Publ. Astron. Obs. Belgrade No. 73 (2002), 153 - 157 *Poster*

RADIAL VELOCITIES OF B-STARS TOWARDS THE GALACTIC ANTI-CENTER

Yu. GORANOVA, Ts. GEORGIEV, L. ILIEV, I. STATEVA, and N. TOMOV
Institute of Astronomy, Bulgarian Academy of Sciences
72 Tsarigradsko Shosse, 1784 Sofia, Bulgaria
E-mail goranova@astro.bas.bg

Abstract. Radial velocities have been determined for a sample of 22 stars of B2-B9 type situated towards the Galactic anti-center. The observations were carried out with the Coudé spectrograph of the 2m RCC telescope at Rozhen NAO in 2000-2001. This research is a part of an initial program aimed at studying the spiral structure of the Milky Way galaxy.

1. BACKGROUND

The spiral structure of distant galaxies can be traced by the distribution of young bright stars and emission line nebulae, the distribution of atomic and molecular gas, the spatial location of dust matter, as well as via pulsar radio emission. Unfortunately, the spiral pattern of our own Galaxy is much less obvious due to our obscured view from within the Galactic dusty disk.

The observed large-scale spiral features can in many cases be explained in frames of the density wave theory (Lin & Shu 1964) by regarding the arms as density perturbations in the galaxy disk. One of the main parameters in this theory is the arm gravitational potential, as far as it determines the strength and location of the density wave. In galactocentric polar coordinates (R, θ) the potential V_s of the main two-fold spiral at time t can be presented with

$$V_s(R,\theta,t) = A\cos[2\frac{\log(R/R_\odot)}{\tan(i)} - 2(\theta - \theta_0 - t\Omega_p)], \quad (1)$$

where Ω_p is the pattern angular speed, and θ_0 defines the phase at the solar radius $R_\odot$ at $t = 0$. The spiral is assumed to be logarithmic with pitch angle i, and amplitude A (Grosbøl 1997).

Spatial distribution of young Galactic OB-stars show clear evidence that they are in spiral arms (Drimmel et al. 1999), therefore their exact location can in principle be used to determine the parameters of the density wave. However the direct observations of density perturbations associated with the spiral arms are difficult due to a correlation between extinction and population effects in these regions (Grosbøl & Patsis 1998).

B-stars are relatively bright and that makes them ones of the most suitable optical tracers of the Milky Way spiral pattern. Late B5-B9 stars have well calibrated photometric properties hence their photometric distances can be derived accurately even in a field with a significant interstellar extinction. By means of spectroscopic observations their radial velocities can be derived and the velocity field can be constructed. Stars in the directions towards the Galactic center and anti-center are a special case. If their effective temperatures are determined from the photometry one can study the relation between radial velocity and age of stars as a function of the distance.

This paper is based on observations collected at the National Astronomical Observatory of Bulgaria. We present 24 CCD spectra of 22 B-stars located in an area of 10x10 square degrees around the direction to the Galactic anti-center. Radial velocities have been derived. The results are listed in Table 1, and the spectra obtained are plotted in Fig. 1.

2. OBSERVATIONS AND DATA REDUCTION

The observational program was carried out with the 2-m RRC telescope of Rozhen NAO during 13 nights from November 2000 to February 2001. The observations were obtained using a Coudé spectrograph equipped with a SITe 1024x1024 CCD. The dispersion was 8.3 Å mm^{-1}. The characteristics of the spectrograph are described in details in Kolev & Tomov (1996). The CCD-spectra were obtained in the spectral region λ 4810–5030 Å. A Th-Ar lamp was used for the wavelength calibration. A total of 24 spectra with exposures of 15 min each were obtained. The mean S/N ratio was about 100. Two reference stars were observed for the radial velocity zero-point determination.

All data reductions (bias subtraction, flat-field correction, wavelength calibration, continuum normalization, Earth motion corrections), as well as the line position determination were done with the ESO-MIDAS system.

As a reference for the line identification synthetic spectra were used. The synthetic spectrum for each of the studied stars was generated under the SYNTH-code (Piskunov 1992). The adopted atmospheric parameters were derived from the published Strömgren *uvbyβ* photometry (Hauck & Mermilliod 1998). The laboratory wavelengths were taken from the VALD-database (Piskunov et al. 1995).

In order to measure the line position each identified spectral feature was fitted with a Gaussian profile.

3. DISCUSSION OF THE RESULTS

Radial velocities have been determined for a sample of 22 B2-B9 stars by using the classical method of individual measurements of spectral lines. The heliocentric corrections were applied. The mean redial velocities were derived for Fe II, S II, Cr II lines. The zero-point was determined from IAU standards for each night, when the reference stars were observed.

The main characteristics and results for the program stars are summarized in Table 1. The stars are presented with their HD-identifiers. Apparent magnitudes m_V, spectral types, as well as the remarks about multiplicity and peculiarity are taken from the SIMBAD database. The effective temperature $T_{\rm eff}$ and the surface

Table 1: Characteristics and results for the program stars.

Star	m_V [mag]	Sp. type	$T_{\rm eff}$ [°K]	$\log g$	Comments	V_r [km/s]	σ	n
HD 34761	8.5	B8	9600	4.0	-	-18.8	3.6	4
HD 34762	6.3	B9IV	16000	3.3	SB	25.7	3.0	3
HD 35132	8.3	B9	-	-	EB, β Lyr-type	30.5	2.4	3
HD 35239	5.9	B9III	11000	3.2	-	-9.3	-	1
HD 35600	5.7	B9Ib	11000	1.9	-	0.2	1.0	5
HD 37098	5.6	B9IV-V	11000	4.5	double/multiple	37.7	7.8	5
						39.3	13.3	9
HD 37367	5.9	B2IV-V	9000	4.3	variable	23.1	4.5	5
HD 37519	5.9	B9.5III-IV	9000	3.6	p	-6.6	13.7	3
						-8.8	5.8	3
HD 38009	8.1	B9	10000	4.0	-	-28.5	2.0	4
HD 38062	8.5	B9	-	-	-	-6.1	11.5	4
HD 38306	7.7	B9	-	-	double star	16.7	-	1
HD 38450	8.0	B9	10000	3.8	-	7.4	6.4	4
HD 38909	8.3	B3II-III	11000	4.3	-	28.1	2.4	4
HD 39939	8.1	B9	-	-	-	-23.1	13.5	4
HD 40163	8.2	B9	-	-	double/multiple	-57.8	9.8	3
HD 40589	6.0	B9Iab	12000	1.8	double system	14.1	1.1	6
HD 40996	7.3	B9	9000	3.5	-	21.1	3.5	4
HD 41251	8.5	B9	-	-	variable	-6.3	1.2	6
HD 41269	6.1	B9	11000	3.5	-	8.8	5.2	8
HD 41600	7.0	B9	-	-	double/multiple	-31.5	2.9	5
HD 41638	7.8	B9	-	-	-	4.2	3.7	5
HD 41639	8.4	B9	-	-	-	27.2	-	1

gravity $\log g$, used for the synthetic spectra generation, are given in the fourth and fifth columns. The last three columns present the determined radial velocities V_r with their rms σ and the number n of the lines used for the radial velocities measurement. Obtained spectra are plotted in Fig. 1.

Main difficulties in determining the B-stars radial velocities come from the small number of the prominent lines. The obtained precision depends on the projected rotational velocity $v \sin i$ and the number of the lines measured. Inaccuracies came generally from the binaries/multiples and the possible peculiarities of the star.

Except for HD 37098 and HD 37519 the observations were performed only once. The results for these two stars show an accuracy sufficient for our purposes. An improvement of the precision can be obtained by using a cross-correlation method with synthetic spectra (see eg. Grenier et al. 1999).

Here we report the preliminary results for radial velocities of 22 B-stars situated in the direction to the Galactic anti-center. A total of 24 stellar spectra were examined. The observations were collected in a spectral region around H_β. In order to improve the statistics of the mean radial velocity obtained, we intend to extend our studies in other spectral regions. The present work is a part of an initial program aimed at studying the spiral structure of our Galaxy.

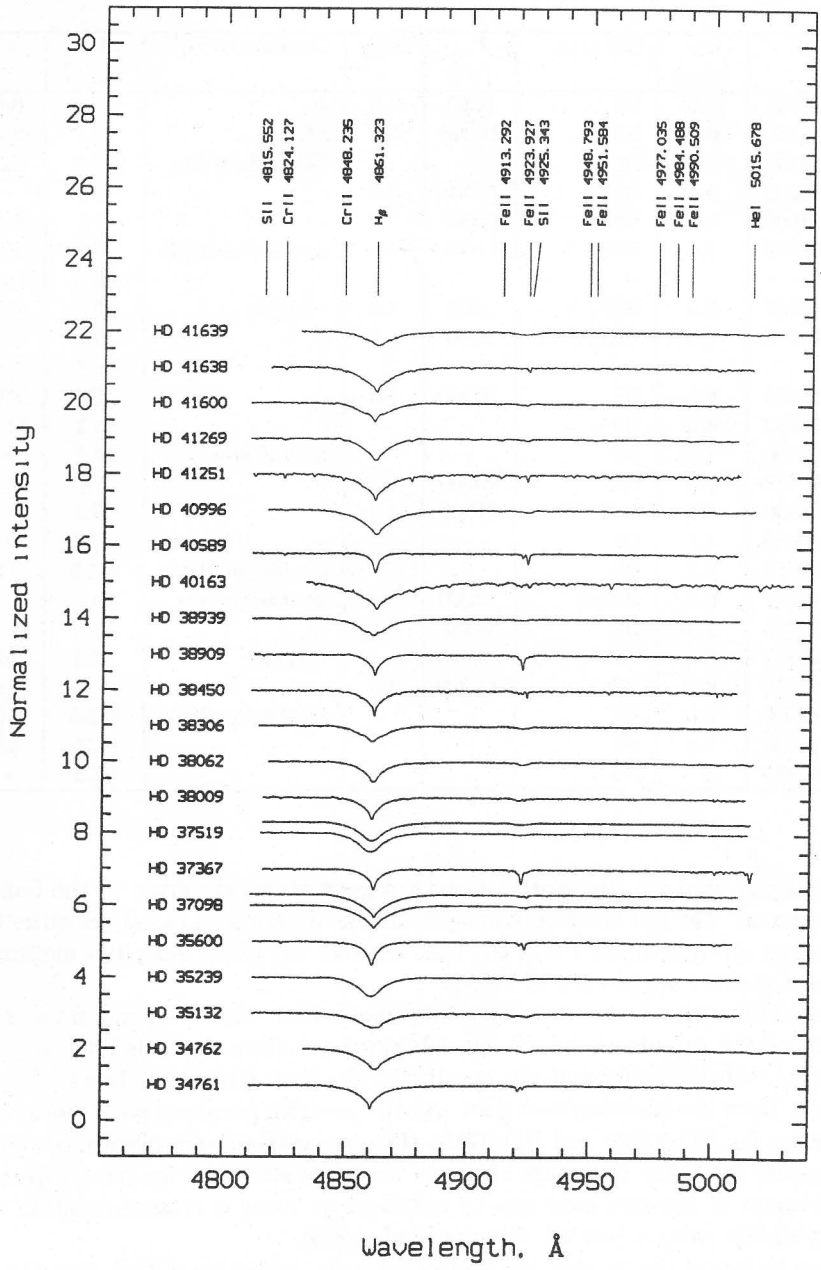

Fig. 1: Plot of the normalized spectra of the studied 22 B2-B9 stars. The identified spectral features of the H_β-line, as well as of the lines of Fe II, S II and Cr II ions are shown. The spectra are ordered with respect to the increasing of their HD-identifiers.

Acknowledgements. This research was made by using the SIMBAD database operated at CDS Strasbourg, France and the VALD database accessible via VALD-EMS Vienna, Austria.

References

Drimmel, R., Smart, R. L., and Lattanzi, M. G. : 1999, *Modern Astromrtry and Astrodynamics, eds. R. Dvorac, H. F. Haupt, K. Wodnar*, Austrian Acad. of Sci., Vienna.

Grenier, S., Burnage, R., Faraggiana, R., Gerbaldi, M., Delmas, F., Gomez, A. E., Sabas, V., and Sharif, L. : 1999, *Astron. Astrophys. Suppl.*, **135**, 503.

Grosbøl, P.J. : 1997, *Wide Field Spectroscopy, eds. E. Kontizas et al.*, ESO A4-8, **18**, 177.

Grosbøl, P. J., Patsis, P. A. : 1998, *Astron. Astrophys.*, **306**, 840.

Hauck, B., Mermilliod, M. : 1998, *Astron. Astrophys. Suppl.*, **129**, 431.

Kolev, D., Tomov, T. : 1996, in *Proc. of 100th Anniversary of the Sofia Univ. Obs., eds. Maslev K., Kurtev R.*, Sofia, Bulgaria, p. 65.

Lin, C. C., Shu, F. H. : 1964, *Astrophys. J.*, **140**, 646.

Piskunov, N. : 1992, in *Stellar Magnetism, eds. Yu. Glagolevskij and I. Romanyuk*, Nauka, St. Petersburg.

Piskunov, N., Kupka, F., Ryabchikova, T., Weiss, W. and Jeffrey, C. : 1995, *Astron. Astrophys. Suppl.*, **112**, 525.

Vallée, J. P. : 1995, *Astron. J.*, **454**, 119.