULTS

The modified version of the linear low pressure pulsed arc (Djeniže et al. 1991,1998) has been used as a plasma source. A pulsed discharge was driven in a quartz discharge tube of 5 mm inner diameter and effective plasma length of 7.2 cm (Fig. 1 in Djeniže et al. (1991,1998)). The tube has end-on quartz windows. The working gas was neon at 130 Pa filling pressure in constant flux flowing regime. A capacitor of 14 μF was charged up to 1.5 kV and 2.5 kV, respectively. Spectroscopic observation of isolated spectral lines were made end-on along the axis of the discharge tube. The line profiles were recorded using a step-by-step technique, described in our earlier publications. The spectrograph exit slit (10 μm) with the calibrated photomultiplier was micrometrically traversed along the spectral plane in small wavelength steps (0.0073 nm). The averaged photomultiplier signal (five shots in each position) was digitized using an oscilloscope, interfaced to a computer.

Plasma reproducibility was monitored by the Ne II and Ne III lines radiation and, also, by the discharge current (it was found to be within 5%). Recorded line profiles can be fitted to the Voigt function as a superposition of the Gauss (instrumental and Doppler broadening) and Lorentz (Stark broadening) functions. The standard deconvolution procedure (Davies & Vaughan 1963) was computerized using the least square algorithm. Stark widths have been obtained with ± 10% accuracy at given T and N. Great care was taken to minimize the influence of self-absorption on Stark width determinations. The opacity was checked by measuring line-intensity ratios within multiplet. The values obtained were compared with calculated ratios of the products of the spontaneous emission probabilities and the corresponding statistical weight of the upper levels of the lines. These ratios differed by less than ±5%, testifying to the absence of the self-absorption. The necessary atomic data were taken from Wiese et al. (1966).

The plasma parameters were determined using standard diagnostic methods (Rompe & Steenbeck 1967). Thus, the electron temperature (T) was determined from the Boltzman-slope on 14 Ne II lines (331.98, 336.06, 337.18, 341.48, 341.69, 341.77, 350.36, 356.83, 366.41, 369.42, 429.04, 439.19, 440.93 and 441.32 nm) with a corresponding upper-level energy interval of 7.52 eV with an estimated error of ± 7%, assuming the existence of LTE, according to criterion from Griem (1974). All necessary atomic data were taken from Wiese et. al. (1966).The electron density (N) decay was measured using a well known single laser interferometry technique for the 632.8 nm He-Ne laser wavelength with an estimated error of ±7%. The electron density and temperature decays are presented in Fig. 1 (for the 1.5 kV bank energy). Our experimental W data are given in Table 1.

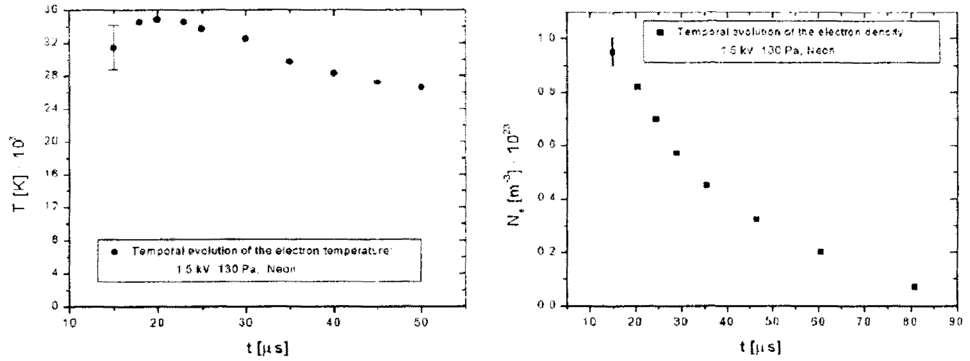

Fig. 1. Electron temperature (T) and density (N) decay at 1.5 kV bank energy.

Table 1. Measured W values with various plasma parameters.

λ (nm)	W (nm)	
	T=31 000 K $N = 0.95\ 10^{23}$ m^{-3}	T=34 500 K $N = 1.83\ 10^{23}$ m^{-3}
336.063	0.01252	0.02183
333.487	0.01330	0.02073
332.716	0.01400	0.02199

3. DISCUSSION AND CONCLUSION

In order to allow easy comparison among measured and calculated Stark width values, we report in Fig. 2. variations of W (FWHM) with the electron temperatures for a given electron density equal to 10^{23} m^{-3}. Theoretical predictions are calculated on the basis of the modified semiempirical formulae (SEM), classical path -approximation (HB) and semiclassical theory (G). INS denote estimated W values calculated on the basis of Eq. (2) taken from Purić et al. (1988) and Djeniže & Labat (1996) which was obtained for the neon isonuclear sequence (see also Djeniže , 2000). The explicit form of this equation is given (for z=2) as:

$$W(m) = 1.97\ 10^{-9}\ T^{-1/2} \tag{1}$$

at an $N = 10^{23}$m^{-3} electron density and T expressed in K. All necessary atomic data in determination of Eq. (1) were taken from Wiese et. al. (1966).

One can conclude that our new experimental data confirm the earlier observed experimental W values at about 30 000 K electron temperature and gravity to the G and HB theoretical values. It should be pointed out that the estimated INS values agree satisfactorily with experimental data including, also, those from Uzelac et al. (1993) at about T=80 000 K. INS and SEM predictions have similar course among electron temperatures. Explaining of these behaviours requires new steps in theory of the Stark widths predictions.

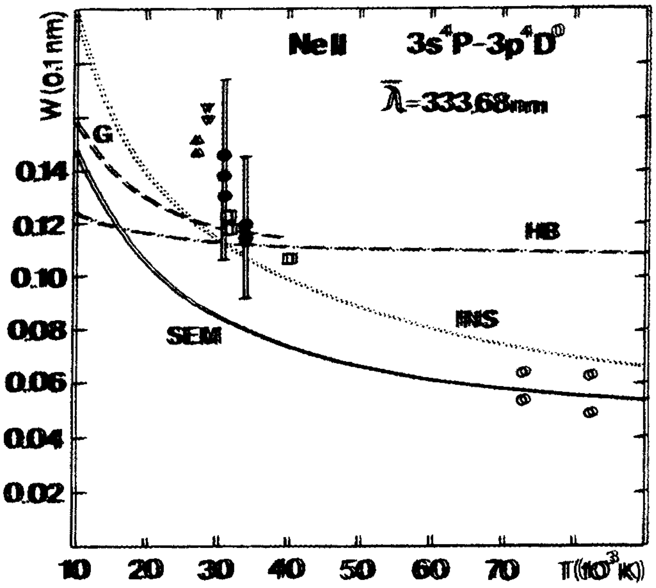

Fig. 2. Stark FWHM values vs. electron temperature at an 10^{23} m^{-3} electron density. ●, this work; ▽, Platiša et al. (1978); △, Konjević & Pittman (1987); , Purić et al. (1987); ⊕, Uzelac et al. (1993). G, Griem (1974); SEM, Uzelac et al. (1993), HB, Uzelac et al. (1993), INS, Djeniže & Labat (1996). Error bars include uncertainty estimates in width (±10%) and electron density (±7 %) measurements. $\bar{\lambda}$ is the mean wavelength in multiplet.

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GRAVITY DARKENING IN SEMI-DETACHED BINARY SYSTEMS TT AURIGAE

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Abstract. From a light-curve analysis of the semi-detached close binary system TT Aur, the exponent of the gravity-darkening has been empirically estimated for the component filling the Roche lobe. In the analysis, the gravity-darkening coefficient for the component underfilling its Roche lobe has been fixed according to von Zeipel's (1924) value $\beta = 0.25$ for stars in hydrostatic and radiative equilibrium. The results of the present analysis show that the estimated empirical value of the gravity-darkening exponent is significantly greater than the one derived from existing theories by von Zeipel for radiative (hot systems) envelopes.

1. LIGHT-CURVE ANALYSIS

An ordinary semi-detached system of Algol-type consists of a main-sequence primary component inside its Roche lobe and a subgiant (or giant) secondary filling the Roche lobe. If the primary component is well deep inside its Roche lobe, the shape of the star is close to being spherical. In this case it is reasonable to fix the value of the gravity-darkening coefficient according to von Zeipel's (1924) value $\beta = 0.25$ for stars in hydrostatic and radiative equilibrium. The exponent of the gravity-darkening has been empirically estimated for the component filling the Roche lobe by the light-curve analysis. In this paper a modern computer programme (Djurašević, et al., 1998) has been used to analyze the photometric observations. The programme is based on the Roche model and the principles deriving from the paper by Wilson & Devinney (1971).

In the analysis of the light curves, instead of the often used and somewhat questionable practice of forming normal points, we used the original observational data in order to avoid negative effect of such normalization.

To achieve more reliable estimates of the model parameters in the programme for the light-curves analysis, we applied a quite dense coordinate grid having $72 \times 144 = 10368$ elementary cells per each star. The intensity and angular distribution of radiation of elementary cells are determined by the star's effective temperature, limb-darkening, gravity-darkening and by the effect of reflection in the system.

The star's size in the model is described by the filling coefficients for the critical Roche lobes $F_{h,c}$ of the primary and secondary components, respectively, which tell us to what degree the stars in the system fill their corresponding critical lobes. The subscripts (**h,c**) refer to the hotter (primary) and cooler (secondary) component respectively. For synchronous rotation of the components (tidal effects are present) these coefficients are expressed via the ratio of the star polar radii, $R_{h,c}$, and the corresponding polar radii of the critical Roche lobes, i.e., $F_{h,c} = R_{h,c}/R_{Roche_{h,c}}$.

For a successful application of the foregoing described model in the analysis of the observed light curves, the method proposed by Djurašević (1992) was used. By that method optimum model parameters are obtained through the minimization of $S = \Sigma(O - C)^2$, where $(O - C)$ is the residual between the observed (LCO) and synthetic (LCC) light curves for a given orbital phase. The minimization of S is effected in an iterative cycle of corrections of the model parameters. In this way the inverse-problem method gives us the estimates of system's parameters and their standard errors.

The values of the limb-darkening coefficients were derived from the star's effective temperature and surface gravity, according to the given spectral type, by using the polynomial proposed by Díaz-Cordovés et al., (1995). Following Rucinski (1969) and Rafert & Twigg (1980), the gravity-darkening coefficients of the stars, β, and their albedos, A, were set at the values of $\beta = 0.25$ and $A = 1.0$ for stars in hydrostatic and radiative equilibrium. In this particular case, as we mentioned earlier, the gravity-darkening coefficient is fixed for the primary component situated inside its Roche lobe.

In previous versions of our programme, there were two different possibilities in the application of the model regarding the treatment of the radiation law: the simple black-body theory, or the stellar atmosphere models by Carbon & Gingerich (1969) (CG). Our current version of the programme for the light-curve analysis employs the new promising Basel Stellar Library (BaSeL). We have explored the "corrected" BaSeL model flux distributions, consistent with extant empirical calibrations (Lejeune et al., 1997, 1998). By choosing and fixing the particular input switch, the programme for the light-curve analysis can be simply redirected to the Planck or CG approximation, or to the more realistic BaSeL model atmospheres.

2. RESULTS AND CONCLUSIONS

In this paper the light-curve analysis is applied to the massive binary system of TT Aurigae (B2V+B4 ; $P \sim 1^d.333$). UBV observations (Demircan, 1999) made at the Ankara University Observatory and BV observations (Bell et al., 1987) were analyses with the fixed mass-ratio of the components $q = m_h/m_c = 0.678$ (Wachmann et al., 1986). Based on the spectral type of the components, B2 V+B4 (Kitamura and Nakamura, 1987), the value of $T_h = 24800K$ was taken as the temperature of the primary. The gravity-darkening exponent of the primary was fixed at $\beta_h = 0.25$, and as the albedos of the components the values of $A_h = A_c = 1.0$ were adopted. Other parameters of the system were estimated in the light-curve analysis. Here we used the "corrected" BaSeL model flux distributions and we assumed solar chemical abundance for the components of the system. This model approximation provides much better agreement between the individual U, B and V solutions than the simple black-body theory, or the stellar atmosphere models by Carbon & Gingerich (1969).

The present analysis of the observations of TT Aur enabled us to estimate the parameters of the system that are mutually consistent. The solutions indicate a semi-detached configuration in which the less-massive secondary fills its Roche lobe. They suggest also a quite possible mass-transfer from the less massive secondary toward the more massive primary.

Table 1 presents the results of the light-curve analysis while Fig. 1 gives a graphic presentation of these results. For the gravity-darkening exponent of the secondary we obtained the value $\beta_c \sim 0.6$, which is greater than twice the expected value $\beta = 0.25$ for stars in hydrostatic and radiative equilibrium. By applying a different model and method Kitamura and Nakamura (1987) found for this system $\alpha_c = 4 \times \beta_c = 3.84$, which is about 1.4 times greater than the value estimated in our present paper. We think that our Roche model is more adequate and that the method of optimization we applied is a direct and efficacious one. In our opinion this discrepancy between our and Kitamura and Nakamura's estimates of the gravity-darkening exponent is a consequence of the simplified model of the system and method used by the two authors.

Table 1. Results of the analysis of the TT Aur light curves obtained by solving the inverse problem for the Roche model. Gravity-darkening coefficient of the cooler secondary component (β_c) is a free parameter.

Quantity	U - filter	B - filter	V - filter	B - filter	V - filter
n	359	360	361	113	113
$\Sigma(O-C)^2$	0.1054	0.0819	0.0932	0.0068	0.0055
$q = m_c/m_h$	0.678				
T_h	24800				
β_h	0.25				
A_h	1.0				
A_c	1.0				
$f_h = f_c$	1.0				
T_c	19800 ±92	19911 ±103	20023 ±117	19960 ±70	19843 ±69
F_h	0.805 ±0.005	0.812 ±0.007	0.764 ±0.008	0.792 ±0.006	0.791 ±0.006
F_c	0.986 ±0.002	0.989 ±0.002	0.997 ±0 002	0.982 ±0.002	0.986 ±0.001
i	86.2 ±0.1	86.2 ±0.13	86.2 ±0.14	86.2 ±0.07	86.3 ±0.07
β_c	0.60 ±0.02	0.60 ±0.02	0.60 ±0.02	0.60 ±0.02	0.62 ±0.02
u_h	0.33	0.35	0.31	0.35	0.31
u_c	0.37	0.41	0.35	0.40	0.35
Ω_h	3.844	3.813	4.018	3.894	3.900
Ω_c	3.234	3.229	3.211	3.243	3.236
R_h [D=1]	0.313	0.316	0.297	0.308	0.308
R_c [D=1]	0.320	0.321	0.323	0.318	0.319
$L_h/(L_h + L_c)$	0.659	0.612	0.550	0.602	0.581

BaSeL approximation of the stellar atmosphere ($[Fe/H]_{h,c} = 0.0$ - accepted metallicity of the components)

Note: n - number of observations, $\Sigma(O-C)^2$ - final sum of squares of residuals between observed (LCO) and synthetic (LCC) light curves, $q = m_c/m_h$ - mass ratio of the components, T_h - temperature of the hotter component, β_h - gravity-darkening coefficient of the hotter component, $A_h = A_c = 1.0$ - albedo coefficients of the components, $f_h = f_c = 1.00$ - nonsynchronous rotation coefficients of the components, T_c - temperature of the cooler component, $F_{h,c}$ - filling coefficients for critical Roche lobes of the hotter primary (h) and cooler secondary (c), i - orbit inclination (in arc degrees), β_c - gravity-darkening coefficient of the cooler secondary component, $u_{h,c}$ - limb-darkening coefficients of the components, $\Omega_{h,c}$ - dimensionless surface potentials of the primary and secondary, $R_{h,c}$ - polar radii of the components in units of the separation [D=1] between the component centres and $L_h/(L_h + L_c)$ - luminosity of the hotter star.

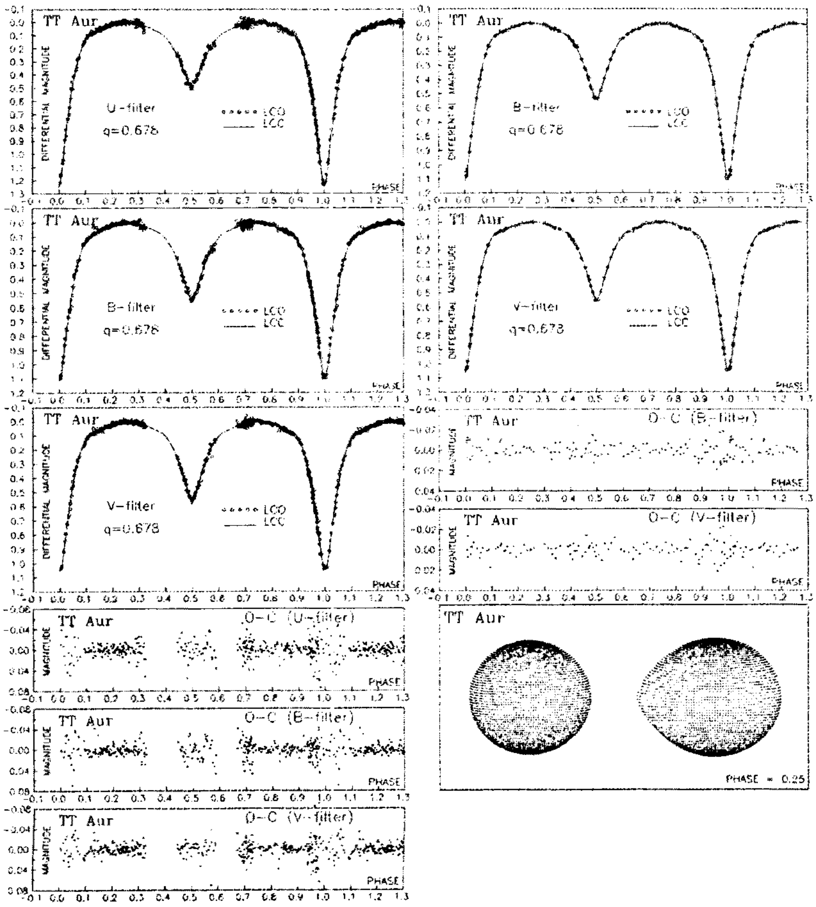

Fig. 1. Observed (LCO) and final synthetic (LCC) light curves of TT Aur with final O-C residuals obtained by analyzing two sets of U B V and B V observations and with the view of the system at the orbital phase 0.25, obtained with the parameters estimated by analyzing the observations.

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ДЕПОПУЛАЦИЈА ГОРЊЕГ ЕНЕРГЕТСКОГ НИВОА ВУВ ЛИНИЈЕ АРГОНА ИНФРАЦРВЕНИМ ЛАСЕРСКИМ ЗРАЧЕЊЕМ

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Абстракт. Утврђено је смањење максимума интензитета линије Ar I 104,82 nm из ВУВ дела спектра услед апсорпције ласерског зрачења таласне дужине 852,1433 nm која одговара линији Ar I чији се доњи енергетски ниво поклапа са горњим нивоом линије 104,82 nm.

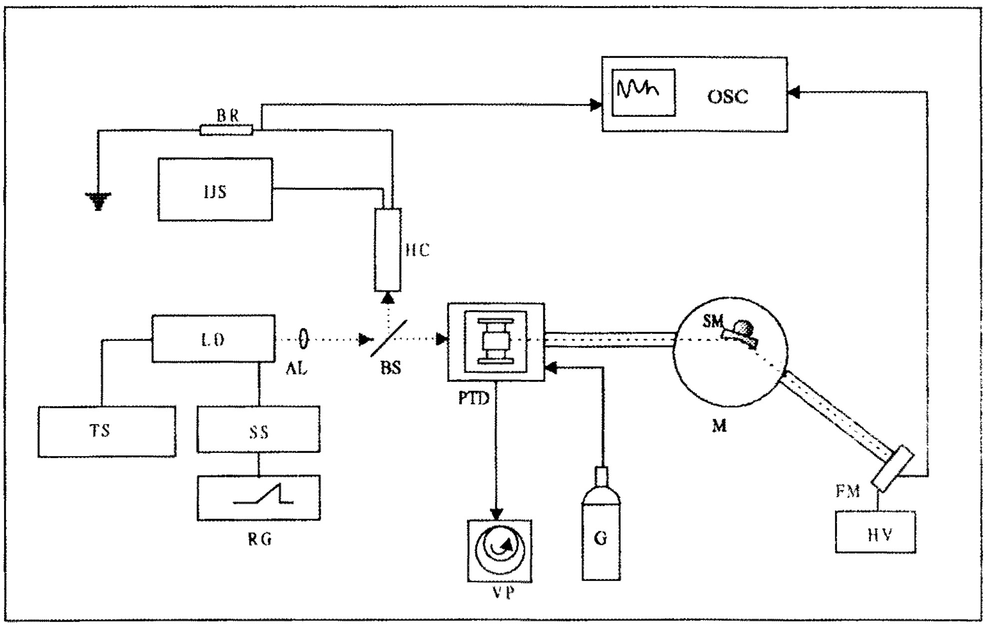
1. УВОД

Пенингово пражњење се користи као стандардни извор зрачења за калибрацију спектрометра у ВУВ области спектра. У пражњењу са аргоном побуђују се резонантне линије 104,82 nm и 106,67 nm. Горњи енергетски ниво линије Ar I 104,82 nm је истовремено доњи ниво линије Ar I 852,1443 nm. На тој таласној дужини је могуће остварити зрачење ласерске диоде. Посматрајући максимум линије Ar I 104,82 nm из Пенинговог пражњења које се истовремено осветљава ласерским зрачењем могуће је приметити опадање интензитета линије. Разлог томе је апсорпција ласерског зрачења од стране електрона са горњег енергетског нивоа линије Ar I 104,82 nm.

2. ПОСТАВКА ЕКСПЕРИМЕНТА

Схема експеримента дата је на Сл. 1. Извор зрачења је Пенингово пражњење које има две алуминијумске катоде постављене једна наспрам друге и изоловане керамиком од месинганог блока који представља аноду. Све електроде се хладе водом. Пражњење је постављено у магнетно поље сталног магнета које стабилише пражњење. Радни гас је аргон, притисак је 1 Pa, струја пражњења је 10 mA при напону од 300 V. Пражњење се директно поставља на улазни прорез монохроматора (Jobin Yvon LHT30) који се користи за ВУВ спектроскопију. Монохроматор је типа Seya-Namioka (упадни и излазни зрак су под углом од 140 степени) и има тороидалну решетку са 275 зареза по mm. У овом случају монохроматор се користи само као спектрални филтер постављен на максимум линије Ar I 104,82 nm. Монохроматор се заједно са пражњењем вакумира турбомолекуларном вакуум пумпом Alcatel ACT200T до 0,1 Pa, пре упуштања радног гаса. На излазни прорез монохроматора постављен је сцинтилатор од натријум салицилата, а затим фотомултипликатор Hamamatsu R212.

Ласерска диода (SDL 5412-H1) емитује једномодно зрачење снаге 100 mW у спектралној области (852 ± 7) nm. У тој спектралној области се налази јака линија аргона λ= 852,1443 nm, која одговара прелазу $4s'[1/2]^0 - 4p'[3/2]$. Спектрална ширина ласерског зрачења је $2\cdot10^{-5}$ nm. Таласна дужина ласерског зрачења се може мењати променом температуре ласерске диоде и променом струје која кроз њу протиче. Промена таласне дужине ласерског зрачења преко аргонове линије се врши променом струје при константној температури диоде. Промена струје кроз ласерску диоду се остварује помоћу генератора функција (Kronhite). Фреквенција тестерастог сигнала генератора функција је 500 Hz. Ласерски сноп се фокусира асферичним сочивом жижне даљине 45 mm, а затим дели тако да један део пада на Пенингово пражњење, а други на шупљу катоду. Сигнал са фотомултипликатора се на дигиталном осцилоскопу (Tektronix TDS 3032) усредњава 512 пута. Овако велики број усредњавања је потребан због нестабилности Пениноговог пражњења. На други канал осцилоскопа се доводи оптогалвански сигнал са баластног отпора електричног пражњења са шупљом катодом. Оптогалвански сигнал показује да је ласерско зрачење на таласној дужини која одговара аргоновој линији λ= 852,1443 nm.

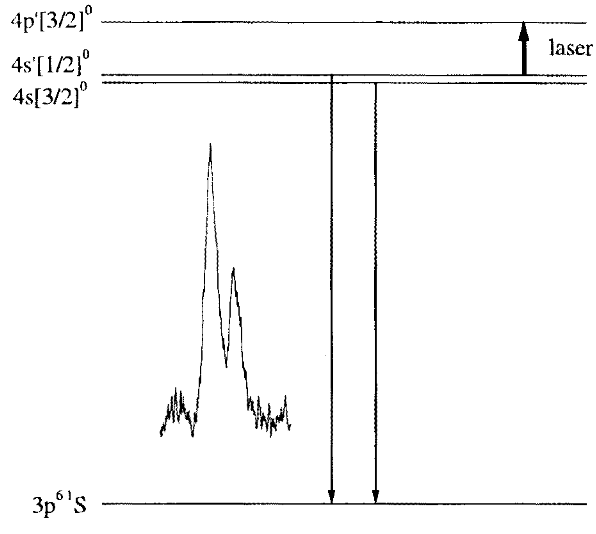


Слика 1. Поставка експеримента. PTD-Пенингово пражњење, VP-вакуум пумпа G-боца с гасом, M-монохроматор, SM-корачни мотор, FM-фотомултипликатор, HV-извор високог напона, LD-ласерска диода, TS-температурно скенирање, SS-струјно скенирање, RG-генератор функција, HC-шупља катода, IJS-извор једносмерне струје, BR-баластни отпор, AL-асферично сочиво, BS-разделник снопа, OSC-осцилоскоп.

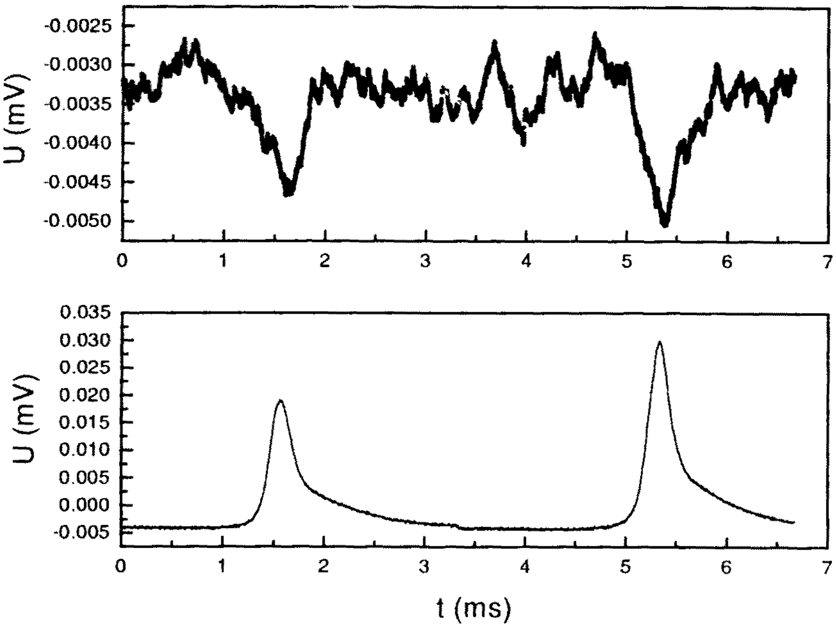
3. РЕЗУЛТАТИ И ДИСКУСИЈА

На Сл. 2. је приказана схема енергетских нивоа спектралних линија неутралног аргона , снимак линија аргона у ВУВ делу спектра (104,82 nm и 106,67 nm) и побуда ласерским зрачењем. Спектрална ширина линије (FWHM) аргона је 0,8 nm.

Сл. 3. приказује истовремени снимак оптогалванског ефекта и ефекта смањења интензитета линије аргона 104,82 nm. Смањење интензитета линије аргона је последица депопулације горњег енергетског нивоа услед апсорпције ласерског зрачења од стране електрона на том нивоу. Да је то заиста тако показује истовременост појављивања оптогалванског ефекта и смањења интензитета резонантне линије аргона. Таласна дужина ласерског зрачења је сразмерна јачини струје која протиче кроз ласерску диоду. При коришћењу тестерасте функције струје, код које је јачина струје директно сразмерна времену, таласна дужина ласерског зрачења је сразмерна времену. Зато је временска оса на Сл. 3. сразмерна таласној дужини.



Слика 2. Енергетски нивои линија Ar I 104,82nm, 106,67nm и 852,1443nm и снимљене спектралне линије аргона 104,82nm и 106,67nm.



Слика 3. Оптогалвански ефекат (доле) и максимум линије 104,82nm (горе) после 512 усредњавања.

4. ЗАКЉУЧАК

Депопулисање горњег електронског нивоа резонантне линије аргона инфрацрвеним ласерским зрачењем омогућава проширење спектралне области примене ласерске диоде. Како је спектрална ширина ласерског зрачења веома мала ($\Delta\lambda = 2\cdot10^{-5}$ nm), то се са веома добром резолуцијом могу испитивати линије у ВУВ области спектра.

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THE LOCAL Mg_2 – $\log\sigma$ RELATION FOR EARLY-TYPE GALAXIES THROUGH THE DATABASE HYPERCAT

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Abstract. We report the local $\mathrm{Mg}_2(r)$ vs. $\log\sigma(r)$ relationship of 9 typical elliptical and 9 typical S0 galaxies whose data are maintained in the extragalactic database *HYPERCAT*. The two relations, for E and S0 galaxies, are significantly different. The contribution of the rotation to the local potential at the time of star formation bulk could provide an explanation of this difference. The analysis shows that the appropriate accounting for the rotational support is conductive to the $\mathrm{Mg}_2(r) - \log\sigma(r)$ relation for S0s becoming like that for the ellipticals. This would mean that the disks of S0s are both old and have a high metallicity. Thus, the qualitative difference between the local $\mathrm{Mg}_2(r) - \log\sigma(r)$ relationship of S0s and ellipticals may still be compatible with a model of dissipative quasi-simultaneous formation of the disk and the bulge.

1. INTRODUCTION

The Mg_2 absorption line-strength index is a measure of one of the most prominent features in the optical spectra of early-type galaxies. It is one of the dozen well-known line-strength indices that are successfully used to study the old stellar populations in early-type galaxies (see e.g. González 1993 and references therein).

It is also well established that the correlation between central Mg_2 absorption line-strength index and the central velocity dispersion σ_0 of dynamically hot stellar systems is very tight (Dressler et al. 1987; Burstein et al. 1988; Bender et al. 1993). Although these systems comprise four orders of magnitudes in mass and luminosity (ranging from the bulges of spirals and S0s up to the giant ellipticals) and their Mg_2 indices differ by up to $0\overset{m}{.}35$, the scatter of $\mathrm{Mg}_2 - \log\sigma_0$ relation remains low (Ziegler & Bender 1997). The relationship between the central Mg_2 index and the central velocity dispersion σ_0 connects one dynamical parameter and another one that arises entirely through the physics of stellar evolution, thus suggesting a remarkably close connection between the chemical and dynamical evolution of early-type galaxies (Davies 1995; González & Gorgas 1995).

On the third hand, early-type galaxies exhibit systematic variations in the line-strength indices going from the center to the external galaxy regions (cf. González 1993; Fisher et al. 1995, 1996). This suggests the change in some fundamental properties of the constituent stellar population of these galaxies. Either the age or the metallicity of the stellar content (or both reasons simultaneously) could probably be responsible for the index variations.

In this report we will focus on the local $\mathrm{Mg}_2(r) - \log\sigma(r)$ relationship of some bona-fide elliptical and S0 galaxies. This work is part of a long-term project dedicated to the study of the scaling relations of early-type galaxies (see Prugniel & Simien 1994, 1996, 1997, and Prugniel et al. 1999) connected with the Lyon's extragalactic database *HYPERCAT* (Prugniel & Golev 1999; Maubon et al. 1999)

2. THE HYPERCAT PROJECT

The *HYPERCAT* database is a collaboration initiated at Observatoire de Lyon, France, involving the University of Sofia, Bulgaria, the Sternberg Institute in Moscow, Russia, and two Italian observatories: Brera in Milano and Capodimonte in Napoli.

The aims of Hypercat project are:

Construct, maintain and interface catalogues of galaxies useful for studying their physics. The data catalogued in *HYPERCAT* complement those available through the major extragalactic databases (NED and LEDA). Links to these data bases and to ADS and SIMBAD are provided for each object or reference. DSS images of the object may also be obtained through the *HYPERCAT* interface. Elaborate data-mining utilities and developed pipelines to extract astrophysical parameters are provided. The first step yet accomplished was assembling of FITS archive (HFA) and link its linking analysis pipelines.

HYPERCAT is a tool designed to support our work on the scaling relation of galaxies, but, being available on the Web, it is also used for other purposes. In particular, it can be a useful auxiliary in the preparation of observations, through its capabilities to select and define a sample. A unique characteristic of *HYPERCAT* is that it is jointly operated at different sites: the catalogues, as well as the FITS archive, are maintained separately in different sites and are daily mirrored to Lyon to update the database. In turn, the database is mirrored to the public *HYPERCAT* sites:

`http://www-obs.univ-lyon1.fr/hypercat/` – the main site in Lyon;
`http://astro.uni-sofia.bg/hypercat/` – mirror in Sofia;
`http://palladio.brera.mi.astro.it/hypercat/` – mirror in Milan;
`http://www.na.astro.it/hypercat/` – mirror in Napoli.

This organization is quite complex, as it involves about 10 computers, but is efficient since it minimizes the need of non- automatic interactions for the operations of database management. It also exerts a heavy pressure on the network, but since all communications are concentrated during the low- traffic hours the network capacity is sufficient. Note however that having distributed mirrors of the database also reduces the long-distance network load during the heavy-traffic hours.

The HFA itself is structured in datasets, each corresponding to a set of observations taken in the same conditions.

Together with the science frames, all other information necessary to the data reduction is also stored in HFA. They are in particular:

(i) Template objects used for flux calibration.
(ii) Spectra of reference lamp for wavelength calibration.
(iii) Mean flat field (and bias) used in the reduction of science frames.

This structure of the database was used to perform the investigation described below.

2. 1. THE SPECTROSCOPIC DATA

More than 200 spectra of 87 early-type galaxies (S0a and ellipticals between E0 and E4) centered around the Mg*b* λ5175 Å triplet and covering a range of 900 Å have been collected using the 1.93m telescope of the Observatoire de Haute-Provence and the *CARELEC* long-slit spectrograph[1] (Prugniel et al. 1992). The FWHM spectral resolution of 3.2 Å was used. This material is already described in details in Prugniel & Simien (1994) and Simien & Prugniel (1997a, 1997b and 1997c) where the internal kinematics of the sample galaxies is analyzed.

The sample galaxies span a wide range of intrinsic luminosity ($-22\overset{m}{.}0 \lesssim M_B \lesssim -17\overset{m}{.}5$), central velocity dispersion ($70 \lesssim \sigma_0 \lesssim 330$ km s^{-1}), and, as a consequence, of metallicity.

We have already used this spectral archive to derive the central values of Mg_2-index for all 87 early-type objects in the archive (Golev et al. 1999). The central Mg_2 measurements were reduced to the homogeneous, standard Lick system following the procedures described in Golev & Prugniel (1998). A catalog of these measurements together with practically all central Mg_2 measurements available in the literature, converted to the Lick system, can be found in *HYPERCAT*.

Now we have used this spectral archive to derive Mg_2-index radial profiles for 9 typical *bona-fide* elliptical galaxies and 9 typical lenticulars. The individual Mg_2-index profiles were obtained for position angles corresponding to the major axis of each galaxy.

3. THE $Mg_2 - \log\sigma$ RELATIONSHIP

3. 1. THE $Mg_2 - \log\sigma$ DIAGRAM FOR CENTRAL VALUES

We have constructed the Mg_2 vs. $\log\sigma_0$ diagram for a sample of 308 bona-fide elliptical galaxies whose data are maintained in HYPERCAT. The relationship derived

$$Mg_2 = 0.225\,(\pm\,0.009)\log\sigma_0 - 0.238\,(\pm\,0.022) \qquad (1)$$

is the best straight-line fit to data with errors in both Mg_2 and $\log\sigma_0$. This diagram is shown in Fig. 1.

If errors in Mg_2 only were taken into account (which is the usual way to derive this relation), the relationship would be $Mg_2 = 0.181\log\sigma_0 - 0.130$, or, within the errors, *exactly* the classical relation published first by Dressler et al. (1987) and discussed in details by Bender et al. (1993).

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[1] Details on the *CARELEC* long-slit spectrograph and its detectors, as well as the information about the 1.93m telescope itself, are available on the WWW at http://www.obs-hp.fr.

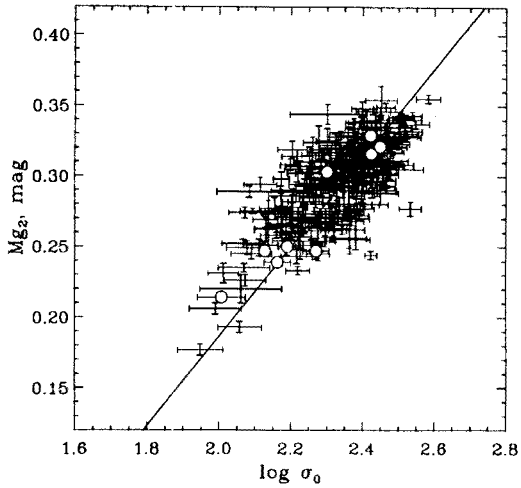

Fig. 1. The relationship between the central Mg_2index and the central velocity dispersionσ_0 for 271 bona-fide elliptical galaxies in HYPERCAT. The solid line represents the best straight-line fit to data with errors in both Mg_2 and $\log\sigma_0$. Open circles represent these 9 ellipticals whose properties are discussed later in the text.

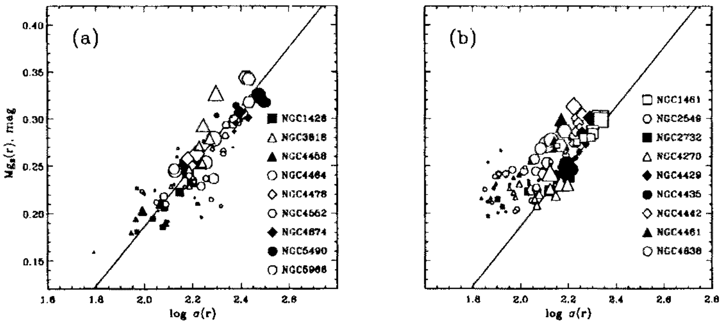

Fig. 2. The local $Mg_2(r)-\log\sigma(r)$ relationship for (a) 9 *bona-fide* elliptical galaxies, and (b) 9 S0 galaxies. Each galaxy is shown with different symbols and the larger the symbol, the closer is the measured radial point to the galaxy's center. The solid line represents the fit to the central relationship for 308 *bona-fide* ellipticals shown in Fig. 1.

3. 2. THE LOCAL $Mg_2(R) - \log\sigma(R)$ DIAGRAM

We have studied the Mg_2 vs. $\log\sigma$ for the local parameters, $Mg_2(r)$ and $\sigma(r)$, derived from the radial profiles of the Mg_2-index and σ over the major axes of both 9 *bona-fide* ellipticals and 9 S0s selected by us from our spectral archive.

Local $\mathrm{Mg}_2(r) - \log\sigma(r)$ relationships for selected ellipticals and lenticulars are presented in Fig. 2(a) and (b) respectively. Each galaxy is shown with different symbol and the larger the symbol, the closer is the measured radial point to the center of the galaxy. The solid line represents the fit to the central relationship for 271 *bona-fide* ellipticals shown in Fig. 1.

Only profile values for which the relative errors $\Delta\mathrm{Mg}_2(r)/\mathrm{Mg}_2(r) \lesssim 25\%$ and $\Delta\sigma(r)/\sigma(r) \lesssim 25\%$ were used for the analysis and plots.

The local relationship for ellipticals studied by us does not differ significantly from the central one for 308 objects. However, this is not the case of lenticulars. The two local relations, for E and S0 galaxies, are significantly different in sense that

1. The S0s have a slightly higher Mg_2 at given $\sigma(r)$ than the ellipticals. This effect is also apparent for the central values in Fisher et al. (1996 - see their Fig. 2), though not discussed there.
2. The local $\mathrm{Mg}_2(r) - \log\sigma(r)$ relationship for S0s *flattens* for low values of $\sigma(r)$ which does not occur for ellipticals. This also corresponds to the outer regions of these galaxies where the disk is predominant over the bulge.

4. DISCUSSION

This difference would mean that the disks of S0s are both old and have a high metallicity. Can this be reconciled with the dissipative collapse enrichment?

The standard model explains the $\mathrm{Mg}_2 - \log\sigma$ relation, either central or local, as a result of enrichment during the bulk of star formation. The fraction of metal-enriched gas left by the supernova-driven winds depends on the local escape velocity (see e.g. Franx & Illingworth 1990). In the framework of such a scenario, a disk having a different history would probably depart from the *bona-fide* $\mathrm{Mg}_2 - \log\sigma$ relation.

An alternative could be to consider the simultaneous dissipative formation of both the disk and the bulge. In such case, the enrichment will be controlled by the local potential, $\Phi(r)$. And if the system has only passively evolved after the bulk of star formation, the $\Phi(r) - \mathrm{Mg}_2(r)$ relation should keep traces of this star-formation process.

Potentials of elliptical and lenticular galaxies are basically different. In the case of S0s, the local velocity dispersion $\sigma(r)$ cannot be used as an estimate of the local potential $\Phi(r)$. The structure and dynamics of lenticulars is more complex, and, as a minimum, it is necessary to include the rotational velocity, V_{rot}, in the estimate of the local kinetic energy.

In the framework of axis-symmetric dynamical models, both oblate and prolate (see e.g. van der Marel 1991), for every point of the major axis the local kinetic energy *projected* over the LOS is $V^2_{\mathrm{rot}}(r) + \sigma^2(r)$. As it was shown by Prugniel & Simien (1994) for ellipticals, the rotational energy, being usually small but not negligible, should always add a positive contribution to the total kinetic energy.

This additional energy could be described by the dimensionless rotational-support term $S \simeq \frac{1}{2}\log(1+\eta V^2_{\mathrm{rot}}/\sigma^2)$. The term was introduced by Prugniel & Simien (1994) in frame of their analysis of contribution of the galactic rotation to the virial equilibrium in ellipticals, and they derived $\eta = 0.81$ for isotropic rotators. Hence, we have studied the relation between the residuals

$$R(r) = \log \sigma_{\mathrm{Mg2}}(r) - \log \sigma(r) \tag{2}$$

to the local $\mathrm{Mg}_2(r) - \log\sigma(r)$ relation as a function of the *local projected* rotational support expressed as

$$S(r) = \frac{1}{2}\log\left(1 + \eta V_{\mathrm{rot}}^2(r)/\sigma^2(r)\right). \tag{3}$$

Here $\log \sigma(r)$ is the observed velocity dispersion at given radial point of galaxy's major axis, and $\log \sigma_{\mathrm{Mg2}}(r)$ is the value of the velocity dispersion predicted by Eq. 1., rewritten for the velocity dispersion.

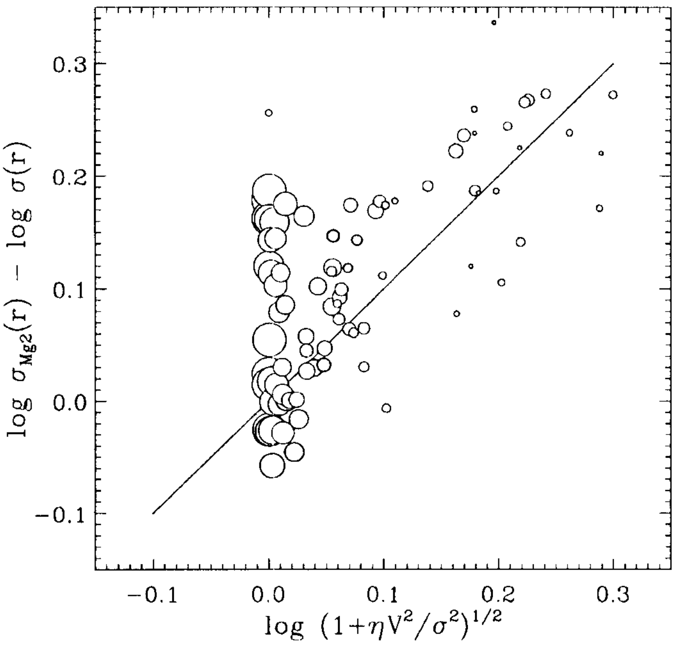

Fig. 3. The residuals $R(r) = \log \sigma_{\mathrm{Mg2}}(r) - \log \sigma(r)$ for the profiles of all 9 lenticulars as a function of the local rotational support $S(r) = \frac{1}{2}\log(1 + \eta V_{\mathrm{rot}}^2(r)/\sigma^2(r))$. The 45° line (or the "best-fit" line in the sense of Eq. 4.) is shown. The larger the symbol, the closer is the radial point to the galaxy's center.

The analysis shows that the accounting for the rotational support leads the local $\mathrm{Mg}_2(r) - \log\sigma(r)$ relation for all S0s to become like that for the ellipticals. In Fig. 3. we present the diagram $R(r)$ vs. $S(r)$. The coefficient η has been determined for all lenticulars taken together by variation of $S(r)$ in order to achieve

$$\sum_r \left(R(r) - S(r)\right)^2 = \mathrm{Min}. \tag{4}$$

The result of this analysis is shown in Fig. 4. There the relation $Mg_2(r)$ vs. $\frac{1}{2}\log(\sigma^2(r) + \eta V_{\rm rot}^2(r))$, which accounts for the local rotational support $S(r)$ to the total kinetic energy, is presented for the profiles of all 9 S0 galaxies studied by us. The mean value of $\eta \approx 1/2$ is derived.

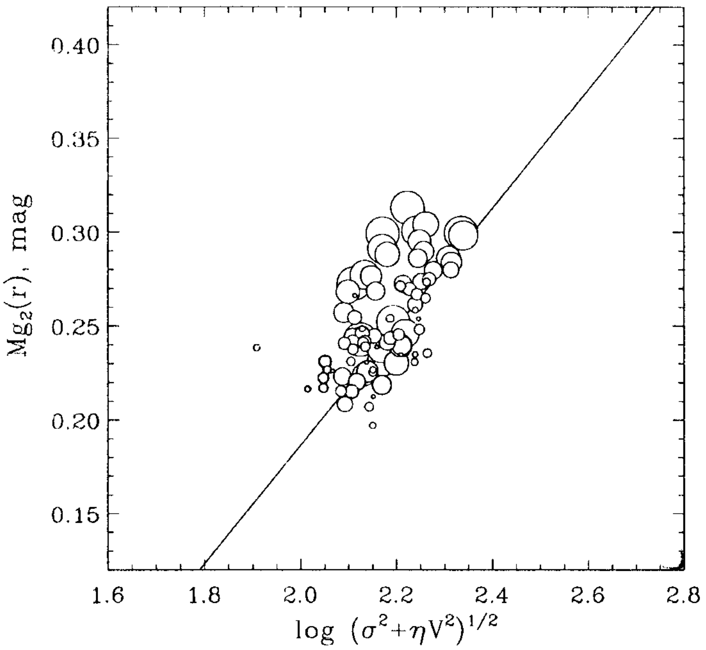

Fig. 4. The relation $Mg_2(r)$ vs. $\frac{1}{2}\log(\sigma^2(r) + \eta V_{\rm rot}^2(r))$ for the profiles of all 9 S0 galaxies which accounts for the local rotational support $S(r)$ to the total kinetic energy. The mean value of $\eta \approx 1/2$ is derived. As before, the larger the symbol, the closer is the radial point to the galaxy's center.

5. CONCLUSION

We have investigated the local $Mg_2(r)$ vs. $\log\sigma(r)$ relationship of 9 typical elliptical and 9 typical S0 galaxies. The two relations, for E and S0 galaxies, are significantly different.

The contribution of the rotation to the local potential, or rather, to the local potential *at the time* of star formation bulk, could provide an explanation of this difference. This would mean that the disks of S0s are both old and have a high metallicity. But the values of η derived by us are yet phenomenological only and need to be discussed in the framework of precise dynamical models.

Nevertheless, the qualitative difference between the local $Mg_2(r) - \log\sigma(r)$ relationship of S0s and ellipticals may still be compatible with a model of dissipative quasi-simultaneous formation of the disk and the bulge.

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STELLAR ASSOCIATIONS IN NGC 6946

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Abstract. A catalogue of 41 OB associations in NGC 6946 is proposed. The distance to the galaxy is derived (about 6 Mpc) from the mean size of the stellar associations.

1. INTRODUCTION

NGC 6946 is a Scd type galaxy (Tully 1988) with two well pronounced spiral arms. The distance to it is 5.5 Mpc (Tully 1988). The spiral arms are dominated by significant number of stellar groups and HII regions. The stellar associations in NGC 6946 are not yet identified. However, this galaxy is a suitable object for identification of OB associations.

2. OBSERVATIONAL DATA

The CCD observations were made on October 9, 1990 in the standard photometric system BVR. The size of the CCD chip is 512 x 512 pixels, one pixel corresponding to 0.61 x 0.81 arcsec. The exposure time in each filter was 900 sec. The stellar associations were identified by means of PCVISTA image processing programs for IBM-PC (Trefferes and Richmond 1989). We located 41 stellar groups that are more than 3σ brighter than the local background. The calibration curves were constructed using the CCD photometry of the open cluster NGC 7790 (Cristian et al. 1985). The mean errors of our calibrations are 0.13 in B, 0.02 in V and 0.05 in R-passband. The integral magnitude V and the integral colour index V-R were obtained for each group.

The contents of Table 1. are as follows: Column 1 gives the sequential number of the associations (see Fig. 1) arranged by increasing right ascension. Columns 2 and 3 give the equatorial coordinates of the associations. Column 4 gives the size of the association in arcsec. Column 5 gives the number of member stars. Column 6 gives the designating number of the HII region(s) which coincide(s) with the association.

3. DISCUSSION

The seeing of our observation (2 arcsec) enables discrimination between blue stars in stellar associations and foreground Galactic stars. The mean visible size of the associations depends on the distance to the galaxy. It is difficult to demarcate their boundaries in a remote galaxy due to resolution problems.

Table 1. Stellar associations in NGC 6946.

No	R.A. 1950	Dec. 1950	V	V-R	SIZE	Nst	No of HII ident.
1	20 33 19.8	60 0 13	20.22	2.90	2.4	3	605
2	20 33 21.3	60 0 17	19.05	1.33	4.1	5	597
3	20 33 22.6	60 0 25	18.37	1.86	4.1	4	589
4	20 33 28.6	59 58 5	15.86	0.96	5.1	5	541
5	20 33 31.7	60 0 60	19.97	1.79	2.0	4	524,525
6	20 33 32.5	60 1 7	18.84	1.19	2.4	4	518
7	20 33 33.6	59 57 55	19.15	0.38	2.4	4	495
8	20 33 33.7	60 1 21	18.41	1.66	5.1	7	501
9	20 33 34.5	59 59 13	16.69	0.39	3.0	3	497
10	20 33 36.3	59 58 51	18.47	2.15	1.6	3	471
11	20 33 45.0	59 57 31	19.72	1.94	3.0	5	386
12	20 33 45.3	60 0 15	16.66	0.88	2.4	5	393
13	20 33 45.7	59 57 54	18.46	1.66	4.1	4	377
14	20 33 46.4	59 57 36	19.04	2.12	3.0	5	376
15	20 33 47.5	60 2 17	20.28	1.76	2.0	3	371
16	20 33 47.8	59 57 21	18.45	1.48	4.1	3	354
17	20 33 48.5	59 59 57	18.63	1.12	2.0	4	-
18	20 33 48.7	60 2 17	20.33	2.32	2.2	4	-
19	20 33 48.8	59 57 3	18.36	1.55	4.1	3	342
20	20 33 50.0	59 56 50	17.88	1.49	4.1	7	324
21	20 33 50.0	60 2 22	16.33	1.19	4.1	7	334
22	20 33 50.9	59 56 55	16.74	0.91	4.1	5	324
23	20 33 51.5	60 0 6	18.37	0.51	1.4	3	313
24	20 33 51.6	60 0 15	17.33	1.17	1.2	3	299,314
25	20 33 51.8	59 57 17	18.67	1.49	2.8	3	293
26	20 33 53.1	60 2 23	17.73	1.02	1.0	3	290,301
27	20 33 53.2	60 0 31	17.63	1.11	3.7	5	288
28	20 33 54.7	60 0 26	16.65	1.02	4.1	7	277
29	20 33 56.5	59 58 1	18.80	1.55	7.1	8	247
30	20 33 56.6	59 58 23	17.95	1.01	4.1	5	250
31	20 33 58.7	59 58 39	17.51	0.63	4.1	5	234
32	20 34 0.7	60 0 32	19.76	2.04	1.2	3	215
33	20 34 2.2	60 0 30	17.83	1.21	3.0	5	181
34	20 34 3.5	60 0 35	16.63	1.36	2.4	4	174
35	20 34 5.5	60 0 49	17.90	1.33	3.0	5	170
36	20 34 6.3	59 59 8	17.17	1.56	3.5	5	159
37	20 34 7.7	59 58 55	18.47	1.54	3.0	5	148
38	20 34 8.2	59 58 33	18.46	1.92	2.0	4	138
39	20 34 9.0	59 58 38	18.56	1.88	3.0	5	124
40	20 34 9.0	59 58 48	18.23	1.81	5.1	7	136
41	20 34 9.5	59 58 11	18.37	2.18	3.5	4	119

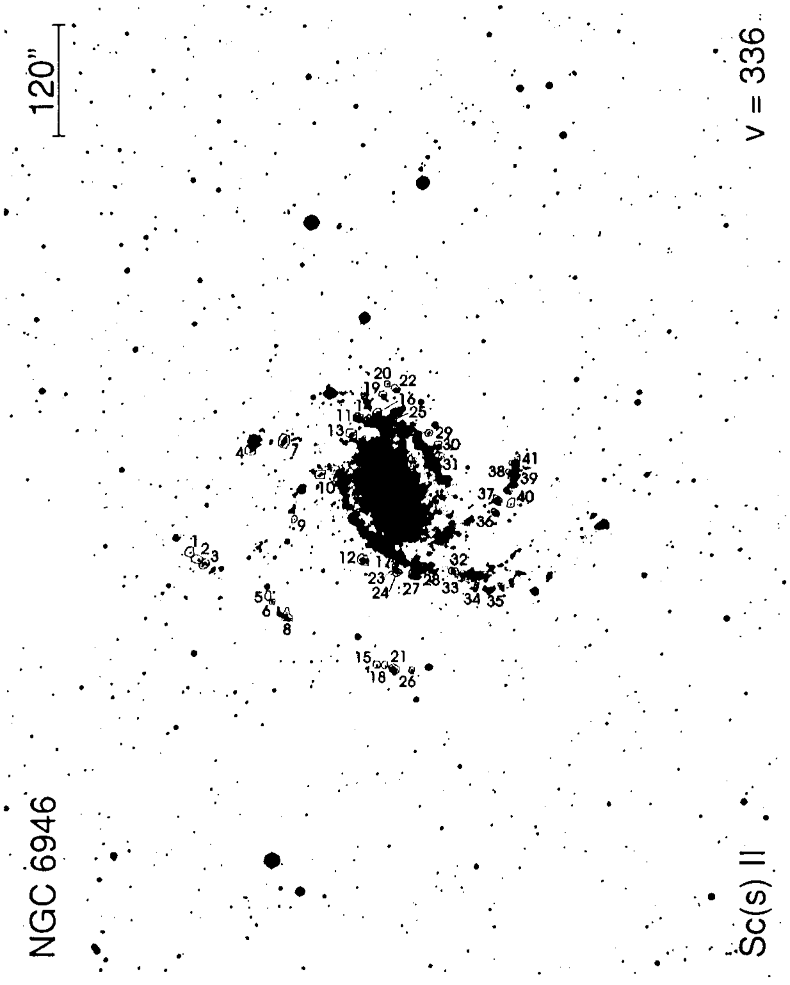

Fig. 1. Stellar associations in NGC 6946.

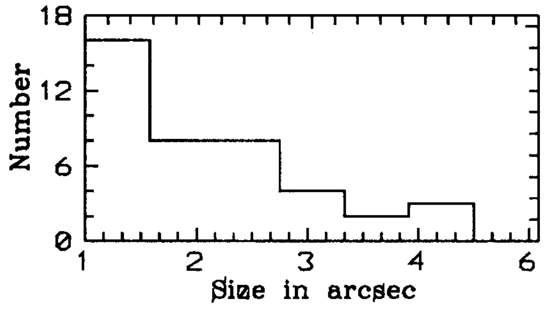

Fig. 2. Size distribution of the stellar association in NGC 6946.

Some of our stellar groups exhibit two or three cores which are resolved into stars. In that case, one deals perhaps with two or more sub-associations. The size and the number of member stars of the studied groups are typical for the stellar associations. Part of the associations are located in severely crowded regions of the spiral arms. In order to test if these are real associations, we performed visual inspection of the Atlas of Sandage and Bedke (1988) and found evident similarity between the selected stellar groups and those identified as OB associations in other nearby galaxies like Magellanic clouds, M31 and M33. Therefore one has to classify them as OB associations.

The size of associations was measured on our CCD frames as well on the maps of Sandage and Bedke (1988). It seems that the seeing of the Atlas is the same as that of our observations. We compared the locations of the associations with those of the HII regions studied by Bonnarel et al. (1984). The majority of the HII regions are ionized by cluster of OB stars in associations and not by a single O star. When the distance to a galaxy is more than 5 Mpc, the stellar clusters could not be resolved into stars. However, the size distribution of our objects shown in Fig. 2. is typical for the stellar associations. Thus the OB associations probably can not be mistaken for other groupings like aggregates and star complexes whose size distributions have their maximum shifted toward larger sizes. The mean size of the aggregates and of stellar complexes is respectively three and ten times larger than that of stellar associations (Ivanov 1987). Supposing that the mean size of a stellar association is about 80 pc (Ivanov 1987), one could obtain the distance of the galaxy. The size distribution of the associations identified with 6 m telescope is shown in Fig. 2. The mean size is 2.9 arcsec which gives a distance to NGC 6946 of about 6 Mpc. This estimate is close to the value from the catalogue of Tully (1988).

Acknowledgements

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2800 MHz SOLAR FLUX AND SAVA RIVER FLUX

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Abstract. The investigation by applying the spectal decomposition theorem to the solar activity impact on the Sava river flux at one station, followed by crosscorelations, indicated that there is an eight year lag between the solar radiation at 2800 MHz maximum and the maximum of the Sava river on the one hand, and, on the other, an eleven year lag between the solar radiation minimum and the minimum minimorum of the river flux. Chi-square test and the Kolmogorov-Smirnov test have been applied for evaluationg the sesults obtained.

1. INTRODUCTION

Looking for better correlation, I started with the total sunspot areas, total areas of sunspot umbrae, total areas of sunspot penumbrae, total areas of faculae, ending with 2800 MHz solar radiation. Then I used series for different rivers' levels, ending with river flux/flow, as a better parameter for water abundance or lack on it[1] to [20].

Experience has shown that all above listed values have an oscillatory character.The water has a basic importance in everyday's life, agriculture, industry, economic planing etc. An exact prediction of its quantity could be of an enormous benefit in general. But, today, the science does not exactly know the mechanism of the hydrologic cycle.One may only suppose what are the causes of many phenomena occurance. Therefore a statistical or a probability analysis may be of some help. So, I will use the solar radiation of 2800 MHz as a promoter of Sava river flux.

2. ATA CHOICE, DATA AND DATA PROCESSING

J.-C.Pecker (1987) confirmed my opinion that the simultaneous usage of data, observed at several stations along a river, in the case of solar – terrestrial influence study, can lead to distortion instead of correlation improvement. Therefore, I took only data recorded at one station on the bank of river the Sava.

Following data notations have been used:

Time series for SOLAR ACTIVITY (yearly means)::

OTTA – SOLAR RADIO FLUX AT 2800 MHz (10.7 cm) from the entire solar disc, corrected to within a few percents for factors such as: antenna gain, atmospheric absorption, bursts in progress, and background sky temperature, in units 10^{-22} Joules/second/square meter/Hertz. Each number has been mutliplied by 10 to suppress the decimal point; published by the National Geophysical Data Center, Boulder, Colorado, USA.

Time series for SAVA RIVER FLUX (yearly means)::

SMQV – MAXIMAL SAVA RIVER FLUX, expressed in m^3/s,
SMQN – MINIMAL SAVA RIVER FLUX, expressed in m^3/s.

At my disposal, I had OTTA series since the year 1947 to 1997 (daily observations), and Sava river flux series starting by the year 1931 until 1996 (monthly means).

The computer processing programme, for technical reasons, limited my investigation to the section between 1947 and 1996.

I applied, for periodogram construction, the so-called SPECTRAL DECOMPOSITION THEOREM, which states that the energy, or variance, of any time series can be broken down into contributions of statistically independent oscillations of different frequencies (periods). Each peak in the periodogram stands for a harmonic. The most outstanding one is called the MAJOR FREQUENCY (PERIOD), and the following ones are HIGHER HARMONICS, or OVERTONES.

Looking for paired up independent oscillations, with the same periods (frequencies), has been performed.

The next assumption was that we have to do with two stationary time series. X_t, and Y_t, and that we wish to asses the extent to which we can use the past of X_t, to predict Y_t; cross-correlation values, between solar radiation and the respective maximal, minimal river flux have been calculated.

Fourier series residuals have been calculated for significance level evaluation. Next, a comparision of such frequency histogram with normal distribution function has been constructed. Chi-square test has been carried out, and, in conclusion the Kolmogorov-Smirnov test has been used as one more significance evaluation.

3. RESULTS

The periodogram for the OTTA 4786 series shows five peaks – five independent oscillations. The major period has 10 years (91.64%), the first overtone has 5 years (3.49%), the second overtone has 3.08 years (1.86%), the third 2.11 years (1.55%), and the fourth 2.5 years (1.45%).

The periodogram for SMQV 4887 series has seven independent oscillations. The major period has 3.63 years (21.44%), the first overtone 5 years (15.36%), the second 2.35 years (15.34%), the third 8 years (13.60%), the fourth 2.11 years (13.27%), the fifth 40 years (13.25%), and the sixth 13.3 years (7.73%).

Comparing the listed periodograms for OTTA and SMQV series we see that there are two independent oscillations in the later corresponding to two of the formar. The first overtone of OTTA has it response in the first overtone of the SMQV, and the third overtone of the first series has its response in the fourth overtone of the second series. 5.45% of the radiation influences 28.63% of the Sava river maximal flux.

The cross-correlation analysis shows that there exists a eight years lag between OTTA and SMQV series (STATGRAF programme).

The highest cross-correlation value corresponds, as we mentioned before, to the eight years lag in the case OTTA 4786 versus SMQV 4887. So, 2800 MHz solar flux influences the MAXIMAL SAVA RIVER FLUX/FLOW, meaning that *maximal Sava river flux may follows, with an 8 year lagging between, the maximal 2800 MHz solar flux.*

Chi-square test for two of seven frequencies of SMQV 4887 series gives the value 5.107141 with 1 degree of freedom and a significance level p=0.0238342.

The Kolmogorov-Smirnov test gave a value of d=0.1000000 with no significance.

The periodogram for SMQN series has again seven peaks – seven independent oscillations. The major period has 3.63 years (25.53%), the first overtone 2.35 years (22.29%), the second 5 years (16.56%), the third 8 years (13.54%), the fourth 40 years (12.25%), the fifth 3.08 years (8.96%), and the sixth 13.33 years (0.88%).

We see, comparing the cited periodograms of OTTA and SMQN series, that they have two corresponding oscillations. The first overtone of OTTA has its response in the second of the SMQV series, as well as the second overtone of the first has its response in the fifth overtone of the second series. 5.35% of the solar radiation influence 25.52% of the Sava river minimal flux.

By means of cross-correlations we found that there exists a lag of eleven years between OTTA and SMQN series.

Cross-correlations have their highest value against eleven years lag in the case of OTTA 4988 versus SMQN 4988. So, 2800 MHz solar flux influences the minimal SAVA RIVER FLUX/FLOW, meaning that *minimal Sava river flux may follow, after an 11 year lagging between, the maximal 2800 MHz solar flux.*

Chi-square test, for two of seven independent frequencies, gives the value 0.4247530 with 1 degree of freedom and a signifiance level p = 5145796.

The kolmogorov-Smirnov test shows a value of 0.0250000 with no significance.

4. CONCLUSION

The spectral decomposition theorem, according to constructed periodograms and after corresponding cross-correlations calculation, for the index of solar activity, known as ADJUSTED 2800 MHz SOLAR FLUX, radiating from the whole solar disc, corrected within a few percents, for antenna gain, atmospheric absorption, bursts in progress and background sky temperature, expressed in units of 10^{-22} Joules/second/square meter/Hertz, OTTA series, at one hand, and maximal Sava river flux, SMQV series, expressed in m^3/s, observed on one station, on the other hand, entitles us to announce that, in statistical sense, the solar activity may influence, with the accuracy given, the MAXIMAL (MAXIMUM MAXIMORUM) SAVA RIVER FLUX, with eight year lag, and the MINIMAL (MINIMUM MINIMORUM) SAVA RIVER FLUX, SMQN series, after a lag of eleven years.

We must, at this place, turn our attention to the fact, mentioned in Jovanović, B.D. (1993c), that maximal Sava river flux followed the maximum of Greenwich total sunspot areas by a seven year lag, supported by a better fitting.

EXPLANATION. To avoid eventual misunderstandings we must add that the river flux has several maxima and minima during a year, but, our maximum maximorum is the greatest one that occurs once in several years, as well as minimum minimorum is the smallest minimum which occurs once in a longer period of years.

Acknowledgement

I am deeply indebted to my colleague Dr. Emilija Nikolic-Djoric, who in this case, as well as in previous ones, lent me her unselfish help in statistical evaluation.

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WHAT HAS BEEN REPORTED ON ASTRONOMY IN THE SERBIAN MAGAZINE "JAVOR" (MAPLE) [1862 - 1863, 1876 - 1893]

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Abstract. The Serbian magazine "JAVOR" (MAPLE) was taken at random to show that in the XIX century there has been, among Serbs, a vivid interest in Astronomy.

0. THE MAGAZINE ITSELF

This review started with a subtitle "Magazine For Amusement And Instruction". In the second period "And Literature" has been added. Publishers were: Zmaj Jovan Jovanovic (1862 -1863), Kosta Trifkovic (1874 - 1875), Luka Jocic (1877 - 1889) and Jova Karamata (1893). The editors were: Dr. Ilija Ognjanovic (1874 - 1892) and Danilo Zivaljevic (1893). It has first been published biweekly, and from the year 1877 on, weekly. We will narrow our attention only to one science – to Astronomy, and we will analyze the published material accordigly. If there is only one data, it is a Julian; and if there are two data the first is Julian and the second is Gregorian.

1. THE SOLAR SYSTEM IN GENERAL

THE EARTH. V. Mladenovic, using Dr. Klein's article, writes "SINCE WHEN EXISTS OUR EARTH" [1]. Among several geological methods the author uses for calculation in one involving the precession of equinoxes. The other astronomical expedient was the Laplacean cosmological theory. The final result was approximately four billion years.

"WHAT WILL FINALLY BE WITH OUR EARTH?" [2] is a short notice on deceleration of the Earth rotation. Mercuty, Venus and Earth will fall onto the Sun. After that, due to Sun's rotation, new planets will be formed.

The earthquakes are caused by the influence of the Sun and Moon [3]. The credit for this idea has been attributed to Prof. Rudolf Falb. But a year later [4] David Milankovic, uncle of our famous scientist Milutin Milankovic, proves that Milutin's great uncle Uros Milankovic was the first who mentioned this idea.

"*THE MOON* AS A CELESTIAL BODY" [5] is a detailed description written by Svetislav Kolarovic; starting with its apparent motions among stars, revolutions, rotation, eclipses, surface formations, continuing with imaginary sights from it, its influence on Earth (tides, eventually climate, ending with popular beliefs), its surface temperature, "days" and "nights", seasons, nonexistence of atmosphere, as well as twilight and dawns, phenomena during occultations, lack of water (reasons for this), blackness of its sky, nonexistence of living creatures, ending with eventual possibility to reach and settle on it, adding the necessary time for, at that time, known vehicles.

In the article "THE SEA" [6] Pavle Padejski describes the reasons for the appearance of tides on Earth, mentioning Newton's law of gravity.

A short notice "THE MOON AND ITS INHABITANTS" [7] considers: the distance Moon-Earth, the surface configurations and their shadows, Edmund Neison's ebservation of the changes in shape of the Linnee's crater, and supposes that there may be some living creatures.

"MOUNTAINS ON THE MOON" [8] considers their number and their height.

THE SUN. Andrija M. Matic (Professor at the Great Gymnasium of the Serbian Orthodox Parish in Novi Sad, comment B.D.J.), using German sources wrote "WHAT IS THE SUN MADE OF AND HOW IT DOES ITS JOB?" [9]. He describes the Sun's size, its influence on terrestrial phenomena, the historical progress of human thought on the subject, the chemical composition, its gaseous atmosphere, chromosphere, prominences, spots, incrustation of its surface, and its cooling, as a consequence.

Another essay on the same subject has been published under the title "WILL THE SUN GET COOL AND WHY?" [10].

P.V. Vujic translated "COOLING OF THE SUN", written by Dr. K. Prell [11]. Some calculations are given how long could the Sun emit such an amount of energy if it is built of different materials. One of consequences would be a shrinking of its dimensions. Some theories on genesis of sunspots are cited.

The result of the investigations of the physicist Dr. O. Froehlich, from Berlin, is reported in the notice "THE TEMPERATURE OF THE SUN IS CHANGING" [12].

In the long article "ON THE SOURCE OF MOTIONS ON OUR EARTH" [13], Todor V. Jovanovic reports on influence of solar radiation on terrestrial phenomena, such as earthquakes, wind, rain, sea currents, tides, warmth, etc.

MERCURY has been described in "THE NEAREST NEIGHBOUR OF THE SUN" [14], by Andrija M. Matic. After a historical introduction the author mentions the discrepancy between theoretical and observed data, the transit across the Sun's disc (on 7th May 1878), the possibility of existing of a new planet nearer to the Sun which was named Vulcan, on observations during the eclipses of the Sun.

VENUS. Andrija M. Matic, wrote a thorough forecast of a very interesting phenomenenon: "TRANSIT OF THE PLANET VENUS (OVER THE SUN) ON 9th DECEMBER 1874" [15]. After a review of the event mentioned he said that the same was in the year 1769, will be in 1882, and that the next occasion will be in 2004! He explained the reasons for that, and mentioned that the same may occur with the planet Mercury. The benefits are listed. At the same time the laws of movements of planets have been explained. It ended by a description of an expedition to Tahiti for observing the transit of 3rd June 1769.

MARS. Andrija M Matic wrote about the "WAR PLANET (MARS) ACCORDING TO THE LATEST INVESTIGATIONS" [16]. Historical introduction is followed by the description of how were his satellites discoverd by Asafh Hall in the previous year, its surface features, winds, atnosphere, polar caps, his age and the possibility of existence of life.

Another writing, "MARS" [17], by the same author, according to Dr I. Pallis, contains the latest data on this planet.

PLANETOID (asteroid or small planet) Nr. 250 has been discoverd on 22nd August 1885 as a "star" of eleventh magnitude. Its position was, at 11^h, 353°40' in right ascension and 16°10' in declination [18].

"PLANET *JUPITER* AND ITS WORLD" [19], again by A. M. Matic, portrays this planet from the earliaest days of observations, its size, its distance, rotation, revolution, satellites, their eclipses by the planet, characteristics in general, its appearance in small telescopes, its atmposhere, its chemical composition.

VULCAN. A short notice [20] announces that astronomer Watson, following Leverrier's instructions, discovered the new planet named Vulcan (!?!).

2. STARS

"ON THE AGE OF STARS" [21] is a report on the lecture given by Pier Julies Cesar Jansen in Paris in 1887. He stated, that according to the results of the spectral analysis, all stars are composed of the same elements which may be found on Earth. One may determine the temperature and the state of evolution of the stars.

"HOW MANY STARS ARE THERE?" [22] states that in the entire clear sky there are about 6000 stars, but we are not able to see them all because a part of them is below our horizon. Therefore we see approximately only 3000 of them. But fog, water vapour and other impurities limit their number to near 2000. Using small telescopes we may see up to 600.000. By means of the latest of them, then known, up to 60.000.000 are visible.

"THROUGH THE WORLD OF STARS" [23] has been written by Sophus Tromholz, translated by Z. D. Vladic in Vienna, is a thorough excursion from Sun to the farthest then known stars. At that time the expression "star" has been used for real stars as well as for planets. Starting by explaining the distances, and how they may appear to the ohservers (to see the star which does not exist any more), their number, apparent magnitudes, double and mutiple stars, imaginary view of the sky on a star (planet), star clusters, by Milky Way, finishing by their structure and composition of nebulae.

3. COMETS

These celestial objects excite a great interest among the people, so, I separated them from their natural place, the Solar system. Svetislav Kolarovic, professor at the Orthodox Great Gymnasium in Sremski Karlovci, wrote a long and detailed article "COMETS "[24]. Historical view, followed by the criticism of superstition, describes what their orbits look like, explaining characteristics, their number, shape, mass, conditions for apparition of their tails, comae, nuclei, their structure, extensions; cites theories on their origins through the history, contens the possibility of existence of living creatures on them, and, tells some anecdotes.

Short notes announce apparitions, or describe the comets seen earlier. [25] concerns one seen before, from 22nd September 1807 to 27th March 1808, registered again on 1st June 1881 (1881 III or 1881b); [26] is devoted to the same , but with more details. (1882 I or 1882b) has been noticed [27] on 6th /18th March and it should be seen from our regions approximately before 21st May/2nd June. It is expected to have an expanded tail, which will be seen also by daylight [28]. (1882 II or 1882d) has been described in [29] noticing that its period is about 730 (exactly 760.9) years. The next one is (1885 III or 1885c): "...on 22nd August at 8^h 26^m its right ascension was 206°, and its declination 37° 6' N, and the magnitude m=9 [30]. The comet (1887 I or 1887a) has been discovered in Cordoba on 18th January [31]. Its tail extended approximately 30°.

4. METEORS, METEORITES AND BOLIDES

One more group of object of public interest, and for that reason again separated from Part 1. were meteors, meteorites and bolides.

P.V.Vujic translated the article "METEORITES" written by K.Prell [32]. He describes the structure, chemical composition, movement through the terrestrial atmosphere, origins, similarities with volcanic ejections, finding of organic material , so, that there, maybe, exists some sort of life in the space, including the hypothesis that they might be products of cosmical decompositions.

Another writing on the same subject [33] deals with origins of life on Earth and discusses the posibilities of its coming from the outer space. Describes their appearence, structure, sorts, chemical and cristalline composition, volcanic (from other celestial bodies) origin, traces of organic material (due to crystals and pseudomorphosis of some minerals). It closes by mentionig chondrites.

Under the title "STARS ARE FALLING" S. M. (Stevan Milovanov?, professor at the Great Gymnasium of the Serbian Ortodox Parish in Novi Sad) [34] mentions the meteor showers on the nights between 21st and 22nd April, 10th and 12th August, 12th to 14th November and 27th and 28th November, citing the historical data, how far they are visible, how long they shine. In the conclusion states that many astronomers connect their aparition with comets and their remains. Their shining comes from the friction with molecules of atmosphere.

Again some short notes inform the readers about intersting events. So [35] is a letter from Belgrade which describes a bolide which fall in the begining of October 1877 near Aleksinacka Banja. A note by the editor completes the writing. A report about the session of the Governmental Geological Society in Vienna, of 24th December 1877, sais [36] that the just referred to was a chondrite.

The people in Cetinje, observing the blue, violet and red sparks in the sky, between 7 p.m. and 8 p.m. on 24th September 1885, thought that it was a firework [37], but after that a thunder has been heard about five seconds. Its height could be about ten thousand meters in NE direction. It has been visible from Bar, Ulcinj, Rijeka, Vir and Podgorica.

On 15th/27th November 1885 again a meteor shower was seen [38]. The author in "THE FALLING STARS", connects them with comets - the former are firm, and the latter fluid remnants (ascording to H. W. Olbers). The paths are elliptical around the Sun. Reaching our atmoshere they start glowing. Some historical data are cited.

In the district of Cacak on 19th November, at $2^h\ 30^m$ [39] a powerful explosion, which lasted about two minutes, has been heard. There were numerous pieces, some of them weighting about three kilograms. No lightning has been observed. The chemical composition is cited.

In Russia, in Cherson district, an aerolit fallen in 1890. In its middle there was an organic matter composed of carbon and some resin [40].

5. LIVING CREATURES IN THE COSMOS

Our ancestors were curious too, as we are , to know: "Are we the only ones belonging to organic features in the Universe?". G.A. Hirn wrote "ON WHICH STARS

THERE MAY BE INHABITANTS" (translated again by S. (tevan) M. (ilovanov)?) [41]. The author mentions the views of B. Fontenelle, H.K. Oersted, N. C. Flammarion, C. Pouillet, Langley and discussed arguments pro et contra. Especially considers the Moon. In conclusion he cites the conditions for life: a) water in liquid state, b) average temperature over 0° C, c) existence of an atmosphere suffincently dense to preserve that body not colder than 0° C. One condition more is that this celestial body must have a central star, a sun, which emit to it light and warmth.

There are again short notes on the same subject such as "ARE THERE IN STARS LIVING CREATURES?" [42]. A certain Dr. Hahn examined some meteorites and found remnants of corals. The editor hopes that these results will be proved and that in the space there are some organic creatures.

Another notice is "ARE THERE ON PLANETS LIVING CREATURES?" [43]. "On the Moon there is no life. Mercury is unknown to us. On Venus we know only that there is no atmosphere. Uranus and Neptune we hardly know. Jupiter and Saturn have no firm crust. Mars is the only one, for which we may assert that life on it is possible, because there the physical conditions are similar to those on Earth, but are there some living creatures, and of what kind, nobody knows".

6. CALENDAR

Dimitrije Ruvarac describes "SLAVENO-SERBSKIJ MJESJACOSLOV ZA 1792 GODINU" (Calendar For The Year 1792) [44]. We will focus our attention on the astronomical part of it. "Astronomical forecasting for the leap year 1792" includes: On winter, On the reiging planet, On spring, On Summer, On autumn, On eclipses.

Prof. Andrija M. Matic wrote "CORRECTION TO OUR CALENDAR" [45]. That is a commentary on the letter to the Patriarch of Constantinople, written by Serbian Metropolitan Mihajlo proposing the election of a council for correcting of the Julian calendar according to astronomical data. The historical facts on both calendars are cited, and their errors are given. J.H. Maedler's proposal was recommanded. Namely, after each 128 years one must omit a leap year.

Dimitrije Ruvarac recommends "HOW ONE MAY IN THE EASIEST AND FASTEST WAY RELIABLY FIND THE WEEKDAY OF A GIVEN DATE?" [46], with worked out examples.

7. HISTORY OF ASTRONOMY

In this case we will follow the chronological series of events. "A SERBIAN EXPERT" [47] informs the reader, inter alia, that "In the year 1404 a monk from the Mons Athos named Lazar, a born Serb, made in Moscow, at the court of the great duke Vasilij Dimitrovic, the first tower clock which struck hours".

Marko Car desribes the life and work of "GIORDANO BRUNO" [48].

The merits and troubles of "GALILEO GALILEI" are reported in two parts [49].

An anecdote on "ISAAK NEWTON AND A SHEPARD" recorded his ignorance of meteorology [50].

The celebration of the centennial of the death of Rudjer Josif Boskovic took place in Beograd on 10th February 1887 [51]. A communication describes his life and the programme. It included a performance, in one act, "A Day In Life Of An Astronomer" written by Jean Mirvole, describing the strugle of Johann Kepler's scientific work against astrology.

Another report of Jozuf (sic) R. Boskovic [52] was written by Hadzi Rizvan. It gives some details on scientist's origins.

The article by A. Bernstein"WHAT MIRACLES WILL THE ASTRONOMY DO" [53] was translated by Vaso T. Gavrilovic (who died as a student of philosophy, and who translated the book "Some Facts On The Life Of Earth And The Velocity Of Light" by A. Bernstein and "From Earth To The Moon And Around The Moon" by Jules Verne, etc) gives a complete picture of work done by Urbain Jean Joseph Leverrier on discovering the planet Neptune.

A short note communicate that KARLO LITTROW [54] died at the age of 67. He was the son of Joseph J. Littrow, after whose death in 1842, he became director of astronomical observatory in Vienna.

Under the title "THE WORK OF RUSSIANS IN THE SCIENTIFIC FIELD [55], among others the role of Fjodor Aleksandrovic Bredihin, in exploring the comets, especially of their tailes, was mentioned.

A necrology on the passing away of Dr. Djordje (Georgije) Maksimovic [56] was published. Living as a city doctor in Sombor he had hobbies: meteorology and astronomy.

8. MYTHOLOGY

Pavle Padejski wrote an article on "MYTHOLOGY AMONG ANCIENT SLAVS" [57]. He discusses the roots and the etymology of names. The sky with Slavs was a round rock. The God divided it into halves, the one he took in his right and the other in his left hand - the latter was given to the devil. One may suppose that the word "nebo" has been taken from Sanskrit "nab hasea", or from the Aryan "nebo, nabo". The son of the highest god Svarog was Dazbog - benefactor, the Sun itself. Rugevit or Ranovit had seven faces and seven swords; he has been taken as a god of summer Sun. At the same time when a baby is born, in the skies there appears a star. It is not good to look for it because if he by chanse catches on it, the star falls and he dies.

9. COSMOGONY

Following German sources Svetozar Stamatovic wrote "THE HISTORICAL DEVELOPMENT OF THE WORLD NOTION" [58]. It is a detailed historical essay starting with Greek philosophers (Homer, Thales, Platon, Aristotheles, Eudoxos...), then over medieval scientist (G. Purbach, N. Copernicus, Tycho de Brache, J. Kepler, ...), concluding with modern ones (C. Huygens, I. Newton, G. Galilei, W. Herschel). Their views have been described.

A reviews of the book 'THE STUDY OF SOCIOLOGY' by Herbert Spencer, Henry S. King & Co, London, 1874, was published [59]. It concerns the thoughts of A. Humboldt and J. Herschel on origins of the solar system.

One more writing by S(tevan) M(ilovanov?) is "HOW THE WORLD SYSTEM ORIGINATED" [60], again following German sources. The hypotheses of Woodward, Burnet, Leibnitz, Whiston, Buffon, Franklin, Lichtenberg, Newton, Laplace, Plateau, Faraday, and some experiments performed by them, were described. As we may see the main attention has been paid to the XVIII century.

"NEW OPINIONS ON THE WORLD GENESIS" [61] written by Dobroslav M. Ruzic. He communicates on earlier coclusions of scientists, how the life may have come to the Earth. Cited were, Thomson, Hahnstein, Chladni, Hahn, Preiss, Darvin, Weinland, Jaeger and their works.

Ideas of P. Tunch, N. Lockyer, Nitzelnadel and others were reported in "WHAT DO THE SCIENTISTS SAY ON THE DESTRUCTION OF THIS WORLD?"[62] by M.D.D.(ejanovic?). One of reasons may be an explosion of a star (according to the event in November 1572). Another is a gigantical body travelling through tha space. The last one is the "falling" of the Earth on the Sun as a consequence of gravity.

10. BOOK REVIEWING

_In the year 1880, the printing shop of Arsenije Pajevic, edited in Novi Sad the translation of the N. Lockyer's "ASTRONOMY"[63], by Djordje Natosevic. M Petrovic gave a thorough description of the contents. Particular value of this book is a plenty of Serbian names of celestial bodies, constellations and terminology used.

11. ASTRONOMICAL INSTRUMENTS

"A NEW TELESCOPE", [64], is a notice on a new instrument. Sir Henry Bessemer installed it in his home, on Denmack Hill, by means of which he will be able to read newspapers in Crystal Palace, in London, at a distance of 3.5 miles, so powerful was its construction.

"THE BIGGEST TELESCOPE", [65], has been mounted in California, at an altitude of 1000 meters. The wealthy American, Jacob Licky, built the whole observatory at his expence, but he did not live long enogh to see the institution finished. He made it for the benefit of science

12. ECLIPSES OF THE SUN AND THE MOON.

A.M. Matic announces the "TOTAL ECLIPSE OF THE MOON", [66], and gives details: it will be seen in our county on 15th/17th February 1877. At the same time he gives a description of the whole phenomenon.

In the same year there were two more eclipses. Only the "ECLIPSE OF THE MOON", [67], will be visible in Novi Sad in the night between 11th/23rd and 12th/24th August 1877. The eclipse of the Sun will not be visible from our country.

"THE PARTIAL ECLIPSE OF THE MOON" will be on 16th/28th December 1879. The data are given for Berlin. For Novi Sad one must add 26^m approximately [68].

An "ECLIPSE OF THE SUN" will be on 5th/17th May 1882. In Africa it will be a total, but in our county it should be visible only a partial one [69].

There is a report on the lecture, under the title "HISTORICAL ECLIPSES", [70], given by Prof. Oppolzer, in Vienna. He described eclipses of the Sun, throughout history. After his calculations Christ has been crucified on 3rd April 33. On that day there was, in Jerusalem, a partial eclipse of the Moon, and the Sun apparently covered by clouds, at the time.

"THE TOTAL ECLIPSE OF THE SUN", [71], will be seen on 7th/19th August 1887 in our region, but the beginning will be before sunrise.

In "SCIENTIFIC GAINS OF THE LAST ECLIPSE OF THE SUN", [72], bearing on the one of the 7th/19th August 1887, the author concludes that German, English, French, Italian, American, Belgian and Russian expeditions were sent to several places on the surface of our Earth, where, one expected, that the conditions of observations should be the best. To the great dissapointment on all places clouds, fog, or rain prevented the observations. Only the twilight could be noticed.

16. CONCLUSION

There were several magazines in Serbian in that time. We chose "JAVOR" AT RANDOM. Therefore no one knows what others, of similar kind, contain on astronomical matter. I hope that there will be enough time to page them also.

We may conclude that among the Serbs, there was a vivid interest concerning these natural phenomena, and that the editors paid due attention to. Serbs living in neighbourhood and in Diaspora were always ready to help them in their efforts to communicate the news and explain the Universe scientifically.

There was no sign of maintaining superstitions, such as e.g. astrology, which we experience today, every day, from all sides, in all media!!! What do we, or the authorities, which are obliged to educate the youth, to prevent the spreading of stupidity and the driving crazy our people???

The teaching of Astronomy with the framework of geography and physics is not enough!!!

IT IS THE LAST TIME FOR INTRODUCING ASTRONOMY AS A SEPARATE SUBJECT INTO OUR TEACHING!!! OTHERWISE WE WILL BE GUILTY OF ALL THE CONSEQENCES!!!

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STARK SHIFT OF SEVERAL Kr II SPECTRAL LINES

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Abstract. Stark shifts of thirteen singly charged krypton (Kr II) ion spectral lines have been measured in the linear, low pressure, pulsed arc at 17 000 K electron temperature and 1.65x10^{23} m^{-3} electron density. The measured shift values have been compared to the theoretical data calculated by us by using the modified semiempirical method.

1. INTRODUCTION

For the first time by means of the Goddard high resolution spectrograph on the Hubble space telescope, krypton has been detected in the spectra of the interstellar medium (Cardelli et al. 1991, Cardelli and Mayer 1997) which represents the material from which the young early type stars (as e. g. Ap and Bp type stars where Stark broadening data are of interest) are formed (Leckrone at al. 1993). Moreover, krypton is present in many light sources and lasers as the working gas. If the Stark broadening is the principal pressure broadening mechanism in plasmas (with 10^{22} - 10^{27} m^{-3} electron density), it is possible to obtain from Stark width and shift values other basic plasma parameters as e.g. electron temperature (T) and density (N), essential for the stellar atmospheres modeling. Consequently, the knowledge of the Stark broadening parameters (the width and the shift) of ionized krypton (Kr II) spectral lines is of interest for plasma diagnostic purpose.

In the case of the Kr II Stark shift investigations the available literature is poor. Namely, since the first Kr II lines Stark shift investigation (Mandel'shtam 1962), only one experiment (Vitel and Skowronek 1987) provided reliable Stark line shifts of three Kr II spectral lines. In Di Rocco et al. (1989) Kr II line shifts have been investigated but without a reliable plasma parameter determination so that the comparison with our results is not possible. In this work we will present measured and calculated Stark shift (d) values of fourteen Kr II spectral lines. Stark shift values of eleven Kr II lines were not known before.

Measurements have been performed at 17 000 K electron temperature and 1.65x10^{23} m^{-3} electron density in krypton plasma created in the linear, low pressure, pulsed arc discharge. The d values have been calculated within the frame of the modified semiempirical method.

2. EXPERIMENT

The modified version of the linear low pressure pulsed arc (Djeniže et al. 1991 - Milosavljević and Djeniže 1998) has been used as a plasma source. The working gas was pure krypton at 130 Pa filling pressure in flowing regime. Spectroscopic observation of isolated spectral lines was made end-on along the axis of the discharge tube. A capacitor of 14 μF was charged up to 1.5 kV. The line profiles were recorded using a shot-by-shot technique with a photomultiplier (EMI 9789 QB) and a grating spectrograph (Zeiss PGS-2, reciprocal linear dispersion 0.73 nm/mm in first order) system. The spectrograph exit slit (10 μm) with the calibrated photomultiplier was micrometrically traversed along the spectral plane in small wavelength steps (0.0073 nm). The averaged photomultiplier signal (five shots at the same spectral range) was digitalized using an oscilloscope, interfaced to a computer.

The Stark shifts were measured relative to the unshifted spectral lines emitted by the same plasma and have been corrected for the electron temperature decay. Stark shift data are determined with ±0.0008 nm error at given N and T. The electron temperature was determined from the ratios of the relative intensities of nine Kr II spectral lines with an estimated error of ±9%, assuming the existence of LTE, according to the criterion from Griem (1974). The electron density decay was measured using the well known single laser interferometry technique (Ashby et al. 1965) for the 632.8 nm He-Ne laser wavelength with an estimated error of ±7% . The electron density and temperature decay are presented in Milosavljević et al. (2000) (Fig. 5).

At 20μs and 300μs after the beginning of the discharge, when the Kr II spectral line center positions were obtained, the found electron densities were $1.65\mathrm{x}10^{23}$ m^{-3} ±7% and $0.03\mathrm{x}10^{23}$ m^{-3} ±80% , respectively.

3. METHOD OF CALCULATION

According to the MSE approach (Dimitrijević and Kršljanin 1986) the electron Stark shift is given as

$$d = N\frac{4\pi}{3}\frac{\hbar^2}{m^2}(\frac{2m}{\pi kT})^{1/2}\frac{\pi}{\sqrt{3}}\cdot\{\varepsilon_{\ell_i,\ell_i+1}\mathbf{R}^2[n_i\ell_i,n_i(\ell_i+1)]\widetilde{g}_{sh}(\frac{E}{\Delta E_{\ell_i,\ell_i+1}})-$$

$$-\varepsilon_{\ell_i,\ell_i-1}\mathbf{R}^2[n_i\ell_i,n_i(\ell_i-1)]\widetilde{g}_{sh}(\frac{E}{\Delta E_{\ell_i,\ell_i-1}})-$$

$$-\varepsilon_{\ell_f,\ell_f+1}\mathbf{R}^2[n_f\ell_f,n_f(\ell_f+1)]\widetilde{g}_{sh}(\frac{E}{\Delta E_{\ell_f,\ell_f+1}})+$$

$$+\varepsilon_{\ell_f,\ell_f-1}\mathbf{R}^2[n_f\ell_f,n_f(\ell_f-1)]\widetilde{g}_{sh}(\frac{E}{\Delta E_{\ell_f,\ell_f-1}})+(\sum_{i'}\mathbf{R}^2_{ii'})_{\Delta n\neq 0}g_{sh}(x_{n_i},x_{n_i+1})-$$

$$-2\sum_{i'(\Delta E_{ii'}<0)}\mathbf{R}^2_{ii',\Delta n\neq 0}g_{sh}(\frac{E}{\Delta E_{n_i,\ell_i,n_{i'},\ell_{i'}}})-(\sum_{f'}\mathbf{R}^2_{ff'})_{\Delta n\neq 0}g_{sh}(x_{n_f},x_{n_f+1})+$$

$$+2 \sum_{f'(\Delta E_{ff'}<0)} \mathbf{R}^2_{ii',\Delta n\neq 0} g_{sh}(\frac{E}{\Delta E_{n_f,\ell_f,n_{f'}\ell_{f'}}}) + \sum_k \delta_k \} \tag{1}$$

where the initial level is denoted by i and the final one by f the square of the matrix element $\{\mathbf{R}^2[n_k\ell_k, n_k(\ell_k \pm 1)], \quad k = i, f\}$ being

$$\mathbf{R}^2[n_k\ell_k, n_k(\ell_k \pm 1)] = (\frac{3n_k^*}{2Z})^2 \frac{\ell_>}{2\ell_k + 1}(n_k^{*2} - \ell_k^2)\Phi^2(n_{\ell_k - 1}^{*2}, n_{\ell_k}^{*2}, \ell_k) \tag{2}$$

and

$$(\sum_{k'} \mathbf{R}^2_{kk'})_{\Delta n\neq 0} = (\frac{3n_k^*}{2Z})^2 \frac{1}{9}(n_k^{*2} + 3\ell_k^2 + 3\ell_k + 11) \tag{3}$$

where $\ell_> = \max(\ell_k, \ell_{k'})$, ℓ denoting the angular momentum quantum number.

In Eqs. (1 – 3) N and T are electron density and temperature, respectively, and Φ^2 is the Bates-Damgaard factor tabulated *e.g.* in Oertel and Shomo (1968). Here, $g(x), g_{sh}(x)_{sh}$ and $\tilde{g}(x), \tilde{g}_{sh}(x)$ are the semiempirical (Griem 1968) and the modified semiempirical (Dimitrijević and Konjević 1980, Dimitrijević and Kršljanin 1986) Gaunt factors for Stark width and shift, respectively. The factor $\varepsilon_{kk'} = (E_{k'} - E_k)/|E_{k'} - E_k|$, where E_k and $E_{k'}$ are respective energies of the considered and its perturbing level. The sum $\sum_k \delta_k$ is different from zero only if perturbing levels strongly violating the assumed approximations exist and may be evaluated as

$$\delta_i = \pm\mathbf{R}^2_{ii'}[g_{sh}(\frac{E}{\Delta E_{i,i'}}) \mp g_{sh}(x_{n_i,n_i+1})], \tag{4}$$

for upper level, and

$$\delta_f = \mp\mathbf{R}^2_{ff'}[g_{sh}(\frac{E}{\Delta E_{f,f'}}) \mp g_{sh}(x_{n_f,n_f+1})], \tag{5}$$

for lower level. In Eqs. (4) and (5) subscripts correspond to $\Delta E_{jj'} < 0$; $x_{n_k,n_k+1} \approx 3kTn_k^{*3}/(2Z^2E_H)$, where $\Delta E_{kk'} = |E_k - E_{k'}|$, n_k is the principal, n_k^* the effective principal quantum number, $E = 3kT/2$ and $(Z - 1)$ is the ionic charge.

4. RESULTS AND DISCUSSION

The needed atomic energy levels for Kr III have been taken from Sugar and Musgrove (1991). The results of the measured Stark shift (d_m) values at T=17 000 K electron temperature and 1.65x10^{23} m^{-3} electron density are shown in Table 1. Our theoretical d_{th} values are presented in Table 2.

Table 1. Measured Stark shift (d_m) values for the Kr II lines at the observed electron temperature (T) of 17 000 K and electron density (N) of 1.65 × 10^{23} m^{-3}. Positive shift is toward the red.

Transition	*Multiplet*	λ (nm)	d_m ,(nm)
5s-5p	$^4P_{5/2}$-$^4P^0{}_{3/2}$	465.89	-0.0010
	$^4P_{3/2}$-$^4P^0{}_{1/2}$	483.21	-0.0014
	$^4P_{5/2}$-$^4D^0{}_{7/2}$	435.55	-0.00
	$^4P_{5/2}$-$^4D^0{}_{5/2}$	473.90	-0.0014
	$^4P_{3/2}$-$^4D^0{}_{5/2}$	476.57	-0.00
	$^2P_{3/2}$-$^2P^0{}_{1/2}$	484.66	-0.00
	$^2P_{3/2}$-$^2P^0{}_{3/2}$	461.53	-0.00
	$^2P_{3/2}$-$^2D^0{}_{5/2}$	461.91	-0.00
5s′-5p′	$^2D_{3/2}$-$^2F^0{}_{5/2}$	463.39	-0.0018
	$^2D_{5/2}$-$^2F^0{}_{5/2}$	457.72	-0.00
	$^2D_{5/2}$-$^2P^0{}_{3/2}$	447.50	-0.0017
	$^2D_{5/2}$-$^2D^0{}_{5/2}$	408.83	-0.0017
5p-5d	$^4D^0{}_{5/2}$-$^4F_{7/2}$	377.81	0.0090

Table 2. Stark shift values (d in nm) calculated by using the modified semiempirical method (Eqs. 1-5) for the Kr II spectral lines, at 10^{23} m^{-3} electron density.

		T (10^4 K)			
λ (nm)	1	2	3	4	5
473.90	-0.0101	-0.0074	-0.0063	-0.0058	-0.0056
465.89	-0.0111	-0.0082	-0.0070	-0.0064	-0.0062
483.21	-0.0111	-0.0082	-0.0070	-0.0064	-0.0062
435.55	-0.0083	-0.0061	-0.0051	-0.0047	-0.0044
476.57	-0.0089	-0.0066	-0.0056	-0.0051	-0.0049
484.66	-0.0125	-0.0092	-0.0078	-0.0071	-0.0069
461.53	-0.0104	-0.0076	-0.0064	-0.0058	-0.0055
461.91	-0.0099	-0.0073	-0.0061	-0.0055	-0.0052
463.39	-0.0056	-0.0036	-0.0029	-0.0028	-0.0028
457.72	-0.0091	-0.0066	-0.0056	-0.0051	-0.0049
447.50	-0.0103	-0.0071	-0.0057	-0.0051	-0.0049
408.83	-0.0065	-0.0047	-0.0039	-0.0035	-0.0033
378.31	0.0057	0.0107	0.0134	0.0149	0.0154
377.81	0.0076	0.0128	0.0155	0.0168	0.0172

One can conclude on the basis of the Table 1. and Table 2., that the d_m values are very small. Within the accuracy of measurements (0.0008 nm) many of them were equal to zero. Our calculations give higher absolute d values than the measured ones. Our calculated and measured Stark shift values, in the case of the Kr II lines (Table 1. and Table 2.), have the same sign. For the lines that belong to the 5s-5p and 5s′-5p′ transitions d is negative and for lines from the 5p-5d transition d is positive. Our measured d_m values confirm the observed negative sign by Vitel and Skowronek (1987) for three Kr II lines (473.90 nm, 465.89 nm and 435.55 nm). Evident Stark shift, in our measurements, was observed only for the 377.81 nm Kr II line which belongs to the higher lying 5p-5d transition. In all cases the shift values are considerably smaller than width values. This indicates that particular important contributions have different sign and that their mutual cancellation results in shifts much smaller than widths. Since the assumed accuracy of the method is ±50 % of the width value, the reliability of these small shifts is much lower. Therefore, d_m/d_{th} ratios are not presented in this paper.

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АНАЛИЗА ПОДСИСТЕМА МЛЕЧНОГ ПУТА

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Абстракт. Аутор анализира подсистеме галаксије Млечни пут полазећи од идеја изнесених у литератури о могућностима постојања посебних подсистема.

1. УВОД

Идеја о хетерогеној структури наше Галаксије - Млечног пута (МП) - је веома стара. Радови Линдблада (1925) и Бадеа (1944) су добро познати. Могло би се рећи да од њих и потичу два израза који се и данас у вези с тим веома често користе. То су израз *подсистем* и израз *популација*. Први, који потиче од Линдблада, односи се на просторну расподелу (која је опет последица начина кретања), док други узима у обзир и физичке карактеристике објеката Млечног пута. У данашње време се употреба ових израза често преплиће. Аутор овог прилога намерава да користи израз подсистем будући да се онда полази од просторне расподеле. Ова последња је, као што је већ речено, последица начина кретања који је, са своје стране, у корелацији са физичким карактеристикама на шта је први указао Баде.

Дакле, приликом дефинисања једног подсистема МП најпре се одређује закон просторне расподеле у МП који следи дати скуп објеката ове галаксије. Математички приказ ових закона се у уобичајеној терминологији зове *модел* МП. У овом тексту наводе се подсистеми предлагани од стране различитих аутора и анализира се њихов значај и допринос укупној маси МП.

2. ПРЕГЛЕД ПОДСИСТЕМА

а) Црна рупа у средишту

Зна се да су црне рупе још увек хипотетички објекти, али се у последње време сматра, по свој прилици с правом, да такви објекти заиста постоје. За МП и проучавање галаксија уопште од интереса су изузетно масивне црне рупе које би требало да се налазе у њиховим средиштима (централне црне рупе - ЦЦР) (на пр. Тремејн и др. 1994). Према прелиминарним прорачунима маса ЦЦР могла би да буде $10^{8-9}\ \mathcal{M}_\odot$. Њено порекло се често везује за квазаре. Када је реч о моделу, формуле за ЦЦР су једноставне, Диракова δ - функција за густину, односно израз за материјалну тачку у случају потенцијала.

б) Језгро

Није сасвим јасно шта се подразумева под појмом језгра (енгл. nucleus), тј. схватања различитих аутора се разликују. Неки под тим подразумевају област активности дате галаксије. МП, додуше, не спада у активне галаксије, међутим трагови евентуалне раније активности су, разуме се, просторно ограничени. На основи изложеног јасно је да се схватања различитих аутора о запремини и маси језгра разликују, рецимо полупречник око 1 *pc*, маса око $1 \times 10^7\ \mathcal{M}_\odot$ (Хауд, Еинасто 1989). Можда се језгро може повезати са особеношћу графика густине за веће подсистеме познатом под именом ,,врх" (енгл. cusp)?

в) Средишње згушњење

Овде се ради о подсистему коме би се приписала ,,одговорност" за постојање евентуалног израженог максимума на кривој ротације (тачније кружне брзине) смештеног на око 350 *pc* од средишта Млечног пута (на пр. Хауд 1979). Маса овог подсистема би такође могла да има ред величине $10^9\ \mathcal{M}_\odot$ (на пр. Петровскаја, Нинковић 1993). Условно би се за овај подсистем могао прихватити енглески термин inner bulge, пре свега, зато што многи аутори за област МП унутар 1 *kpc* од средишта користе израз bulge (на енглеском), али подсистем са таквим именом је посебна целина (на пр. Петровскаја, Нинковић 1993, с напоменом да ови аутори нису користили израз inner bulge). На крају треба, свакако, рећи да постојање овог израженог максимума на кривој ротације није опште прихваћено и да постоје и алтернативне интерпретације криве ротације где таквог максимума уопште нема (на пр. Денен, Бини 1998).

г) Централни овал

Централни овал је израз који аутор овог прилога предлаже за оно што се у англосаксонској литератури обично назива *bulge*. Нема сумње да постојање овог подсистема није спорно. Он фигурише у готово свим моделима МП. Његов облик је сферичан премда се спљоштеност често не занемарује. Укупна маса износи негде $1-2 \times 10^{10}\ \mathcal{M}_\odot$ и она је претежно сконцентрисана унутар галактоцентричног радијуса $1-3$ *kpc* (на пр. Бекол 1986).

д) Диск

Овде се такође ради о подсистему чије је постојање неоспорно, можда неоспорније од било ког другог јер се често диск сматра као нека врста МП у ужем смислу. Овакво схватање није без разлога јер све до открића тамне материје диск је важио, не само за најсјајнији подсистем МП, него и за његов најмасивнији подсистем. Осим велике спљоштености по којој је добио име, а која потиче од његове брзе ротације, диск је познат и по томе што његови објекти у просеку садрже релативно знатне количине хемијских елемената тежих од водоника и хелијума. У том погледу постоји извесна сличност између диска и централног овала.

Грађа диска је сложена. Може се говорити о неком ,,основном диску" који садржи далеко највећи део његове укупне масе и где се просторна расподела објеката одликује обртном симетријом. За овај део диска се најчешће примењује тзв. експоненцијална формула: $\sigma(R)exp(-\alpha R)$ (на пр. Фримен 1970), где је $\sigma(R)$ површинска густина његове материје, R је растојање до осе симетрије (ротације) МП, док је константа означена са α реципрочна вредност карактеристичне дужине за овај диск. Осим тога, опште је познато да се младе и сјајне звезде диска, већи део развејаних звезданих јата и међузвездана материја концентришу у облику спиралних грана. С друге стране није искључено да известан део, нарочито старијих објеката, диска тежи да образује неки диск мање спљоштености који често називају дебели диск (енгл. thick disc, на пр. Бекол 1986). Иначе укупна маса диска се често процењује на неколико десетина милијарди Сунчевих маса и сконцентрисана је углавном унутар око 15 *kpc* од средишта МП (на пр. Бекол 1986).

ђ) Хало

Хало је такође добро познат подсистем МП, у најмању руку онолико колико и диск. Обично се ова два подисистема узимају као супротности. Диск је веома спљоштен, хало је скоро сферан, објекти диска су релативно богати хемијским елементима тежим од водоника и хелијума, за разлику од објеката халоа који су врло сиромашни тим истим елементима. Међутим, премда су њихове укупне масе сконцентрисане унутар приближно истих галактоцентричних растојања, укупна маса халоа је, посвој прилици, знатно мања од укупне масе диска - она износи, рецимо, $2-3 \times 10^9\ \mathcal{M}_\odot$ (на пр. Бекол 1986).

е) Тамни подсистем

Тамна материја је данас широко прихваћен појам премда је њена природа још увек нејасна. За подсистем који она образује користе се различити изрази. Неки га зову тамни хало или само хало па онда хало (в. ђ) називају неким другим именом, рецимо сфероид (на пр. Бекол 1986). У овом прилогу биће коришћен израз тамни подсистем (ТП). Укратко у литератури се за њега обично узима приближно сферни облик, веома велик радијус ($\gg 100$ *kpc*) и врло велика маса (рецимо око $1 \times 10^{12}\ \mathcal{M}_\odot$ - Петровскаја, Нинковић 1993). Као што је познато, улога ТП је да одржава гравитацијски МП због велике кинетичке енергије ротације.

3. ДИСКУСИЈА

Унутар овог скупа подсистема МП могло би се извршити следеће груписање:

а) средишњи подсистеми

б) распрострти подсистеми.

У прву групу аутор овог прилога би сврстао подсистеме а-г. Од њих, као што је већ речено, централни овал представља незаобилазни подсистем, без кога се готово ниједан модел МП не може замислити. Што се тиче осталих, не би требало мислити да они не постоје. Вероватно су сви они стварни (можда је постојање ЦЦР мало проблематично), али централни овал, врло вероватно, има релативно сложену структуру, тј. он, по свој прилици, укључује у себе остале средишње подсистеме (б и в) што се може видети из околности да укупне масе поменута два чине сразмерно мали проценат његове укупне масе. Ово тврђење би остало на снази и када би се централном овалу прикључила ЦЦР.

За подсистеме друге групе може се рећи следеће. Диск има знатну средњу густину и могао би се упоредити са средишњим подсистемима, који иначе, по дефиницији, имају велику средњу густину. Хало и ТП имају врло малу средњу густину. Овај први због малог радијуса има и врло малу укупну масу и због тих околности не сматра се битним у прорачуну гравитационог поља МП. Дакле, није чудно што готово сви актуелни модели МП усвајају три подсистема - централни овал, диск и ТП. Формуле за густину су доста компликоване па се зато овај прилог неће њима бавити. С друге стране, потенцијал пружа добру алтернативу. Ако је он аналитички дат, могу се, с обзиром на својства Поасонове једначине, лако израчунати и густина и остале неопходне величине. Варијанта са потенцијалом датим аналитички има такође предност када треба рачунати галактоцентричне путање пробних објеката.

Најпознатија, а такође и најједноставнија и самим тим највише примењивана, формула за потенцијал је, свакако, Пламер-Шустерова формула. Она гласи

$$\Pi = \frac{G\mathcal{M}}{(r^2 + b^2)^{1/2}} ,$$

где је П потенцијал, G константа гравитације, $\mathcal{M}$ укупна маса датог звезданог система (или подсистема), r је растојање до средишта и b је константа. Као што се јасно види, ова формула је сферно симетрична. Дакле она се може применити на подсистеме који немају изражену спљоштеност, а међу поменутим то су сви осим диска; за посебан случај ЦЦР константа b би била једнака нули. Уколико се наглашава сложеност структуре подсистема, рецимо за централни овал, може се у имениоцу увести још једна константа као сабирак испред квадратног корена (на пр. Нинковић 1998). У случају када се спљоштеност не може занемарити (пример диска) најчешће се примењује Мијамото-Нагаијева формула (на пр. Нинковић 1992).

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KINEMATIKA UZORKA OD 269 VIZUELNO DVOJNIH ZVEZDA

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Abstract. Uporedjivane su odgovarajuće polarne koordinate (ρ i θ) iz kataloga WDS i HIPPARCOS-a jednog manjeg uzorka vizuelno dvojnih zvezda. Analiza je pokazala da je većina razmatranih dvojnih zvezda dinamički vezana.

1. UVOD

U okviru programa Hipparcos posmatrano je oko 8000 već poznatih vizuelno dvojnih i višestrukih sistema. Za njih su, pored koordinata, sopstvenih kretanja i paralaksi, odredjene i polarne koordinate ρ i θ. Svi podaci su dati za epohu J1991.25 .

Do danas je za vrlo mali procenat već poznatih vizuelno dvojnih zvezda potvrdjena dinamička veza. Razlog ovoga su, uglavnom, dugi periodi rotacije oko centra masa koji znatno prevazilaze vreme od kada je počelo sistematsko praćenje njihovog relativnog kretanja (oko 200 godina).

Katalog WDS – Washington Double Star katalog (Worley and Douglass, 1984), pored ostalih podataka, sadrži i polarne koordinate prvih merenja (ρ i θ) dvojnih sistema. To omogućuje da se iz uporedjenja polarnih koordinata iz kataloga WDS sa odgovarajućim koordinatama iz Hipparcos kataloga, i vodeći računa o paralaksama (π), izvedu neke dinamičke karakteristike.

Preliminarna ispitivanja izvršićemo na uzorku od 269 vizuelno dvojne zvezde uzete iz Beogradskog kataloga vizuelno dvojnih zvezda (Sadžakov i Dačić, 1990), čije su disparicije $1" \leq \rho \leq 10"$.

2. FORMIRANJE TABLICE PODATAKA ZA ANALIZU

Polarne koordinate ρ svakog dvojnog sistema su prevedene iz lučnih sekundi ["] u astronomske jedinice [AJ] na sledeći način:

$$\rho_{AJ} = \rho" / \pi"$$

i na taj način su postale medjusobno uporedive.

Promene u ρ za razmatrane razlike epoha su bile neznatne, te je uzimana njihova srednja vrednost. Promene u pozicionom uglu ($\Delta\theta$) za isti interval (Δt) računate su po formuli:

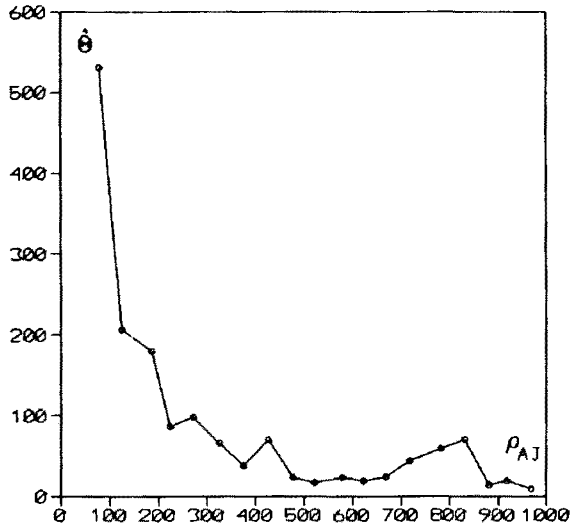
$$\frac{\Delta\theta}{\Delta t} = \frac{|\theta_{HIPP} - \theta_{WDS}|}{t_{HIPP} - t_{WDS}} \approx \dot{\theta}$$

Zbog kratkoće luka $\Delta\theta$ u statističkom smislu bilo je ispravno $\Delta\theta/\Delta t$ zameniti izvodom.

Potom je izvršeno usrednjavanje ρ i $\dot{\theta}$ po intervalima $\Delta\rho = 50$ AJ . Dobijeni podaci predstavljeni su u Tabeli 1. Grafički prikaz zavisnosti $\dot{\theta}$ od ρ_{AJ} dat je na Slici 1.

Tabela 1. Usrednjene vrednosti ρ_{AJ} i $\dot{\theta} \times 10^{-5}$ u radijanima.

ρ_{AJ}	$\dot{\theta} \times 10^{-5}$	ρ_{AJ}	$\dot{\theta} \times 10^{-5}$
79	531	578	23
125	206	623	19
186	180	669	24
224	86	718	44
271	98	782	59
325	66	831	70
375	38	881	14
426	70	918	19
477	23	968	9
521	17		



Slika 1. Zavisnost $\dot{\theta}$ od ρ_{AJ} (na osnovi podataka iz Tabele 1.)

3. ANALIZA REZULTATA

Kako protumačiti krivu $\dot{\theta} = \varphi(\rho_{AJ})$?

Drugi Keplerov zakon predstavljen je u obliku:

$$\rho^2 \cdot \dot{\theta} = C \tag{1}$$

odakle sledi da je

$$\dot{\theta} \propto \frac{1}{\rho^2} \ . \tag{2}$$

Kriva sa Slike 1. asocira na funkcionalnu zavisnost $\dot{\theta} \propto 1/\rho^n$, gde je $n > 1$.

4. ZAKLJUČAK

1. Za većinu parova ovog uzorka može se konstatovati da je dinamički vezana.
2. Ovu analizu bi trebalo proširiti na ceo spisak zajedničkih dvojnih zvezda u katalozima WDS i Hipparcos, da bi prethodni zaključak bio pouzdaniji.

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ЕМИСИОНЕ ЛИНИЈЕ СА ДВА ПИКА У СПЕКТИРМА АКТИВНИХ ГАЛАКТИЧКИХ ЈЕЗГАРА

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Емисионе линије Активних Галактичких Језгара (АГЈ) имају веома комплексан облик, што указује на динамичне процесе који се одвијају у емисионој области код ових објеката. Код једног броја АГЈ линије имају јасно изражена два пика, или избочине у крилима које могу да индицирају да један део емисионе области зрачи линије са два пика. Природа и облик линија са два пика код АГЈ је разматрана у великом броју радова (види нпр. Alloin et al. 1988, Chen et al. 1989, Chen & Halpern 1989, Halpern 1990, Miller & Peterson 1990, Sulentic et al. 1995, Gaskell 1996, Eracleous & Halpern 1994, Livio & Pringle 1996, Newman et al. 1997, Pariev & Bromley 1998, Popović et al. 1998, Corbett et al. 1998, итд.). Настанак линија са два пика код АГЈ може бити објашњен помоћу следећих модела:

1. *Модел ротирајућег акреционог диска* (Chen et al. 1989, Chen & Halpern 1989, Halpern 1990, Pariev & Bromley 1998);
2. *Емисија два млаза материје,* (Zheng et al. 1990, Zheng et al. 1991, Robinson 1995, Corbett et al. 1998);
3. *Фотојонизација од једног неизотропног извора* (Wanders 1996, Koratkar et al. 1996);
4. *Модел двојне црне* (види нпр. Gaskell 1996, Popović et al. 1998)

Сваки од предложених модела има одређене предности и недостатке у поређењу са посматраним линијама. У раду ће детаљно бити образложени модели и размотрене њихове предности и недостатци, при чему ће се разматрати облик емисионих линија код АГЈ 3c390.3 и Arp 102B. Такође, даће се кратак осврт на деформацију емисионих линија код АГЈ услед деловања микрогравитационих сочива (Popović et al. 2000).

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EXPERIMENTAL STARK WIDTH OF THE 581.198 nm C IV SPECTRAL LINE

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1. INTRODUCTION

Spectral lines of multiply ionized emitters, like C IV, were discovered in the spectra of stellar atmospheres of hot stars (Bruhweiler & Kondo 1983 and references therein; Dupree & Raymond 1982; Bruhweiler 1985). Thus, the necessity of knowledge of Stark widths of these lines was imposed. On the basis of Stark width values it is possible to obtain other basic plasma parameters e.g. electron temperature (T) and electron density (N), important in the modeling of the stellar atmospheres.

We have measured Stark FWHM (full-width at half intensity maximum, W) of the C IV 581.198 nm line at an T=24 000 K electron temperature and $N = 1.66\ 10^{23}$ m^{-3} electron density in the CO_2 plasma. It should be pointed out that the existing experimental W values are obtained at electron temperatures higher than 38 000 K. However, the low temperature region is important for sensitive evaluation of the W values. Namely, various theoretical approximations involve stronger temperature dependence in this temperature region and show mutual discrepancies. Their reliability can be arbitrary with reliable experimental data.

2. EXPERIMENT

The modified version of the linear low pressure pulsed arc (Djeniže et al 1998) has been used as the plasma source. A pulsed discharge was driven in a quartz discharge tube of 5 mm i.d. and has an effective plasma length of 7.2 cm. The tube has end-on quartz windows. On the opposite sides of the carbon electrodes the glass tube was expanded in order to reduce sputtering of the electrode material onto the quartz windows. The working gas was CO_2 at 130 Pa filling pressure in flowing regime. Spectroscopic observation of isolated spectral lines was made end-on along the axis of the discharge tube. A capacitor of 14μF was charged up to 2.8 kV. The line profiles were recorded by a shot-by-shot technique using a photomultiplier (EMI 9789 QB , EMI 9659 B) and a grating spectrograph (Zeiss PGS-2, reciprocal linear dispersion 0.73 nm/mm in the first order) system. The exit slit (10μm) of the spectrograph with the calibrated photomultiplier was micrometrically traversed along the spectral plane in small wavelength steps (0.0073 nm). The photomultiplier signal was digitized using oscilloscope, interfaced to a computer. A sample output, as example, is shown in Fig.1. The investigated C IV spectral lines are recorded in the ionization phase of the discharge when the spectral lines from lower ionization states (C II, O II, C III, O III) can not disturb the observed C IV spectral region.

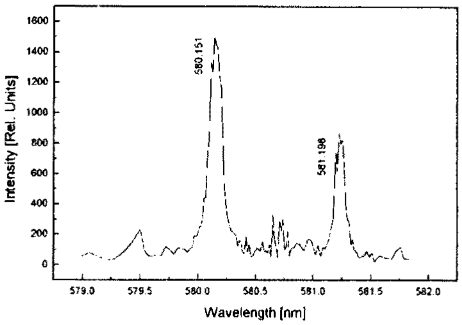

Fig.1.Recorded spectrum at $5^{th}\mu$s after the beginning of the discharge

The measured profiles were of the Voigt type due to the convolution of the Lorentzian Stark and Gaussian profiles caused by Doppler and instrumental broadening. Van der Waals and resonance broadening were estimated to be smaller by more than an order of magnitude in comparison to the Stark, Doppler and instrumental broadenings.

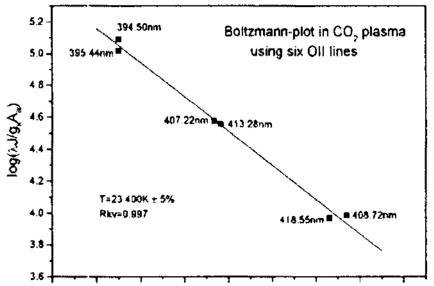

Fig.2. Boltzmann-plot of six O II lines

A standard deconvolution procedure (Davies & Vaughan 1963) was used. The Stark widths were measured with ±12% error at given T and N.

The plasma parameters were determined using standard diagnostics methods. The electron temperature was determined from the Boltzmann-slope of six O II lines

(394.50, 395.44, 407.22, 408.72, 413.28 and 418.55 nm) with a corresponding upper-level energy interval of 5.2 eV. The necessary atomic data were taken from Wiese et al. (1966). At 15.μs after the beginning of the discharge (the moment when the spectral line profiles were analyzed) the found electron temperature was 24 000 K ±5%.

For electron density measurement we used the well-known laser interferometry method and, also, the convenient Stark widths of the mentioned O II spectral lines. The obtained value was $N = 1.66 \cdot 10^{23}$ m^{-3} ± 7% (at the 15. μs after the beginning of the discharge).

3. RESULTS

Our experimental result of the measured Stark FWHM value at 24 000 K electron temperature and an $N = 1.66 \cdot 10^{23}$ m^{-3} electron density is 0.103 nm.

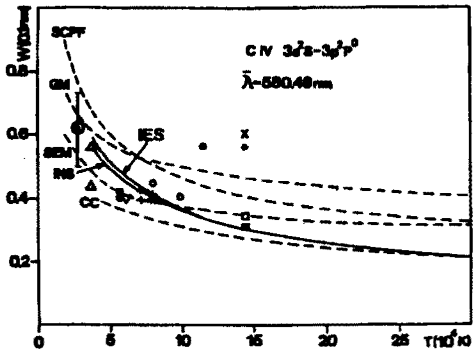

Fig.3. Stark FWHM dependence on the electron temperature at 10^{23} m^{-3} electron density. Measured values: ⊙, this work; 0, Glenzer et al. (1992); +, Blagojević et al. (1999); △, Djeniže et al. ((1988); ∇, Bogen (1972); •, Ackermann et al. (1985); ⊕, El Farra & Huges (1983); ⋆, Böttcher et al. (1988). Calculated values (see text for explanation): GM, SEM and SCPF, Blagojević et al. (1999); CC, Seaton (1988); x, Baranger (1962); , Hey & Breger (1982) and Hey & Breger (1980). Estimated values: on the basis of the regularities along the isonuclear (INS) and isoelectronic (IES) sequences (Djeniže 1999). Error bar represents 19% uncertainties. $\bar{\lambda}$ is the mean wavelength in the multiplet.

4. DISCUSSION

In order to allow easy comparison between measured and calculated Stark width values, we display in Fig. 3. variations of W (FWHM) with the electron temperatures for a given electron density equal to 10^{23} m^{-3}. Theoretical predictions, (dashed lines) present electron contribution to the Stark width only. The previous calculation of the Stark width values of the mentioned C IV spectral lines was performed by Dimitrijević & Konjević (1980) on the basis of the simplified semiclassical approximation after Griem (1974) (GM) and of the modified semiempirical formulae (SEM) (Dimitrijević & Konjević). Seaton's calculations, using the close-coupling theory (CC), have been presented in 1988. Böttcher et al. (1988) have calculated the Stark width values of these lines at 145 000 K electron temperature with the impact and classical path approximations (Hey & Breger 1980,1982) and Baranger's (1962) theory for nonhydrogenic ions. Blagojević et al. (1999) have calculated the new values of the Stark widths in a wide range of the electron temperatures (20 000 K - 300 000 K) using the semiclassical perturbation formalism (SCPF) (Sahal-Brechot 1969a, 1969b). This is an extension of the calculations performed by Dimitrijević et al. (1991). INS and IES denote estimated W values (Djeniže 1999) using Stark width regularities along isonuclear and isoelectronic sequences, respectively.

5. CONCLUSION

Our measured W value at 24 000 K electron temperature agree, within experimental accuracy, with GM and SEM theoretical predictions. On the other hand, good agreement was found, also, with the estimated INS and IES Stark FWHM values.

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ФОТОГРАФСКО ПОСМАТРАЊЕ ПОМРАЧЕЊА СУНЦА 11. 08. 1999. НА СЕМЕРИНГУ У АУСТРИЈИ

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Абстракт: Из мерења само 21 снимка фаза помрачења Сунца добијених помоћу телеобјектива Максутов МТО 100/1000 мм на Семерингу у аустријским Алпима изведени су тренуци првог и четвртог контакта, са грешком од 7 секунди, и трећег контакта са грешком 12 секунди.

1. УВОД

Опис експедиције за посматрање помрачења са Семеринга у аустријским Алпима $(\varphi=+47^0 37{,}7', \lambda=-01^h 03{,}22^m, h=1035m)$ дат је у чланку Б.А. Јовановића у часопису ВАСИОНА. Снимано је телеобјективом МТО 1000А, $D/F=110/1000(mm)$ на црно - бели филм $Kodak\ T\max 100pro$, уз употребу желатинских филтара из комплета уз телеобјектив. Време је бележила Љиљана Јањић, очитавано са часовника џепног рачунара ГПС.

За обраду имали смо на располагању само 21 снимак, јер су неки оштећени или загубљени у процесу обраде (?!) која је поверена једном бечком фотографу. Ради поређења са резултатима посматрања са Палића покушали смо извући тренутке контаката и из овако скромног скупа података, обзиром да то омогућава метод "функције тетиве" (Томић, 1976).

Мерења су вршена помоћу инверзног микрометра (Чабрић и др., 1985). У мерењу се појавила додатна тешкоћа - због велике надморске висине и разређеног ваздуха, и кроз облаке сјај Сунца је био знатан, што је на стакленим површинама филтара произвело веома јаке рефлексије, нарочито када лик Сунца није био строго симетричан у односу на оптичку осу. Оптички, ефекти су лепи али су отежавали мерење.

2. ПОСТУПАК И РЕЗУЛТАТИ

У Табели 1. наведени су тренуци снимања (TU) и величина тетиве изражена у пречницима лика Сунца (x), као улазни подаци. Вредност одговарајуће функције тетиве $f_{(x)}$ и појединачни тренуци контаката које даје свако поједино мерење за први, трећи и четврти контакт, дати су у преостале три колоне. На основу ових вредности добијена је средња грешка с којом су ушле у даљу обраду измерене вредности, $7s$ за први и четврти контакт и $12s$ за трећи контакт, што није лоше обзиром на мали број мерења. Поступак обраде био је следећи. Прво је нацртан график $x^2=f(t_p)^2$, где је t_p тренутак посматрања. Са графика је утврђено да мерења бр. $1\div 9{,}16\div 21$ леже на параболи која одређује први и четврти контакт, а мерења бр. $10 \div 15$ трећи контакт. Функција тетиве рачуната је по формули:

$$f(x) = \sqrt{(1-x^2)(q^2-x^2)} - x^2. \tag{1}$$

Ова величина повезана је са тренуцима посматрања t_p параболичном функцијом:

$$f(x) = a \cdot t_p^2 + b \cdot t_p + c \tag{2}$$

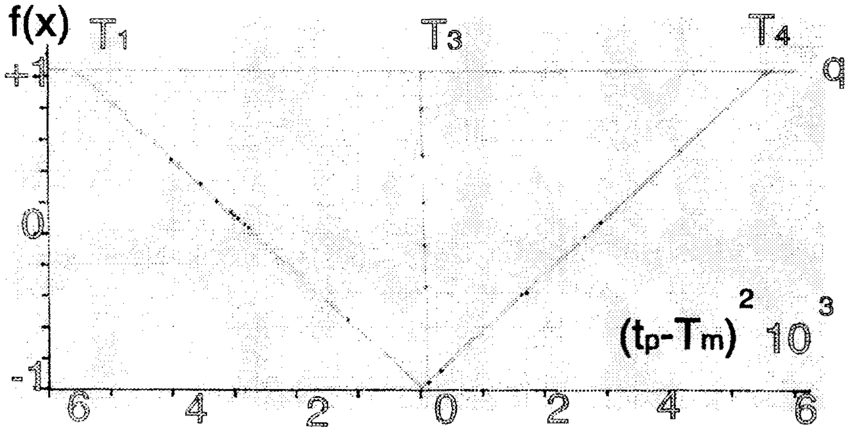
За снимке бр. $1 \div 9, 16 \div 21$ методом најмањих квадрата добија се: $a = 0{,}000368804$, $b = -0{,}073413874$, $c = 2{,}659814026$, што је дало за теме параболе тренутак максимума фазе (T_m) у скали времена са почетком у $09^h TU$, половину трајања помрачења (T) за тачке са $f(x) = q$ на параболи, и тренутке контаката (T_1, T_4): $T_m = 99{,}530^m$, $T = 74{,}242^m$, $T_1 = 25{,}288^m$, $T_4 = 173{,}772^m$.

Сада је могуће израчунати за свако посматрање тренутак симетрично у односу на максимум фазе, по формули:

$$t_p - T_m = \pm\sqrt{A \cdot f(x) + B} \tag{3}$$

Табела 1. Мерене (TU , x) и израчунате вредности ($f(x), T_1, T_3, T_4$)

РБ	$TU(^h;^m)$	X	$f(x)$	T_1	T_3	T_4
1	09:36,183	0,532	+0,4729	24,987		173,533
2	40,117	0,5985	+0,3236	25,621		174,167
3	42,033	0,6478	+0,1989	24,634		173,181
4	44,183	0,6704	+0,1408	25,380		173,926
5	44,650	0,676	+0,1246	25,449		173,995
6	45,117	0,684	+0,1029	25,379		173,925
7	46,150	0,6987	+0,0613	25,366		173,912
8	46,833	0,704	+0,0473	25,692		174,238
9	64,367	0,892	-0,5547	24,566		173,112
10	101,733	0,344	+0,8024		101,701	
11	101,900	0,539	+0,4579		101,822	
12	102,317	0,643	+0,2118		102,206	
13	102,783	0,750	-0,0867		102,633	
14	102,967	0,832	-0,3468		102,783	
15	103,117	0,972	-0,8626		102,868	
16	110,283	0,992	-0,9477	25,002		173,548
17	117,700	0,973	-0,8667	24,957		173,503
18	139,533	0,846	-0,3939	24,949		173,495
19	140,817	0,842	-0,3804	25,781		174,327
20	150,917	0,728	-0,0216	24,172		172,718
21	153,133	0,696	+ 0.0697	25,158		173,704



Сл.1. Линеаризовани график помрачења.

Поново је примењен метод најмањих квадрата и добијено је: $A = 2715{,}452861$, $B = 2694{,}605593$ одакле следи могућност да свако мерење да једну вредност за први и четврти контакт, по формулама:

$$T_1 = t_p + \sqrt{A \cdot f(x) + B} - T\,,\quad T_4 = T_1 + 2 \cdot T \tag{4}$$

за грану параболе пре тоталитета и:

$$T_1 = t_p - \sqrt{A \cdot f(x) + B} - T\,,\quad T_4 = T_1 + 2 \cdot T \tag{5}$$

за грану после тоталитета. Тако добијени скуп од 15 вредности даје средњу вредност и њену грешку за ове контакте:

$$\overline{T_1} = 25{,}140''' \pm 0{,}116'''\,,\quad \overline{T_4} = 173{,}686''' \pm 0{,}116'''$$

Вредности које даје метод најмањих квадрата:

$$T_1 = T_m - T = 25{,}257'''\,,\quad T_4 = T_m + T = 173{,}803'''$$

као највероватније, налазе се унутар интервала тачности. За други и трећи контакт парабола $f(x)$ као функција од t_p је много стрмија. Овдев располажемо подацима само за једну грану, па смо користили линеарну зависност:

$$f(x) = C \cdot (t_p - T_m) + D\,. \tag{6}$$

За скуп од 6 вредности ($10 \div 15$ у Табели 1.) метод најмањих квадрата дао је: $C = -0.1965848$, $D = 0{,}607194357$. Тако, као највероватније, следи:

$T_3 = 102{,}381^m$. Свако мерење додатно је дало своју вредност за тренутак трећег контакта по обрасцу:

$$T_3 = t_p + \frac{q - f(x)}{C} \tag{7}$$

чиме су добијене средња вредност и грешка средње вредности и за трећи контакт: $\overline{T_3} = 102{,}336^m \pm 0{,}205^m$. Коначно, додавањем полазне вредности показивања часовника, добијамо следеће елементе помрачења по TU:

$$\begin{aligned} T_m &= 10^h39^m31{,}8^s \pm 7{,}0^s & 2 \cdot T &= 2 \times 74{,}242^m = 2^h28^m29^s \\ T_I &= 09^h25^m15{,}4^s \pm 7{,}0^s & T_{III} &= 10^h42^m22{,}9^s \pm 12{,}3^s, \end{aligned}$$

$$T_{IV} = 11^h53^m48{,}2^s \pm 7{,}0^s$$

Рачунато је за измерену топоцентричну вредност односа угаоних пречника Месеца и Сунца: $q = 1{,}0392$. На графику (сл. 1) представљена је једначина (3), са координатама: $(t_p - T_m)^2$-као апсцисом и $f(x)$-као ординатом. Тренуци контаката су одређени пресецима са правом паралелном апсциси, на вредности $f(x) = q$. Лако уочљива линеарност ове функције представља свакако погодност која доприноси тачности рачуна. Напомињемо да за други контакт нисмо располагали снимцима.

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THE WIDE-FIELD PLATE ARCHIVES IN EUROPE

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Abstract. We examine the wide-field plate archives located in Europe and included in the Wide-Field Plate Database. The total number of wide-field plates stored in 231 archives in Europe (including all former Soviet Union republics) is estimated at ~ 1 140 000 or 56% of all known wide-field plates in the world. Distributions of the number of plates by European regions and countries, and as a function of the instrument aperture are given. The possibilities for plate digitization are discussed.

1. INTRODUCTION

The first attempt for the creation of an inventory of the astronomical plates obtained world-wide was made by Hauck (1982a, 1982b). He sent questionnaires to 48 observatories, 42 of which answered and 32 reported about the situation of the possessed plate archives and the conditions of plate storage. On the basis of these questionnaires the total number of plates, independent of the field size, was estimated at ~ 1.5×10^6. Only in 9 cases the log books for the archived plates were prepared in a computer-readable form. Most of the inquired observatories supported a centralization of the information about plate archives. Later Jaschek (1988, 1989) continued the work on the plate inventory creation by summarizing information from 70 observatories. He estimated the total number of plates at more than 1.5×10^6 and concluded that 50% of all existing plate archives were in Europe.

In 1991 in the frames of Commission 9 Working Group on Wide-Field Imaging (later Working Group on Sky Surveys) of the IAU began the preparation in Sofia of the Wide-Field Plate Database (WFPDB, Tsvetkov 1992, Tsvetkov *et al.* 1998). The WFPDB contains (1) a catalogue of all known archives of wide-field (> 1°) plates and (2) a merged catalogue of wide-field plates.

The last version of the Catalogue of Wide-Field Plate Archives from March 2000 includes 338 archives with an estimated total number of 2 036 179 plates, while the catalogue of wide-field plates contains 323 635 plates from 57 archives. The data for about 100 000 plates more are in preparation for inclusion in the database. The WFPDB is accessible on-line through the VizieR catalogue browser in CDS-Strasbourg at http://vizier.u-strasbg.fr/cats/VI.htx (catalogue number VI/90).

In the present paper we examine that part of the WFPDB which concerns the wide-field plate archives in Europe. The information for these archives may be useful for those astronomers who are interested in using archived photographic observations. Let us note that the possibilities for an effective usage of the European plate archives are expected to increase considerably in the next years due to the planned creation of an European Plates Centre in the Royal Observatory of Belgium, Brussels (see http://midasf.oma.be/~fido/ovid.html).

2. THE EUROPEAN ARCHIVES IN THE WFPDB

We have first processed the data in the Catalogue of Wide-Field Plate Archives in order to find how the number of plates is distributed by continents (Fig. 1). It should be noted that in order to calculate this distribution we have not sticked rigidly to the geographical borders between Europe and Asia. Instead we have considered as "European" all archives situated on the territory of the former Soviet Union. Let us also note that some of the plate archives located in Europe have been obtained at observatories outside of Europe. As seen in Fig. 1, the total number of wide-field plates in Europe is about 1 140 000 which is about 56% of the total amount of wide-field plates in the world. We have found from comparison of our Catalogue of Wide-Field Plate Archives with the Hauck's and the Jaschek's data that probably about 80 000 plates more, partly wide-field ones for which we still do not possess information, exist in the European plate vaults.

The European wide-field plates are stored in 231 archives located in 68 observatories/institutes as seen in Table 1 (in the WFPDB each observational instrument has a separate archive, or several separate archives if, e.g., it has been moved to different observational sites). Most of the plates are direct observations while the number of objective-prism plates is only about 4% of the total number. So far the information for 316907 plates from 56 archives (28% of all wide-field plates in Europe) have been included in the WFPDB.

In Fig. 2 the distribution of the number of European plates by different regions is shown. More than half of the plates are in Western and Central Europe and nearly 40% are in Russia and the former Soviet republics. The distribution of the number of plates by countries, separately for the direct plates and the objective prism plates, is given in Fig. 3. Germany is the country with the largest number of plates (nearly 370 000) thanks mainly to the very large collection of plates of the Sonneberg Observatory. Russia, Ukraine, Tajikistan, Georgia, and the Czech Republic also possess large archives with more than 50000 plates.

Table 1. Number of European archives and plates

Method of Observation		Archives	Instruments	Observatories	Plates
Direct	all	231	204	67	1 095 022
	in WFPDB	55	55	11	311 100
Objective prism	all	29	27	23	44 202
	in WFPDB	8	8	6	5 807
Total	all	231	204	68	1 139 224
	in WFPDB	56	56	12	316 907

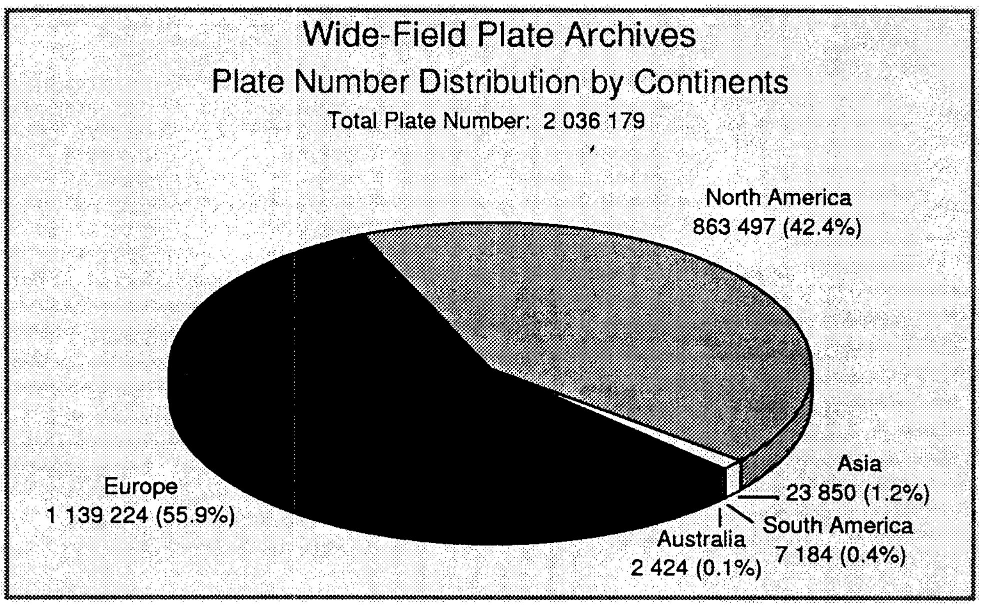

Fig. 1. Distribution of the number of wide-field plates by continents

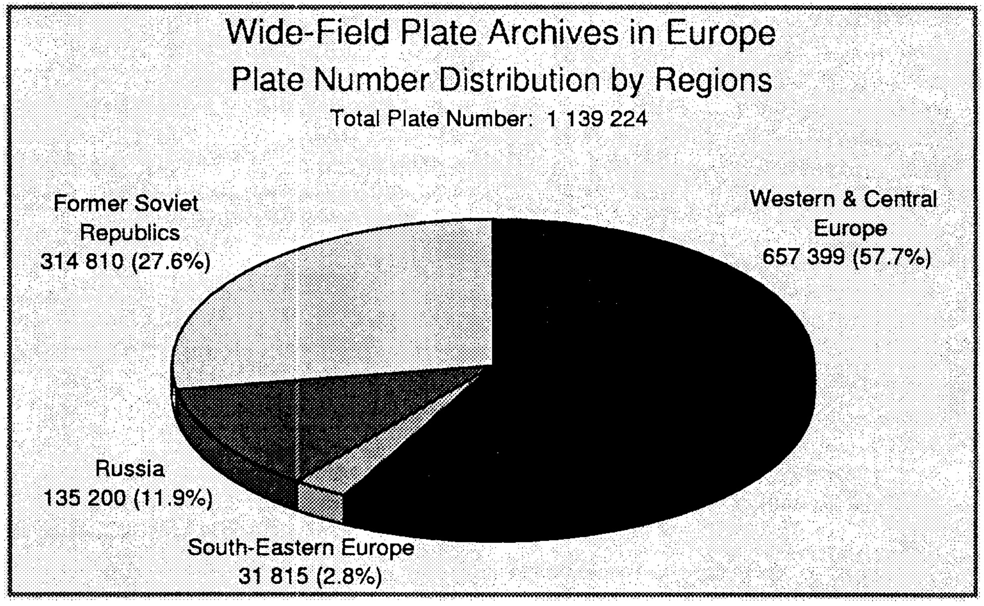

Fig. 2. Distribution of the number of wide-field plates in Europe by regions

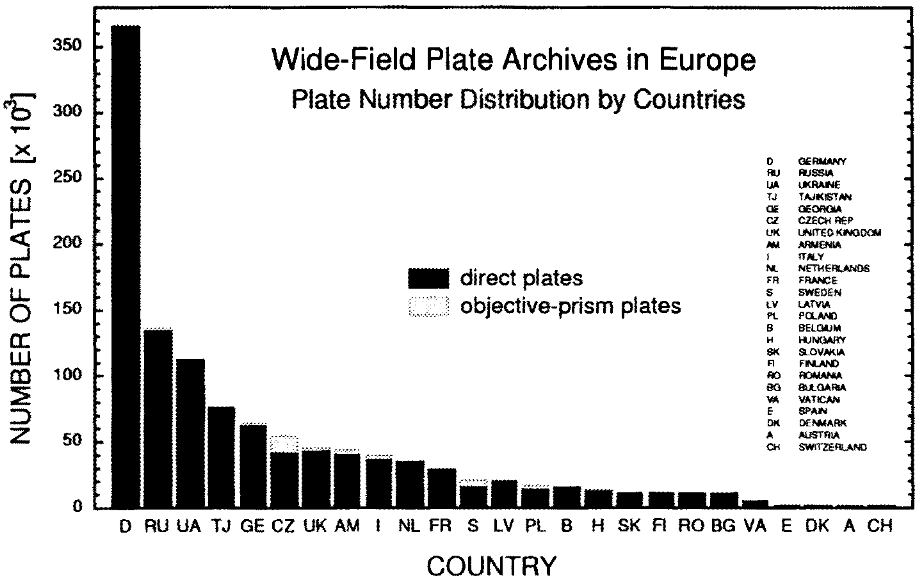

Fig. 3. Distribution of the number of wide-field plates in Europe by countries

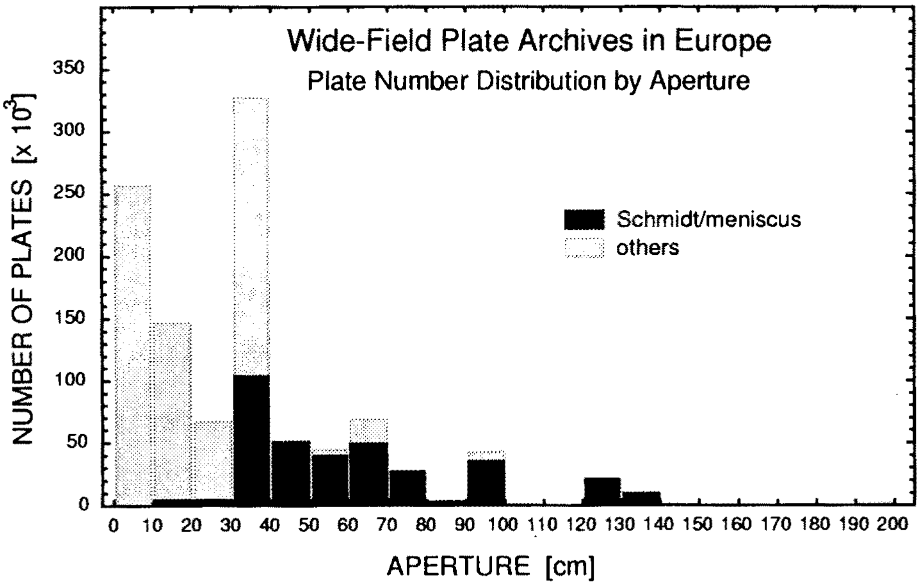

Fig. 4. Distribution of the number of wide-field plates in Europe by telescope aperture

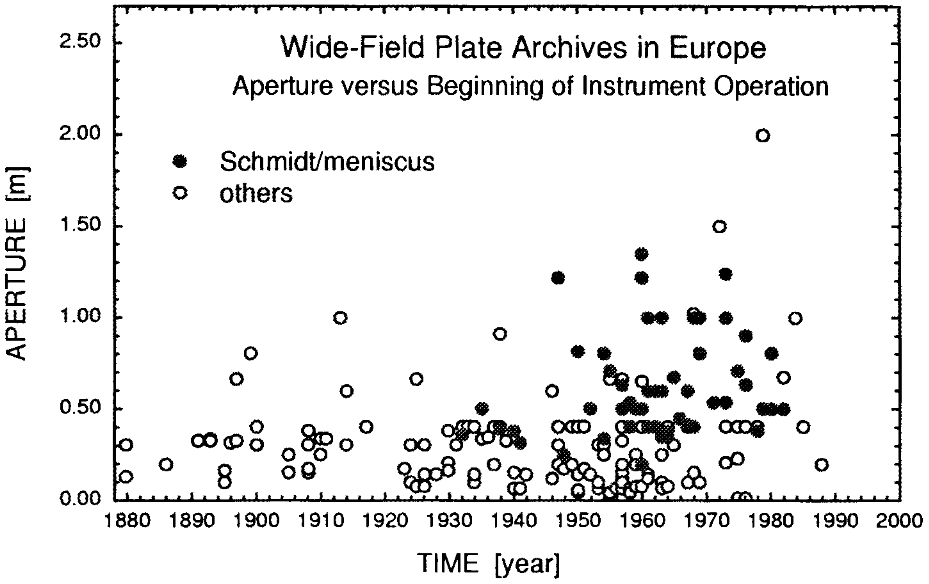

Fig. 5. Aperture versus beginning of instrument operation for the European wide-field telescopes

Fig. 4 shows the distribution of the number of plates as a function of the instrument aperture, separately for the Schmidt/meniscus telescopes and for all others. It is well seen that the great majority of the archived wide-field plates in Europe have been obtained with instruments with aperture < 0.4 m. Fig. 5 shows the increase with time of the number of instruments with larger apertures in Europe in the period 1880-1990. After 1990 new telescopes for wide-field photography stopped to appearing any more due to the wide application in astronomy of electronic detectors of light.

3. PLATE DIGITIZATION

A number of high-speed and high-accuracy scanning machines operating in different European astronomical institutes offer good possibilities for digitization of archived plates. Table 2 contains a list of some larger European microdensitometers. The PDS1010 microdensitometer of the Sofia Sky Archive Data Center (SSADC) was moved from ESO in 1998 and plate digitization started in 1999. Another microdensitometer - the PDS2020GM+ in Muenster (Germany) - was moved this year to Tbilisi (Georgia).

Some of the general pilot projects for plate digitization, proposed by us, are as follows:

- Digitization of the plates in stellar aggregates: Pleiades, Orion-M42, etc.,
- Digitization of the First/Second Byurakan Spectral Survey and the field of M31,
- Wide-field plate archives digitization open tasks: visual binary search, symbiotic long-term variability search, etc.

Table 2. Precise microdensitometers for wide-field plate digitization in Europe.

Country	Observatory/ Town	Microdensitometer
United Kingdom	ROE, Edinburgh	SuperCosmos (WFAU)
	RGO, Cambridge	APM
Germany	Hamburg	PDS1010GM+
	Tautenburg	TMM
	Sonneberg	HSS
France	Paris	MAMA
	Nice	PDS1010
Russia	Pulkovo	Fantazia
Italy	Trieste	PDS1010
Bulgaria	Sofia	PDS1010
Georgia	Tbilisi	PDS2020GM+

4. CONCLUSIONS

The existing 231 wide-field plate archives in Europe contain 1 139 224 plates representing more than half of all known wide-field plates world-wide obtained with professional instruments. We surmise from the comparison of our results with those of Hauck (1982a, 1982b) and Jaschek (1988, 1989) that some 80 000 plates more, part of them wide-field plates, may exist in European archives. Plate vaults are mostly concentrated in Western Europe, but large collections of plates are maintained also in Russia and the former Soviet Union republics. The operating high-speed and high-precision microdensitometers in Europe provide good opportunities for an effective processing of the archived observations.

An important task towards the effective use of the wide-field plate archives in Europe is the continuation of the plate logs cataloguing in a database format despite the great difficulties with organizing and funding of such kind of activity. We expect that the planned creation of a Central Plate Store Unit for the European plate archives will encourage much the usage of the huge quantity of archived photographic observations accumulated during the last century.

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PRIBLIŽNO ODREDJIVANJE OBLASTI LINEARNOSTI CCD KAMERE IZ SPEKTRALNIH LINIJA SUNCA

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Abstrakt. U ovom radu je prikazana jedna metoda ispitivanja oblasti linearnosti CCD kamere pomoću spektralnih linija Sunca. Posebno je analizirana oblast linearnosti ST6 SBIG CCD kamere koja se koristi za posmatranja na Astronomskoj opservatoriji u Beogradu. Procenjeno je da je kamera linearna u oblasti popunjenosti nivoa od 40200 ADU do 4520 ADU.

1. UVOD

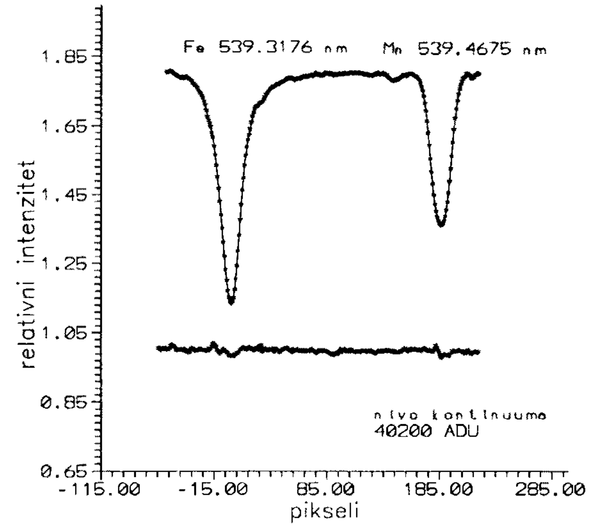
Pri upotrebi nekog detektora koji se koristi za odredjeno posmatranje potrebno je poznavati njegove karakteristike. U slučaju CCD kamere to su: oblast linearnosti CCD kamere, struja u mraku, šum isčitavanja itd. U ovom radu će se prikazati jedna spektrografska metoda za brzo procenjivanje oblasti linearnosti CCD kamere. Prvo će biti reči o ideji na kome se bazira ova metoda a zatim će se analizirati konkretan slučaj ST6 SBIG CCD kamere koja se koristi za spektroskopska posmatranja na Astronomskoj opservatoriji u Beogradu.

2. IDEJA

Odredjivanje oblasti linearnosti CCD kamere se zasniva na sledećoj ideji. Snimi se deo spektra, koji sadrži spektralne linije različitih centralnih dubina, sa različitim ekspozicijama. Ukoliko podelimo dva spektra koja su snimljena u linearnom delu mernog opsega kamere, dobićemo konstantnu rasopodelu odnosa relativnog intenziteta u funkciji od piksela duž celog snimljenog spektra. Ukoliko podelimo spektar koji je u nekim delovima snimljen u nelinearnom delu mernog opsega sa spektrom koji je snimljen u linearnom delu mernog opsega dobićemo raspodelu koja nije konstantna duž celog snimljenog spektra već ima ekstremume upravo u onom delu spektra koji je snimljen u nelinearnom delu mernog opsega.

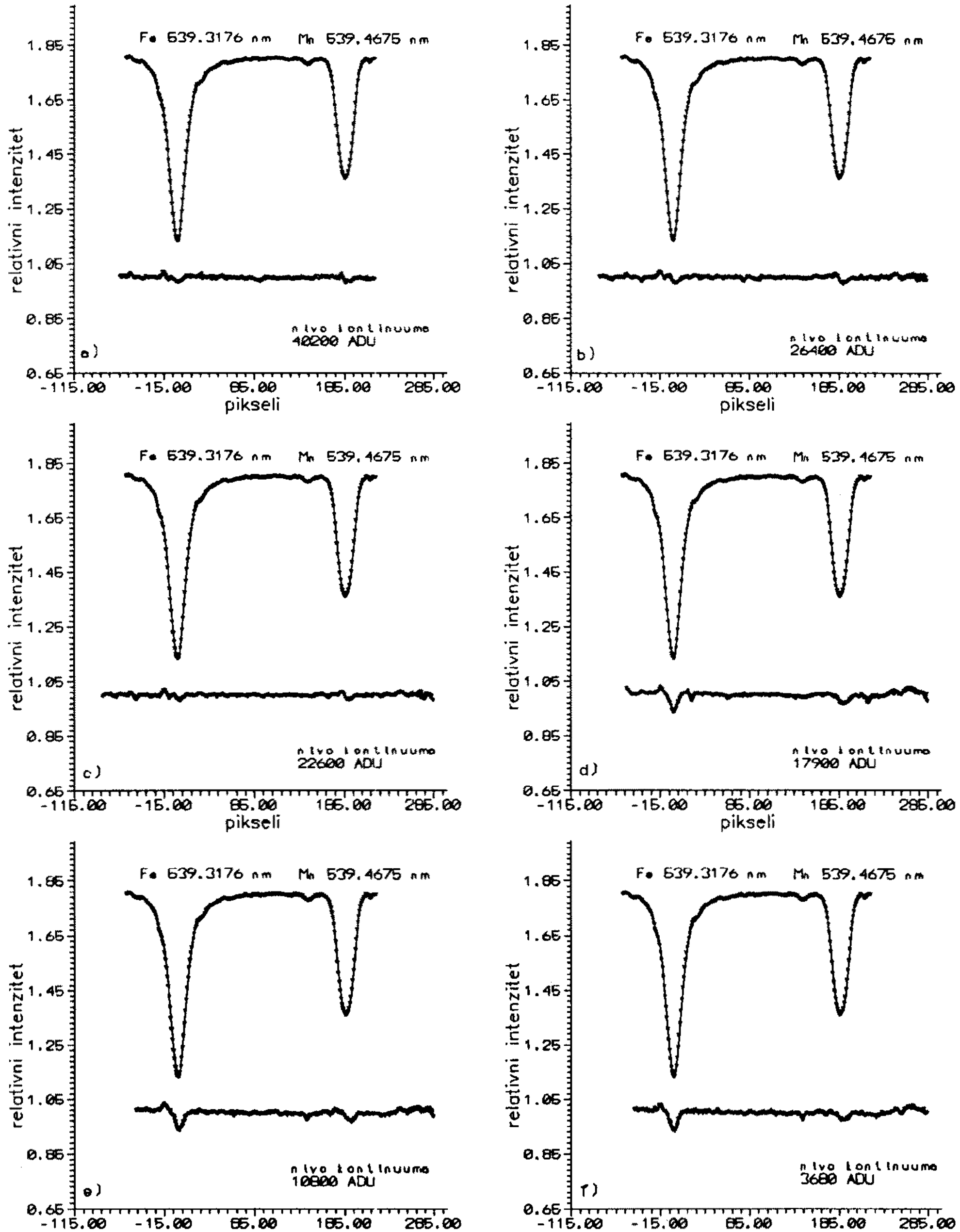
3. METODA ODREDJIVANJA OBLASTI LINEARNOSTI ST6 SBIG CCD KAMERE

U konkretnom slučaju sa ST6 SBIG CCD kamerom postupak odredjivanja oblasti linearnosti je bio sledeći. Snimljen je deo spektra koji sadrži dve spektralne linije (Fe 539.3176 nm i Mn 539. 4675 nm) sa različitim ekspozicijama. CCD spektrogrami su zatim obradjeni kako bi se dobila zavisnost relativnog intenziteta od talasne dužine (profil spektra - spektar). Znajući da je merni opseg CCD čipa od 0 do 65536 ADU (Analog Digital Unit) i predpostavljajući da je CCD čip negde na sredini mernog opsega (32768 ADU) linearna, izabrana su dva obradjena spektra čiji je kontinualni deo u blizini te sredine. Deljenjem ovih spektara dobija se konstantna raspodela odnosa relativnog intenziteta u funkciji od piksela što ukazuje na to da su oba spektra snimljena u linearnoj oblasti CCD čipa. Na Sl.1 prikazan je grafik dobijene raspodele. U gornjem delu grafika nalazi se deo snimljenog spektra (služi samo za uporedjivanje u kom delu spektra dobijena raspodela ima/nema ekstremne vrednosti), a u donjem delu se nalazi raspodela odnosa relativnog intenziteta u funkciji od piksela koja se dobija deljenjem dva spektra.



Sl. 1. Raspodela odnosa relativnog intenziteta u funkciji piksela koja se dobija deljenjem spektara čiji su nivoi kontinuuma 40200 i 31300 ADU

Jasno se uočava da je dobijena raspodela konstantna duž čitavog spektra koji je snimljen. To znači da su oba spektra snimljena u linearnom delu mernog opsega CCD čipa. Spektar sa kontinuumom od 31300 ADU je izabran da bude normalizacioni faktor preostalim spektrima. To znači da su preostali spektri podeljeni sa spektrom čiji je nivo kontinuuma 31300 ADU. Rezultat deljenja je prikazan na Sl.2. Raspodele odnosa relativnog intenziteta u funkciji od piksela na slikama a), b) i c) su, kako vidimo, konstantna duž celog spektra koji je snimljen. Prema tome i kontinuum i linija su snimljeni u linearnom delu mernog opsega CCD čipa. Medjutim, na slikama d), e) i f) vidimo da ta raspodela ima ekstremne vrednosti u predelu jezgra linije gvoždja Fe 539.3176 nm. To znači da je linija izvesnim delom snimljena u nelinearnom delu mernog opsega.



Sl. 2. Raspodele relativnog intenziteta u funkciji piksela koja se dobija deljenjem svih spektara sa spektrom čiji je nivo kontinuuma 31300 ADU

4. ANALIZA

Sl.2 a): Nivo kontinuuma je 40200 ADU. Centralne dubine linija Fe 539.3176 nm i Mn 539.4675 nm su 0.2 i 0.6 respektivno. Prema tome, nivo popunjenosti u jezgru linije gvoždja je (0.2*40200 ADU) oko 8040 ADU a mangana oko 24120 ADU. Pošto je raspodela odnosa relativnog intenziteta od piksela konstanatna duž celog snimljenog spektra možemo reći da je nivo od 8040 ADU do 40200 ADU linearna.

Sl.2 b): Nivo kontinuuma je 26400 ADU. Analognim razmišljanjem kao u predhodnom slučaju možemo reći da je nivo od 5280 ADU do 26400 ADU linearna.

Sl.2 c): Nivo kontinuuma je 22600 ADU. Zavisnost odnosa relativnog intenziteta od piksela je i ovde konstantna kao u predhodna dva slučaja. To znači da je nivo od 22600 ADU do 4520 ADU u oblasti linearnosti mernog opsega.

Sl.2 d): Nivo kontinuuma je 17900 ADU. Raspodela odnosa relativnog intenziteta od piksela u predelu jezgra linije Fe 539.3176 nm ima ekstremnu vrednost što znači da je linija gvoždja u tom delu snimljena u nelinearnom delu mernog opsega CCD čipa. Znajući da je centralna dubina linije gvoždja 0.2 možemo reći da je nivo od 3580 ADU u nelinearnom delu mernog opsega.

Sl.2 e) i f): Slična je situacija kao u prethodnom slučaju što se i očekuje. Naime, nivo u predelu jezgra linije je manji nego u predhodnom slučaju i očekuje se da taj nivo bude u oblasti nelinearnosti mernog opsega.

Na osnovu dobijenih rezultata može se zaključiti da je oblast mernog opsega od 40200 ADU do 4520 ADU linearna. Nelinearnost se ispoljava, kako smo videli, na nivou popunjenosti od 3580 ADU. Gde je prelaz iz linearnog dela u nelinearan deo mernog opsega nemože se reći na osnovu postojećih merenja. U tu svrhu trebalo bi detaljnije ispitati deo nivoa od 4520 ADU do 3580 ADU.

5. ZAKLJUČAK

Ako želimo brzo odrediti oblast linearnosti CCD kamere može se primeniti metoda pomoću spektralnih linija Sunca. Naravno, nije ograničeno primena metode samo na spektralne linije Sunca već se može iskoristiti bilo koji laboratorijski ili drugi spektar. Ukoliko postoji dovoljan broj snimaka sa različitim ekspozicijama može se dobiti kvalitetan rezultat na kom nivou CCD čip prelazi iz linearnog u nelinearan deo mernog opsega. U slučaju ST6 SBIG CCD kamere koja se koristi za posmatranja na Astronomskoj opservatoriji u Beogradu rezultat primene ovog metoda ukazuje na to da je nivo od 40200 ADU do 4520 ADU u linearnom delu mernog opsega CCD čipa. Gde je tačno prelaz iz linearnog u nelinearan deo mernog opsega nije bilo moguće ispitati usled nedostatka podataka izmedju 4520 ADU i 3580 ADU. Treba napomenuti da su snimljeni CCD spektrogrami gde su nivoi kontinuma veći od 40200 ADU (47200 ADU, 64000 ADU i 64300 ADU) ali se oni nisu mogli iskoristiti za obradu jer su kontinualnim delom ušli u nelinearnu oblast mernog opsega kamere (zasićenje). Na kom nivou dolazi do zasićenja nemože se reći na osnovu postojećih rezultata. U tu svrhu trebalo bi detaljnije ispitati nivo izmedju 40200 ADU i 47200 ADU.

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УГАОНА БРЗИНА И ОБЛИК ЗВЕЗДЕ

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Абстракт. У раду су дати прелиминарни резултати моделирања звездане структуре са ротацијом везани за промену радијуса и облика звезде. Добијени резултати потврђују резултате који су раније добијени иако су у моделирању коришћени другачији изрази за брзину ослобађања нуклеарне енергије и непрозрачност. Дакле, звезде се под утицајем ротације шире, а њихов облик престаје да буде сферан. Разматрана је промена облика за константну угаону брзину и различите масе и обрнуто, за константну масу и различите брзине ротације.

1. УВОД

Ако се у моделирању звездане структуре узме у обзир и ротационо кретање звезде, она се више не може посматрати као сфера. Услед обртања око осе ротације долази до одступања од сферног облика и то у различитој мери у зависности првенствено од угаоне брзине. Другим речима, радијус звезде тада зависи од угла који заклапа са осом ротације. Површина звезде у случају ротације може бити задата на следећи начин:

$$R = Rsr(1 - \frac{\Omega^2}{3GM} Rsr^3 P_2(\theta)) \tag{1}$$

где је R-радијус звезде који се мења у зависности од угла који заклапа са осом ротације, Rsr-средња вредност радијуса звезде, Ω-угаона брзина ротације, M-маса звезде, G- гравитациона константа, $P_2(\theta)$-Лежандров (Legendre) полином, θ-угао између посматраног радијуса и осе ротације.

У случају ротирајуће звезде гравитациони потенцијал има следећи облик:

$$V(R,\theta) = -\frac{GM}{R} - \frac{1}{2}\Omega^2 R^2 (1 - \cos^2\theta) \tag{2}$$

Дакле, посматра се ефективни потенцијал, јер на сваки делић масе осим гравитације која тежи да сабије звезду, делује и центрифугална сила која тежи да је развуче и зато се ефективна гравитација на површини звезде, као и у осталим слојевима, смањује.

2. МОДЕЛИРАЊЕ РОТИРАЈУЋЕ ЗВЕЗДЕ

Кипенхан и Томас (R. Kippenhahn, H.C. Thomas) су 1970. године дошли на идеју како изменити једначине структуре у случају ротирајуће звезде. Наиме, разматра се стратификација звезде задата изразом (1) и рачунају се коректривни фактори f_p и f_t.

$$f_p(r) = \frac{4\pi r^4}{GM_r P} \cdot \frac{1}{\langle g^{-1} \rangle} \tag{3}$$

$$f_t(r) = \left(\frac{4\pi r^2}{P}\right)^2 \cdot \frac{1}{\langle g \rangle \langle g^{-1} \rangle} \tag{4}$$

где је P-површина задата изразом (1), $\langle g \rangle$- средња вредност гравитационог убрзања на површини (1), $\langle g^{-1} \rangle$-средња вредност реципрочне вредности гравитационог убрзања на површини (1), M_r-маса унутар средњег радијуса слоја, r-средњи радијус посматраног слоја.

Једначине структуре сада добијају следећи облик:

$$\frac{dp}{dM_r} = -\frac{GM_r}{4\pi r^4} f_p \tag{5}$$

$$\frac{dT}{dM_r} = -\frac{3\kappa}{16\sigma T^3} \cdot \frac{L_r}{(4\pi r^2)^2} f_t \tag{6}$$

$$\frac{dL_r}{dM_r} = \varepsilon \tag{7}$$

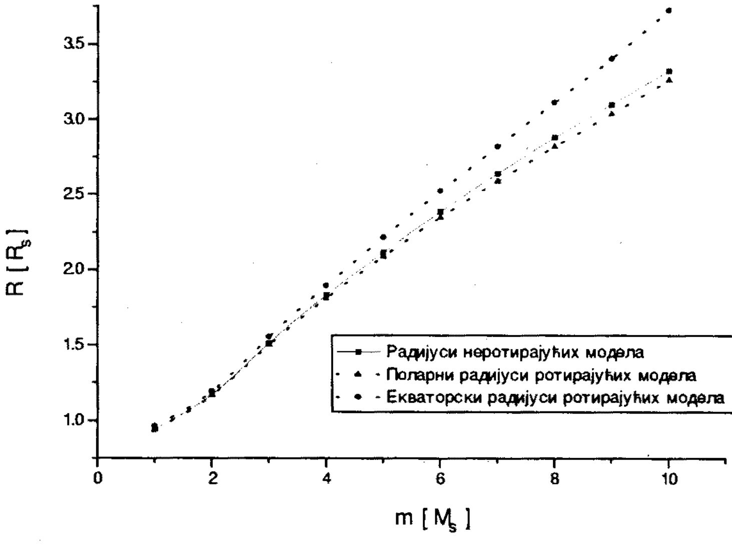
$$\frac{dr}{dM_r} = \frac{1}{4\pi\rho r^2} \tag{8}$$

где је κ-коефицијент непрозрачности, L_r- луминозност дела звезде унутар средњег радијуса слоја, ε-брзина ослобађања нуклеарне енергије, ρ-густина. Ако су корективни коефицијенти једнаки јединици једначине се своде на случај неротирајућих звезда. Када се звездана структура моделира према коригованим једначинама, добија се да ротација утиче на промену параметара звезде, дакле, ефективне температуре, луминозности, затим централне густине, централне температуре и радијуса. У овом раду ћемо размотрити промене везане за радијус и облик звезде.

3. РЕЗУЛТАТИ МОДЕЛИРАЊА

У овом раду су урађени модели звезда маса од једне до десет Сунчевих ($X = 0.71, Y = 0{,}27$) за угаону брзину 0.00015 s^{-1}. Добијене су вредности средњих, поларних и екваторских радијуса и упоређени са радијусима неротирајућих модела. Затим су урађени модели звезде од десет Сунчевих маса за угаоне брзине од 0.00001 до 0.00015 s^{-1} и посматрана је промена средњег, поларног и екваторског радијуса, као и промена облика звезде у зависности од угаоне брзине ротације. Поларни радијуси су израчунати из израза (1) за вредност угла $\theta = 0$, а екваторски за вредност $\theta = \pi/2$.

Из резултата се може видети да, као што се и очекивало, звезда која ротира одступа од сферног облика и њен поларни радијус је обавезно мањи од екваторског. На слици 1. се може видети да је за исту угаону брзину, одступање од сферног облика утолико веће уколико је маса звезде већа. Дакле, масивније звезде се лакше спљоште под дејством ротације.

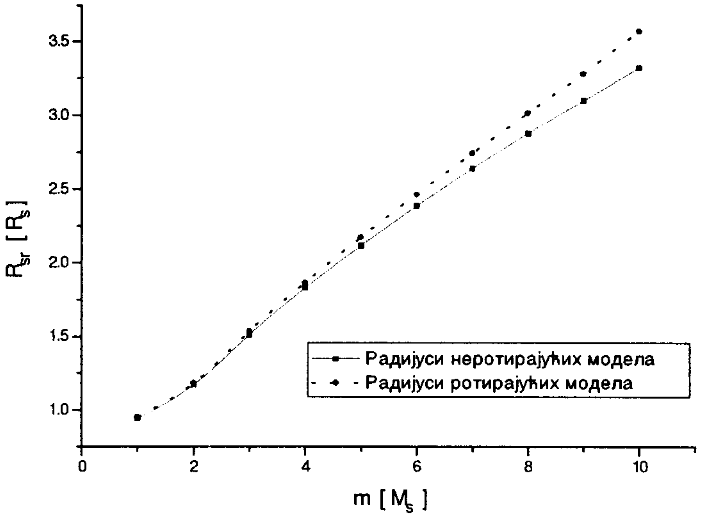


Слика 1. Одступање поларних и екваторских радијуса за угаону брзину 0.00015 s^{-1}

Промене радијуса код звезда масе једне и две масе Сунца су изузетно мале за посматрану угаону брзину. То је зато што су критичне брзине (ефективна гравитација једнака нули) ових звезда пар пута веће од 0.00015 s^{-1} и промене облика звезде још нису уочљиве. Међутим, код звезда чије су масе близу десет Сунчевих маса, одступање од сферног облика је очигледно.

На слици 2. се могу видети средње вредности радијуса ротирајућих модела у односу на неротирајуће. Јасно се види, да се звезде под утицајем ротације шире и то, на фиксној угаоној брзини, утолико више уколико су масивније. Дакле, ако

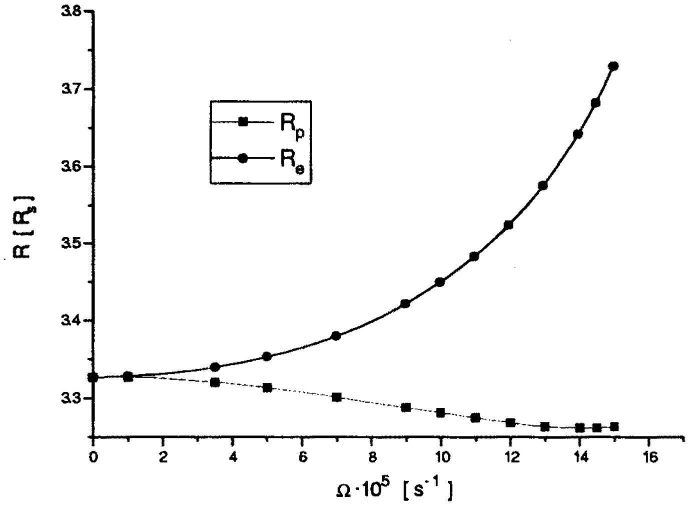
фиксирамо угаону брзину, масивније звезде показују веће одступање од сфере и израженије повећање своје површине.



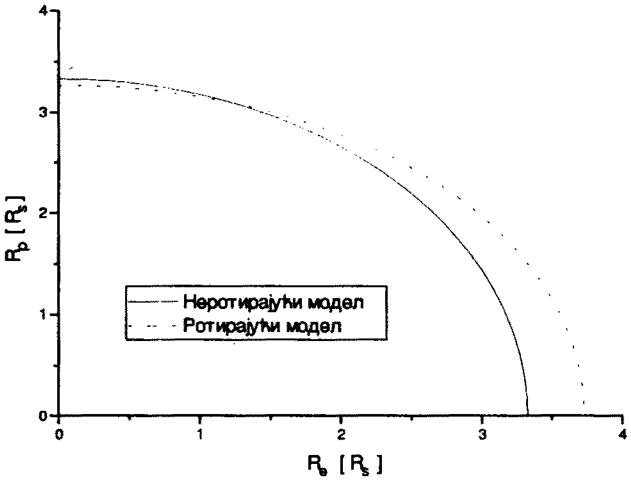
Слика 2. Одступање средњих радијуса звезда за угаону брзину 0.00015 s^{-1}

Што се тиче модела звезде масе десет Сунчевих маса на разним угаоним брзинама, може се закључити да средњи радијус расте са повећањем угаоне брзине. Поларни радијус се веома мало повећава за мале угаоне брзине, јер средњи радијус расте, а одступање од сфере није велико, затим почиње да опада све до брзина које су блиске критичној брзини ротације када почиње полако да расте услед наглог ширења звезде. Екваторски радијус стално расте. Облик звезде све више одступа од сферног облика како се угаона брзина повећава. Разлика између поларног и екваторског радијуса је све већа.

На слици 3. се може видети промена поларног и екваторског радијуса звезде масе десет Сунчевих маса у зависности од угаоне брзине ротације. Дакле, екваторски радијус све брже расте са повећањем брзине ротације, док поларни полако опада, да би у близини критичних брзина почео веома мало да расте. На слици 4. је дата четвртина меридијанског пресека звезде масе десет Сунчевих маса, у случају да она не ротира и у случају угаоне брзине од $0.00015 s^{-1}$. Може се јасно видети како ротација мења облик звезде.



Слика 3. Промена поларног и екваторског радијуса звезде масе десет Сунчевих маса



Слика 4. Промена облика звезде масе десет Сунчевих маса услед ротације.

4. ЗАКЉУЧАК

Резултати изнети у овом раду су у складу са раније добијеним резултатима. Услед ротационог кретања долази до ширења звезде и одступања њеног облика од сфере. Дакле, еквипотенцијалне површи више нису сфере, већ су више или мање спљоштене у зависности од угаоне брзине ротације, али и масе звезде.

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ИНДЕКС АУТОРА

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