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Active Galactic Nuclei: Progress and Problems

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I first give a short review of our basic knowledge of the structure of line- and continuum-emitting regions of active galactic nuclei and the relationship between the various components. I argue that we have a fairly good overall framework of how AGNs work. I then draw attention to what I consider to be some of the major unsolved AGN problems and suggest some ways forward.

Virtual atomic and molecular data center (VAMDC), Serbian virtual observatory and other databases for spectroscopical research

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One will explain the idea and objectives of Virtual Atomic and Molecular Data Center (VAMDC), an European FP7 project aiming to build a flexible and interoperable e-science environment based interface to the existing Atomic and Molecular data. The VAMDC will also be a connection between existing Atomic and Molecular databases providers, data producers and users and will organize trainings, tutorials, workshops and conferences on regional and European levels. The databases entering in VAMDC will be described as well as other databases of spectroscopic interest, as well as the idea and objectives of Serbian Virtual Observatory. It will be also discussed the benefits of VAMDC and SerVO for AGN community.

Revisiting the microfield formulation of Stark broadening using stochastic processes

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About four decades ago, Frisch and Brissaud [1] proposed conspicuous Stark broadening calculations by replacing the true microfield with a simpler stochastic process for which the mean evolution operator could be calculated exactly. This approach was the starting point for the microfield formulation of Stark broadening which allowed extensive calculations of line shapes which are currently used for plasma diagnostics [2], and motivated the development of other approaches for which the properties of the electric microfield determine the line profile [3]. There is a new interest today for the use of stochastic processes such as the Poisson-step and the Kangaroo process, since those may provide computationally efficient solutions for the investigation of radiative and transport properties of media submitted to fluctuations of the plasmas parameters. In this work we first revisit such approaches for calculating the ion dynamics effect on the Lyman alpha line in weakly coupled plasmas, and we then further explore possible improvements of the stochastic process. This may be done by using the Continuous Time Random Walk theory (CTRW), an approach first proposed by Montroll and Weiss [4]. Indeed, the standard Kangaroo process where the waiting time distribution between electric field jumps follows a Poisson distribution can be extended to various waiting time distribution including Lvy distributions. The standard Kangaroo process for the microfield uses a Markov approximation for the microfield [1], and we will show that using the CTRW allows to retain non-Markovian effects. We will tentatively compare the previous and new results obtained with these models with profiles obtained by a plasma computer simulation coupled to a numerical integration of the Schrödinger equation.

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Spectral optical monitoring of 3C390.3 in 1995-2007

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In this lecture we present the results of the long-time variability (1995-2007, 13 years) of the continuum flux and broad emission line profiles of the Seyfert radio galaxy - 3C 390.3, a well known AGN with double-peaked broad emission lines. High quality spectra (S/N> 50 in continuum near Hα and Hβ) were obtained in the spectral range $\sim$ 4000 to 7500 Å, with a resolution between 5 and 15 Å, using the 6-m and 1-m SAO's telescopes (Russia), and the GHAO's 2.1-m telescope (Cananea, México).

During the monitoring period the broad emission component of the Hα and Hβ lines, and the continuum flux varied by a factor of $\approx$4-5. We found that in the Hβ and continuum light curve a quasi-periodical oscillations (QPOs) exist, that are usual observed in stellar mass black holes. Also, the QPOs variations of the observed flux ratio of the blue and red Hβ wings, with period of $\sim$10 years (P$\sim$10 yr), that were also detected by Veilleux and Zheng (1991), probably really exist.

The Hα and Hβ line fluxes and parts of lines are well correlated to the continuum flux, indicating that the ionizing continuum was a good extrapolation of the optical one.

The Hα and Hβ profiles varied, corresponding to a Sy 1 type in the maximum activity state and to a Sy1.8 type in the minimum activity state. Also, we detected different structures in the line profiles of Hα and Hβ. It seems that an additional central component is present and superposed to the disk emission. In the period of high activity (after 2002), Hβ became broader than Hα and red wing of Hβ was higher than the one of Hα. We found time lags of $\sim$95 days between the continuum and Hβ flux, and more than 100 days between the continuum and Hα flux. This difference in lags as well as in FWHM of Hα and Hβ may indicate stratification in the BLR (disk) of 3C 390.3. There is no significant lag between the blue and red wings and core relative to each other indicating a predominantly circular motions in the BLR of 3C390.3 .

Variation in the line profiles, as well as correlation between the line and continuum flux during the monitoring period is in the favor of the disk origin of the broad lines with the possible contribution of some additional region and/or some kind of perturbation in the disk.

Relativistic plasma as the source of variable optical continuum emission in broad-line radio galaxies

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The localization of the region of variable continuum emission, and hence of a broad-line region, is not well understood in radio-loud AGN because of complex structure of their nuclear regions. In radio galaxies, continuum emission from the relativistic jet can dominate at all energies, swamping emission originated in other central regions. A link between optical and radio emission is evidenced from the VLBI-optical monitoring of individual radio galaxies (3C 390.3 and 3C 120) covering the time period of 14 years. We found a correlation between the formation of new bright knots in the jet and the variable optical continuum emission in both radio galaxies. We interpret this correlation as evidence for the non-thermal optical flares being generated in the inner jet. Evidence for non-virial motions in the broad-line region and its implications in radio-loud AGN will be discussed.

León-Tavares, J. et al. 2010, ApJ, 715, 355
Arshakian, T. G. et al. 2010, MNRAS, 401, 1231

X-rays as a tool for disentangling nuclear activity from star formation processes

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The circum-nuclear regions of active galaxies hold fundamental information concerning the relationships existing among AGN and their hosts. Unfortunately, the simultaneous study of an AGN and its close environment is not straightforward, because, when the central source is directly observed, its extreme luminosity dominates the emission, suppressing the signals originated from neighboring regions. As a consequence, the best opportunity to investigate such environment comes from those cases where the strong continuum of the central engine is shielded by the intrinsic structure of the AGN and we are able to observe the host very close to the nucleus, as it happens in the case of type 2 objects. Optical spectroscopy shows that the circum-nuclear regions of active galaxies have signicantly different physical properties than those inferred for the same environment of the other systems. Indeed, while the spectral continuum close to the nucleus of a normal galaxy can be easily identied with that of an old, evolved stellar population, the stellar components of Seyfert 2 spectra show clear signatures of younger stars, with a systematically smaller continuum break at 4000 Å, indicating an excess of the spectral class A. The existence of hot stars in the nuclear environment leads us to conclude that a relatively recent star formation event must have occurred. On the other hand, the analysis of chemical abundances in the interstellar medium (ISM) found in these galaxies provides further suggestive indications. Several techniques, exploited to estimate the chemical composition of the Narrow Line Region (NLR), agree on the conclusion that heavy elements are more abundant in gas ionized by an AGN than in the nuclear regions of galaxies involved in ongoing star formation processes. The ISM of active galaxies, therefore, is evolved with respect to the case of star forming galaxies. Put together, all these hints place the circum-nuclear regions of active galaxies somewhere between the properties of normal galaxies, hosting an evolved stellar population, and those of galaxies where star formation occurred recently, as pointed out by the properties of their gaseous and stellar components. These results were veried on a large sample of spectra, covering the nuclear regions of galaxies with

redshift $z \leq 0.1$, collected at the public archive of the Sloan Digital Sky Survey (SDSS). Taking into account the limits imposed by the survey, whose observations are mainly concerned with the use of a xed aperture and a well established ux limit, it can be estimated that the physical properties found in the circum-nuclear regions of the observed galaxies are not signicantly affected by selection effects or by the distance dependence of the spectral sampling region and that they are an actual characteristic of the different object classes. A natural question, arising from the indications of recent star formation history in the nuclei of active galaxies, concerns whether star formation and AGN activity might be regarded, at least in some cases, as subsequent stages of an evolutionary sequence. As soon as the accreting black hole paradigm was established, together with the increasing evidence that every galaxy hosts a Super Massive Black Hole (SMBH) in its center, it has been argued that dynamic perturbations of the circum-nuclear environment are required to transfer matter towards the central engine. However, the processes which imply a perturbation of the circum-nuclear environment can either directly descend from star formation or they are at least very likely to enhance it, in agreement with the observational result. In order to further investigate the connection among AGN and star formation activity, we started a search for objects where the signature of nuclear activity might be hidden behind an ongoing process of star formation. Taking advantage from the recent technological achievements, that opened new frontiers in the amount and quality of the available data in several frequency ranges, it has now become possible to investigate the physics of galactic nuclei with unprecedented detail. The advance is particularly relevant in the eld of high energy signals, a distinguishing feature of AGN, since modern observatories are becoming able to trace direct hints of nuclear activity even in those cases where their typical signatures are suppressed by heavy absorption in the source. As a consequence of the small interaction cross section of photons with energy $E \leq 10$ keV, indeed, the most energetic tail of the intense AGN radiation eld might be able to penetrate the obscuring structures, which could prevent us from detecting the source at lower frequencies. Comparing our sample with the most recent catalogues of data released in the domain of X-rays, mainly by the XMM Newton satellite, but also taking observations from other missions, such as Chandra, we found out that various sources were detected in the energy range of hard X-rays. The largest number of detections, yielding 54 objects belonging to the Seyfert 2 class out of 2138 candidates, came from the sample of active galaxies. However, high energy activity was spotted in star forming galaxies, too, though with a smaller incidence of 16 detections out of 1302 candidates. The purpose of our project is to look for signatures connected with the presence of an active nucleus, hidden in the optical by the effects of surrounding star formation, in the range of high energy emission. At present, large amounts of archival material are becoming available to the scientic community, which could be of fundamental importance for this research, and more promising perspectives are developing thanks to the forthcoming observations. In order to identify hidden AGN activity and to provide a reliable distinction from external factors, such as the evolutionary processes of young stellar populations in the circum-nuclear region, which may also give raise to X-ray emissions, we looked at the X-ray properties of AGN affected by increasing amounts of obscuration. We exploited the Lipovetskys Catalogue of Seyfert Galaxies to select a reference sample. Applying the constraint $z \leq 0.1$, we found 121 Seyfert 1 galaxies detected as X-ray sources, with 29 having SDSS optical spectra in addition. Furthermore, 105 Seyfert 2 galaxies were recorded, with 27 providing additional SDSS spectra, while 43 lower ionization objects (LINERs) are detected as X-ray sources, out of which 2 have optical data available as well. In conclusion, it is our aim to develop a comparative analysis of objects where both optical and high energy observations are either available, or in the range of modern instruments technical capabilities. Looking at the main features which characterize the electro-magnetic emission of AGN in the domain of high energy signals, we shall probe the core of star forming galaxies, detected as X-ray sources, to clarify the origin of this radiation. The spectral energy distributions observed at these frequencies are starting to yield suggestive indications concerning the presence of nuclear activity, thus leading us to identify objects where the circum-nuclear star formation process may coexist with an AGN phase, possibly concealing its characteristic signatures in the optical spectrum.

Extragalactic Dark Matter Haloes and QSO properties Through Microlensing

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In this talk we make a review on the most recent work of our group in the field of extragalactic microlensing. Based upon information derived from parametrized sets of magnification maps, we offer an interpretation of the spectra of some real lensed sistems that leads to important conclusions regarding different aspects of lens Galaxies and QSO, namely the low content in MACHOs of the dark matter haloes or the structure of the -otherwise unresolved- quasar accretion disk.

This talk summarizes the both the paper published in ApJ under "Microlensing-based Estimate of the Mass Fraction in Compact Objects in Lens Galaxies" (2009ApJ...706.1451M) and the ongoing work of the group on the accretion disk structure of QSOs as well.

Exoplanet searches with micro and pixel lensing

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Gravitational microlensing (including pixel-lensing) is among the most promising techniques with an opportunity of detecting Earth-like planets at distances about a few astronomical units from their host stars. So, this technique could give a possibility to find exoplanets in the habitable zone even in other galaxies, in Andromeda galaxy, for instance. We compare the microlensing technique with other methods to discover new exoplanets.

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