14. Supplement: Galactic Structure Studies Recently Carried Out in the USSR

14.1 Introduction

During the triennium under review some proceedings and books have been published in the USSR concerning the field of galactic research. Among them there are the proceedings of the international colloquium "Stellar Catalogues: Data Compilation, Analysis, Scientific Results", held in Tbilisi, USSR, 10–15 September, 1984 (Kharadze and Kogoshvili, 1985), and "Problems of Astrometry" (Podobed, 1984). A number of books were published: "The Galaxy" (Marochnik and Suchkov, 1984), "Physics of Gravitating Systems", volumes I and II (Fridman and Polyachenko, 1984ab), "Stellar Astronomy" (Agekyan, 1985), "Magnetic Fields in Space" (Bochkarev, 1985), "Methods in the Qualitative Theory of Dynamical Systems in Astrophysics and Dynamics" (Bogyavlensky, 1985), "Supernovae and Stellar Wind: Interaction with the Gas of the Galaxy" (Lozinskaya, 1986).

14.2 Basic Data and Calibrations

Glushneva (1985ab) published a spectrophotometric star catalog in which effective temperatures, angular diameters, bolometric corrections, radii, luminosities and gravities were presented for different groups of stars. The scale of effective temperatures has been constructed. A catalog of metal-deficient F–M stars was compiled by Bartkevichius (1984ab, 1985, 1986). Alksnis (1985) presented a catalog of carbon stars based on the data obtained with a Schmidt telescope. Salukvadze (1985) presented a catalog of trapezium-type multiple systems. Lebedev and Lebedeva (1985) and Lebedev (1986ab) compiled a catalog of chemically peculiar stars and studied their spatial distribution and kinematics.

Catalogs of stellar magnitudes and colour indices of stars in different regions of the sky were compiled by Kazanasmas *et al.* (1984, 1985), Kazanasmas *et al.* (1985), Tokhtas'ev (1985), and Baltabaev *et al.* (1985). Zdanavicius and Cerniene (1985) published new, accurate values of photoelectric magnitudes and colour indices of 33 stars in the Cygnus standard region in the Vilnius photometric system. Eglitis (1986) obtained the absolute energy distribution shown in the spectra of 22 carbon stars. Kazanasmas *et al.* (1986) published stellar magnitudes and $B-V$ colour indices in the BV system for eight photometric standards in the direction of Wirtanen-Vyssotsky areas.

Analysis of spectra of four red giants in the Hyades by the model atmosphere method, performed by Mishenina *et al.* (1986) showed metallicity excess in the atmospheres of Hyades giants of $\Delta[Fe/H] = 0.08$. Mishenina and Panchuk (1986) found from analysis of homogeneous spectroscopic observations of a sample of K giants that the metallicity dispersion is equal to 11 with an error of $\Delta[Fe/H] = 0.1$. Sil'chenko (1984) confirmed a new metallicity scale of globular clusters on the basis of calculations of model integrated $B-V$ colours. Kopylov (1985) constructed a $(U-B)_o$ vs. $(B-V)_o$ diagram for O5–K5 stars of the luminosity class V with solar chemical composition.

Avedisova (1985) cataloged star formation regions in our Galaxy. Sleivyte (1986) calculated the ratios of colour excesses and the R ratios in the UBV and Vilnius photometric systems for carbon and barium stars. Straizys (1985) summarized the calibration of a number of important photometric systems. A program for two-dimensional quantitative spectral classification of stars in the Vilnius photometric system was developed by Jasevichius (1986). Smriglio *et al.* (1986) described an automatic method of two-dimensional stellar classification from photographically determined magnitudes using the seven-colour Vilnius photometric system. Malyuto and Shvelidze (1985), Kuzmin *et al.* (1986) and Malyuto (1986) developed a method of deducing external weights of catalogs from data residuals and applied this method to $[Fe/H]$ and T_{eff} catalogues.

14.2.1 Photometry

Bartasiute (1984, 1985ab) published results of photoelectric photometry of stars near the galactic poles in the Vilnius photometric system. Results of photoelectric photometry in the same system in the region of open cluster M29 were presented by Kazlauskas and Jasevichius (1986). Straizys *et al.* . (1986) published photometric data for about 100 metal-deficient stars. Sleivyte (1986b) presented results of photoelectric photometry in the Vilnius photometric system for 27 low-temperature carbon stars. Cernins (1986) performed the Vilnius photometry in Kapteyn areas 92, 108 and 112, and Janulis (1986) did the same in the direction of globular cluster M56. Zdanavicius (1986) measured about 30 metal-deficient G–K giants in the $UBVR$ system . Kizla and Paupers (1985) presented observations of 73 stars also in the $UBVR$ system. Dzervitis and Paupers (1985) published results of photoelectric photometry in the Vilnius system for 12 stars in the immediate neighbourhood of WCMa. A photometric classification of these stars has been performed. Andruk and Kharchenko (1987) performed observations (photoelectric and photographic) for the determination of $UBVR$ magnitudes.

14.2.2 Spectra and Luminosity

Karimova and Pavlovskaya (1985) compiled a list of high-luminosity stars and Cepheids for meridian observations. It contains stars with radial velocities, photometry and a two-dimensional spectral classification. Garibdzhanyan *et al.* (1984) presented results of a spectro-photometric study of 277 OB stars in the region around P Cyg. Zakomanova (1984) identified faint carbon stars in the direction of the galactic anticenter on infrared-sensitive spectral plates. Nikolashvili (1987) detected 180 carbon stars on the basis of the low dispersion spectral material. A spectral classification of 89 faint O–B starts around the cluster IC 1805 has been carried out by Kuznetsov (1984) with the use of unwidened objective prism spectra. Catalogs of *BV* magnitudes and spectral classes of 6000 stars have been compiled by Pugach *et al.* (1985).

14.3 Local Galactic Structure

14.3.1 Low Galactic Latitudes

On the basis of catalogs of photographic *BV*-magnitudes and spectral classes of stars Guseva *et al.* (1984) investigated the distribution of absorbing matter and B0–B2 stars in $5° \times 5°$ region toward the Rosette nebula. In the same direction Guseva (1986) identified the interstellar dust clouds of various densities. Guseva and Metreveli (1986) studied the distribution of the interstellar absorbing matter in the direction $l = 207°$, $b \approx -3°$. Levina (1985) investigated the distribution of the dust material in the region centered at $\alpha_{1950} = 4^h34^m$ and $\delta_{1950} = +26''$. Kolesnik and Metreveli (1985ab) investigated the structure of galactic spiral arms and star formation regions. Kolesnik (1986) studied the distribution of dust clouds along the line of sight in the direction of the CO molecular cloud in the W3 region of star formation. Kalandadze *et al.* (1986) studied absorbing matter in NGC 2264 and its relation to the star formation.

On the basis of photoelectric absorption curves Uranova (1985) determined the form and location of the dust-arm axis up to the distance of 4 kpc from the Sun. Pavlovskaya and Suchkov (1984) performed a statistical analysis of the space distribution of bright stars and open clusters in the fourth quadrant of the Galaxy. It was shown that the Sagittarius-Carina spiral feature cannot be a chance density fluctuation in an actually homogeneous distribution of stars. Basharina *et al.* (1985) studied the stellar structure of the Orion arms by numerical experiments. Melik-Alaverdyan and Tovmasyan (1986) studied the distribution of late-type giant stars in the galactic plane. Avedisova and Kondratenko (1984) derived the distribution of diffuse nebulae in the galactic plane. Avedisova (1985) found some parameters of spiral arms of the Galaxy traced by 255 emission nebulae with known photometric distances. Petrovskaya (1986) studied the large-scale distribution of neutral hydrogen in the Galaxy. Yudaeva (1985) discussed the fine structure of the gas layer in the region $220° < l < 260°$, $|b| \leq 15°$ obtained on the basis of the 21-cm radio line observations with the *RATAN*-600 radio telescope. Amnuel *et al.* (1986) showed that the birthplaces of pulsars are located within OB-associations and/or in the galactic arms.

14.3.2 High Latitude Optical Studies

Bartasiute (1987) estimated the variation of metal abundance perpendicular to the galactic plane, using data on metallicities and distances of 190 F–K stars in the direction of the North Galactic Pole. The resulting gradient amounts to -0.7 ± 0.1 kpc^{-1}. Einasto *et al.* (1985) described an observational program of the main meridional section of the Galaxy. Complex (astrometric, photometric, spectral) observations of stars in selected areas have been continued. The aim of this program is study of the spatial and kinematic structure of physically homogeneous subsystems of stars. Gradients and other parameters of subsystems will be determined. In the frame of this program Kharchenko (1984, 1987) outlined the data to be used and compiled a catalog of proper motions of 14,100 stars with respect to 206 galaxies. Rybka (1985a) recommended reference stars at high galactic latitudes with relatively small proper motions to be used to decrease the cosmic error of stellar proper motions.

14.4 Overall Galactic Structure

14.4.1 Galactic Disk

Kharadze *et al.* (1985) obtained stellar density values in the solar neighbourhood, and the β parameter defining stellar distribution along the z-coordinate. The distribution of B stars in the projection on the plane of the Galaxy was investigated. Mdzinarishvili (1985) obtained information on the stellar density function $D_s(r)$. Catalogs of *BV* photometry and MK classification were the source of this information.

Statistical investigation of the field-star luminosity function was carried out by Vereshchagin and Piskunov (1984) on the basis of some photometric and spectral machine-readable catalogs. Myakutin (1984) estimated the influence of small systematic differences in the definition of luminosity and effective temperature in the 4-colour Strömgren photometric system and MK spectral classification on the inclination of the initial mass function. Dluzhnevskaya *et al.* (1985) found mass distributions on the basis of photo-electric *UBV* data for 12 open clusters. Malkov (1987) showed that the uncertainties of the BC-scale and effects of unresolved binaries could essentially influence the slope of resulting IMF.

Suchkov (1986) analyzed the mass-diameter relation for stellar systems. Gvaramadze and Lominadze (1986) modelled the galactic disk by an oblate spheroid with confocal isodensity surfaces. Kasak (1986) applied the accretion theory to the generation of spiral structure of galaxies and derived formulae to calculate brightness profiles of spiral arms. Gusejnov and Yusifov (1986ab) found the luminosity function of pulsars and evolutionary ages of most known pulsars ($5 - 10 \times 10^6$ years). Vladimirskij (1985) studied the spatial distribution of pulsars and found that their mean distance to the galactic plane is $\sim$ 50–70 pc.

14.4.2 Galactic Center

Zakhozhaj (1984) analyzed stellar populations within 10 pc. Gurzadyan (1985) studied dynamical structure of the central region of the Galaxy. Ozernoj (1986) proposed a hybrid model for the active source at the center of our Galaxy, containing a very massive star coupled with a black hole. Kardashev (1985) developed a phenomenological model of the galactic core. Stern (1984) collected data for and against the black hole hypothesis. Ozernoj (1984a) argued that a symbiotic object consisting of a superstar and a moderate-mass black hole seems to be able to explain the principal features of the galactic centre emission. Ozernoj (1984b) found that recent observations of broad HeI and HI lines from IRS 16 located at the galactic centre indicate an outflow of matter from it. Seitnepesov and Khanberdiev (1984, 1985) proposed a mechanism for the activity of the non-thermal radio source in the centre of the Galaxy. Different models of the activity of the non-thermal radio source in the galactic centre were analyzed.

14.4.3 Galactic Rotation Curve

Haud (1984) demonstrated that the existing observational data do not conflict with the hypothesis of the flat rotation curve of our Galaxy. Kolesnik and Yurevich (1985) determined the galactic rotation curve up to 16 kpc using the relation between parameters of OH molecular absorption features of clouds and distances to the clouds. Yurevich (1985) determined the distance of the Sun to the galactic centre from the rotation curve with the use of OH clouds. The rotational curve of the Galaxy was constructed by Avedisova (1985) with the aid of 178 diffuse nebulae with known radial velocities and photometric distances obtained in a uniform way. The rotation curve of the outer parts of our Galaxy from neutral hydrogen 21-cm line profiles was analyzed by Petrovskaya and Teerikorpi (1986).

14.4.4 Integrated Galactic Spectrum for UV and Optical Data

Zavarzin (1984) presented results of surface photometry of the northern Milky Way in the *V* system. Zvereva *et al.* (1985) presented observations of the far-UV spectrum (1300–1800 Å) of the sky background at different galactic latitudes.

14.4.5 Evolution of the Galaxy

Marsakov and Suchkov (1985) discussed the chemical pattern of the Hertzsprung-Russel diagram of red giants and the age of the galactic disk. They used photometric data for about 1400 disk-population red giants. The data support the view that the disk is $\sim 6 \times 10^9$ years younger than the halo, the age of which is apparently not less than 13×10^9 years. Marsakov and Suchkov (1984, 1985b) discussed also the distribution of metallicity $[Fe/H]$ and found that it cannot be described by a Gaussian. The center of the distribution of giants at the galactic poles is found to demonstrate a statistically significant gap similar to the one found earlier for the main sequence stars. Suchkov *et al.* (1987) found some discrepancies in characteristics of UV excesses and metallicity distributions of F–G–K dwarfs. They can be eliminated if we assume that UV excess of K and late G dwarfs and $[Fe/H]$ values from detailed analysis of F dwarfs were underestimated. Bartkevichius (1984) also discussed the metallicity distribution of metal-deficient field stars. Shchekinov (1985) discussed the abundance of deuterated molecules in the Galaxy. Shklovskij (1985) concluded that specific features of the galactic center, observed at different regions, can be explained by a permanent star formation process. Shatsova (1984) discovered traces of the torus-like structure of the Kapteyn group, which permitted an evolutionary interpretation. In the paper of Traat

(1986) spiral arms of galaxies have been modeled by a young stellar component with prolonged and symmetrical star formation rate.

14.5 Kinematics

14.5.1 Stars

Loktin (1984) discussed kinematics of red giants in the solar neighbourhood. Karimova and Pavlovskaya (1984b) studied kinematics of young objects in the Galaxy. Kharchenko (1984) dealt with kinematics of stars in the galactic plane. Barkhatova *et al.* (1984) discussed the distance scale of the Galaxy. Barkhatova *et al.* (1985) estimated the angular velocity gradient and scaling galactic parameter for open cluster systems.

Palous and Piskunov (1985) investigated the mean velocity and the velocity dispersion versus age relations for B and A stars. Rybka (1985b) used the maximum likelihood method to divide 2463 faint stars in 30 areas with galaxies into two groups at different distances. Kinematics of distant stars was shown to have departures from the Oort-Lindblad model. Khrutskaya (1984) analysed galactic rotation and the correction to the constant of precession and coordinates of the solar apex according to proper motions of bright stars. Petrovskaya (1987) discussed the structure of the neutral hydrogen subsystems in the Galaxy. Allakhverdiyev *et al.* (1985) investigated space kinematic characteristics of pulsars and their connection with supernova remnants.

14.5.2 Interstellar Matter

Gorbatskij and Usovich (1986) found that ringlike structures consisting of clouds must be formed in spiral galaxies due to viscosity. Shapirovskaya and Bocharov (1986ab) performed an analysis of observed and theoretically calculated characteristics of pulsar radiation scattering. The results show that hot ionized plasma may be responsible for the scattering properties of the diffuse interstellar medium. They constructed the spatial distribution of the mean electron density for the diffuse interstellar medium in the galactic disk on the basis of dispersion measures of pulsars with known distances. Dogiel *et al.* (1986) investigated processes of distribution of accretion and energy losses of cosmic rays in the vicinity of molecular clouds.

Eelsalu (1986) discussed formulae underlying the use of intensity profiles of the interstellar gas medium for large-scale galactic studies. Gurevich *et al.* (1985) investigated the mechanism of generation of fluctuating electromagnetic fields affected by neutral gas turbulence of giant molecular clouds. Dogiel *et al.* (1985) made an attempt to determine the mechanism which could lead to the increase in the cosmic-ray density in clouds. Suchkov and Shchekinov (1985) discussed ionization processes in the interstellar gas. Kissel'man and Frolov (1986) found a numerical solution for the size distribution function of solid charge particles in interstellar clouds. Mirzoyan and Ambaramyan (1986) discussed the connection of optical HII regions with molecular clouds of the Galaxy.

14.6 Radio Studies

Berlin *et al.* (1984) presented the results of the very deep cross-cut of the Galaxy at 7.6 cm wavelength. Berlin *et al.* (1985) also presented the results of observations of the giant HII regions situated at the longitudes $4° - 10°$, also at 7.6 cm wavelength. Pyatunina (1984, 1985, 1986) performed a survey of the galactic plane in the region of some associations carried out at 7.6 cm wavelength at the *RATAN*-600 radio telescope, and discussed the outer Galaxy and different statistics of radio sources. Vitkovskij *et al.* (1985) performed a radio survey in the Orion Loop region, a giant ring-like feature in the radio-continuum emission. Anisimova (1984) calculated the correlation between the stars and the continuous 240 MHz radio emission intensity distribution in the Loop I system. Abramenkov (1985) carried out decameter observations of HII regions in the galactic disk, $147° < l < 153°$. Strukov and Skulachev (1987) presented the results of an atmospheric survey of the galactic plane at the frequency of 37 GHz. Gulyaev and Sorochenko (1985) reported data on the catalog of radio recombination lines. For the radio source at the centre of the Galaxy $V_{exp} = 2 - 1 \pm 7$ km.s^{-1}. Bystrova (1985) made an additional representation of the Pulkovo sky survey results for the HII radio line.

14.7 Dynamics of Our Galaxy

14.7.1 Dynamics

The basic theory for the galactic, spatial and kinematical structure as a whole is provided by dynamics starting with the theory of stellar orbits dictated by gravitational potential and the integrals of motion (Genkin and Genkina, 1984, 1985; Ivannikova and Maksumov, 1985). The galactic gravitational potential has been modeled by Kosenko (1986), Abramyan (1986), Kutuzov and Osipkov (1986), Kondrat'ev (1984) and Danilov (1984). Various aspects of the large-scale dynamics have been discussed by Osipkov (1985) and Omarov (1985). The equations of dynamics have been analysed by Osipkov (1985), while Batt (1986) has attempted to introduce the Vlasov-Poisson equations into stellar dynamics. A special problem related to phase dynamics has been treated by Genkin and Genkina (1984). Dissipational and interactive mechanisms have been treated by a number of theoreticians: Gurzadyan and Savvidin (1984, 1986), Fridman *et al.* (1985), and Sagintaev and Chumak (1984). Vinokurov *et al.* (1985) have worked at collisionless relaxation. Numerical experiments have been conducted by Zotov and Morozov (1987).

14.7.2 Disk Dynamics

If the presence of a spiral structure is postulated, its study becomes a matter of disk dynamics. Spiral density waves are consistent with the solutions of gas-dynamical equations. Because of the small dynamical role of the galactic gaseous medium, the two kinds of theories need not be mutually exclusive. The interaction of the gaseous spiral waves with stars has been studied by Korchagin (1985) and Korchagin and Ryabtsev (1987). The following authors have attacked the theory of spiral waves: Abramyan and Mikhajlova (1986), Litvintsev (1985), Korchagin and Korchagin (1984, 1985), Abramyan and Arutyunyan (1985), Moroz *et al.* (1985), and Korchagin and Ryabtsev (1986). The stability of disks has been studied by Zasov *et al.* (1985), Abramyan (1985), Morozov *et al.* (1985), Morozov (1985), and Bisnovatyi-Kogan and Seidov (1985). The latter two authors have studied magnetized disks, too (Bisnovatyi-Kogan and Seidov, 1985ab). Disk dynamics have been interpreted in terms of observational data by Zasov and Morozov (1985ab), Fridman (1986) and Abramyan *et al.* (1986). Mishurov (1984), Korchagin (1986), Grivnev (1985) and Morozov *et al.* (1985) have carried out numerical computations, while Nezlin *et al.* (1986) have made laboratory experiments. Korchagin and Prokhovnik (1985) have simulated numerically a situation where a wave pattern is imposed by a companion stellar system. Global properties of disks have been discussed by Zasov and Osipova (1987) and Morozov and Khoperskov (1984).

14.7.3 Violent Dynamics

Violent dynamics are concerned with explosive point sources such as the galactic nucleus or supernovae, but also with the nature of shock waves occurring in disk dynamics, as well as with early stages of the galactic evolutionary scenario, where the gravity is inefficient. Violent phenomena can be either local or global. The galactic nucleus as an energy source has been discussed by Illarionov and Romanova (1986), Dokuchaev and Ozernoj (1985) and Baranov (1986). The influence of a supernova explosion upon the interstellar gas medium has been described by Kovalenko and Shchekinov (1985). The effects of galactic shock waves to radio source scintillations have been described by Pimenov (1984), and their effects upon cosmic rays by Ptuskin (1986), Galeev *et al.* (1986) and Berezhko (1986).

Galaxy formation scenarios include studies of collapsing systems. Collapsing disks have been studied by Nuritdinov (1985) and Kolykhalov and Shandarin (1984); collapsing spheres have been studied by Malkov (1987) and Nuritdinov (1985). Osipkov (1985) and Nezhinski and Osipkov (1987) have discussed violent relaxation. Concepts of thermodynamic stabilization have been developed by Suchkov *et al.* (1985), Terletskij (1984) and Tsitsin and Simentsov (1984). A pulsation model for stellar systems has been outlined by Malkov (1984). Korchagin and Ryabtsev (1986) have modeled the star formation process.

14.8 X-rays, Cosmic-rays, Gamma-rays, Magnetic Fields

Bochkarev (1987) considered the structure of the local interstellar medium and sources of the soft X-ray background radiation. Ginzburg and Ptuskin (1986) reviewed the cosmic-ray origin problem. Kuznetsov (1986) discussed the influence of cosmic rays on the stability and large-scale dynamics of the interstellar medium. According to Gurzadyan (1985), stellar aggregates may be powerful sources of cosmic rays. Fomin *et al.* (1985) searched super-high-energy γ-rays from various objects and regions of the Galaxy. Agaronyan *et al.* (1985) analyzed the ultra-high energy γ-ray absorption on the microwave background radiation. Mukhanov and Fomin (1986) observed the galactic disk at ultra-high energies. Dogiel and Uryson (1986) calculated the distribution of relativistic protons in the Galaxy. Shapirovskaya and Bochkarev (1985) discussed the distribution of electron density and scattering inhomogeneities over Galaxy. Seitnepesov and Khanberdiev (1985) discussed the structure of the large-scale magnetic field of the Galaxy. Radio background intensity variations and the structure of the galactic magnetic field has been studied by Dogkemansky and Shoutenkov (1987).

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