33. STRUCTURE AND DYNAMICS OF THE GALACTIC SYSTEM (STRUCTURE ET DYNAMIQUE DU SYSTEME GALACTIQUE)

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1. Introduction

Commission 33 has the long-standing tradition of producing two versions of the report covering its activities in the general field of Galactic Structure during the past triennium. The short version of the report is the one presented here. A longer, more complete version, is being printed by the President for distribution to all members of the Commission.

Compilation of the triennial summary is one of the major tasks of Commission officers. Section 2 of this report was prepared by M. Major; section 3 by L. Balasz; sections 4 and 8 by L. Blitz; section 5 by G. Lynga; section 6 by D. Hartmann; section 7 by J. Bloemen; sections 9 and 10 by U. Haud and J. Einasto; section 11 by R. Wielen; section 12 by B. Fuchs; section 13 by J. Binney; and section 14 by V. Malyuto and J. Einasto.

2. Basic Data and Calibrations

2.1 Basic Data

Basic data useful for Galactic astronomy are more and more numerous but with the generalization of the machine-readable catalogues and data bases they become very easily accessible. More than 450 machine catalogues are presently available to observatories upon request. This short report merely summarizes work done in the field of the acquisition of basic data; reading of the different issues (numbers 27 to 32) of the "Bulletin d'Information du Centre de Données Stellaires" of Strasbourg (France) is recommended, or of the NSSDC-WDC-A-RS publication no. 83–84 and Astrosoviet preprint **3–86** of the Soviet Center of Astronomical data. You will find, for example, detailed documentation for machine-readable catalogues done by Warren and Roman for the majority of large catalogues (for ex. 37.002.008 to .015, 37.002.096, 38.002.039 to .042). Procedures for obtaining data from the Astronomical Data Center and policies for distribution have been described by Warren (42.002.049) or can be found in the Bull. Inf. CDS **32** (1987), p. 127. Star catalogues and files available at the Stellar Data Center are listed in (41.002.075). The various data retrieval capabilities of the new *SINBAD* data base of the Centre de Données Stellaires have been described by Wenger and Ochsenbein (37.002.031/032). Among the new catalogues let us mention *IRAS* catalogues and atlases: Atlas of low-resolution spectra by Olnon *et al.* (42.002.038); the Bibliographic Catalogue of stellar radial velocities (1970–1980) by Barbier-Brossat and Petit (42.002.035); the Catalogue of 900 faint star UV spectra based on observed data of the Space Observatory Orion-2 by Gurzadyan et al. (41.002.027); the *HEAO A-1* X-ray source catalogue by Wood et al. (38.002.048) including positions and intensities for 842 X-ray sources; the General Catalogue of variable stars discovered until 1982, by Kholopov (39.002.023, 40.002.068): a Supplement to the Bright Star Catalogue containing data for stars with $V = 7.1$ and brighter that are not listed in the Bright Star Catalogue, Hoffleit *et al.* (37.002.007). For metal deficient stars, see Bartkevicius (38.002.005, 37,002.39 and 38.002.075), for $uvby\beta$, see Hauck and Mermilliod (39.002.016), for Vilnius photometry (38.002.052) and for *UBVRI* see Lanz (42.002.036), for MK classification (39.002.108) and for $[Fe/H]$ determinations (39.002.001). A new and extensive catalogue of *UBV* photoelectric photometry has been compiled by Mermilliod (1987) who collected all data published between 1953 and 1985, which led to a final catalogue of 136,319 entries concerning 87,267 stars. A new version of the Geneva photometric catalogue is being prepared by Rufener and should include about 4×10^4 stars.

A large set of basic data for galactic structure is expected from the future *HIPPARCOS-TYCHO* space mission: star positions, parallaxes, proper motions, magnitudes. Intensive preparation work has been done in relation with

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the Input Catalogue (INCA). Ground-based astrometric and photometric observations are in progress. A first possible Input Catalogue is described by C. Turon (1986), Scientific Aspects of the Input Catalogue preparation have been discussed in an ESA colloquium (40.012.019).

Becker and collaborators have published volume ten of the Basel Photometric Catalogue (*RGU* system) for fields in Anticenter, Carina, Centaurus, Aquila and Cassiopeia (39.002.010).

During the last triennium Gliese and Jahreiss continued the compilation of the "Third Catalogue of Nearby Stars" which will be extended to 25 pc from the Sun. At least 3000 objects (singles and systems) are expected to be included in this catalogue.

A Catalogue of Infrared Observations by Gezari *et al.* (37.002.079) summarizes all infrared astronomical observations published between 1965 and 1982.

A new edition of the Yale parallax catalogue is in preparation by van Altena (37.002.086, 38.002.029). New parallaxes have been determined by Upgren et al. (39.111.016), Vilteki *et al.* (42.111.018), Ianna (42.111.009), Scales and Zhao (37.111.011) and Harrington *et al.* (39.111.005).

From the proper motion survey with the 48-inch Schmidt telescope, Luyten and collaborators have published a list of double stars with common proper motions (37.111.020), the proper motions of 6056 stars in the Pleiades-Hyades region (39.111.025) and for 7698 stars in the Hyades region (41.111.027).

A survey of trigonometric parallaxes and proper motions with the UK Schmidt telescope yields astrometric and photometric data for a complete sample of 6125 stars brighter than $B = 17.5$ in the South galactic cap. Murray *et al.* (42.111.014, 42.111.012).

A search has been made by Halbwachs to find common proper motion systems among AGK3 stars (42.111.012). Part of the Second Cape Photographic Catalogue 1950.0 containing provisional positions of stars in the Cape zone −40° to −52° has been published by Nicholson *et al.* (37.002.024); new proper motions have been determined for 22,731 stars.

Absolute proper motions of stars relative to galaxies have been determined by Zhu and Wang (38.111.016) and by Baltahaev, Rakhimov and Umarova (39.002.086/087/088/089). An objective prism survey carried out by Stephenson provided a sample of more than 2000 candidates for K and M dwarf status, generally having proper motions that are either unknown or less than 0″.2 per annum (41.114.085) and a sample of high proper motion K and M stars (42.111.007).

A very large number of radial velocity measurements was published during the last three years. Many investigations have been directed towards halo kinematics. Fouts and Sandage (41.111.016) have obtained new radial velocities for 889 high-proper-motion stars and have rediscussed previously known relations between space motion and chemical composition. Carney and Latham (42.155.035) have examined the kinematics from new radial velocities of 85 metal-poor field red giants. Carney, Latham (1987) have also published *UBV* photometry and radial velocities for about 900 G-stars selected from the Lowell Proper Motion Survey without any metallicity bias. Their radial- velocity data indicate a binary fraction of the high velocity stars probably exceeding 25%. Radial velocities of 57 RR Lyrae stars have been obtained by Hawley and Barnes (40.111.008). Kinematic investigations of the outer galactic halo have been published by Sommer-Larsen and Christensen (39.111.001, 41.111.004) using a sample of blue horizontal branch field stars and by Ratnatunga and Freeman (39.155.100) using faint K giants. Radial velocities of these giants show that the outer halo is at most slowly rotating and that the line-of-sight velocity dispersion is approximately constant with increasing distance from the Sun. Stock's catalogue of radial velocities from objective prism plates of (40.002.083) has been used to select southern stars of high radial velocities, Stock *et al.* (38.111.021, 38.111.009).

Radial velocities of 790 late-type bright stars, Andersen *et al.* (39.111.002) and 551 A and F type stars, Nordstroem and Andersen (40.111.001) complete the V_r data of the Bright star catalogue. Part of a large survey of the population II stars radial velocities has been acquired for a preliminary list of 146 F stars, by Andersen and Nordstroem (40.111.001).

Photoelectric radial velocities of 406 ninth-magnitude KO stars located in ten small regions at galactic latitudes ±35° have been acquired by Griffin (41.111.003). Jones and Fisher (37.111.012) have published the velocities of 116 southern red stars.

The first eight years of radial velocity studies at Fick Observatory have yielded 16,000 observations of over 2000 late-type stars; Beavers and Eitter (42.111.010) and (1986).

Radial velocities of standard stars have been discussed by Barnes *et al.* (41.111.010), Maurice *et al.* (38.111.003), Mayor and Maurice (39.111.040) and Stefanik *et al.* (1985).

Fehrenbach and collaborators (42.111.020; 42.111.021) published prism objective radial velocities. Part of these velocities were obtained for stars of the *HIPPARCOS* astrometric mission.

We also wish to mention the Bibliographic Catalogue of Stellar Radial Velocities done by Barbier (39.002.097) and Barbier & Petit (42.002.035).

Numerous photographic photometry surveys are done in various directions in order to determine reddening density and luminosity function, but also to test galactic models. Due to the developments of an automatic measuring device, star counts to faint magnitudes are more and more recognized as an important information on galactic structure, Morton (41.155.082), Bahcall (42.155.031).

In *RGU* three-colour photometry, Fenkart and collaborators have done investigations in the directions of the anticenter (38.113.005, 39.113.004) as well as the anticenter-northern galactic meridian (38.113.012). Other starfields were investigated in the direction of VelaII by Marsoglu (38.113.052), around NGC 2158 by Topaktas (38.113.051), near IC 2581 by Alfaro and Garcia-Pelayo (38.113.019), in the direction of Praesepe by Karaali (38.113.004) or in the direction of Scutum (39.155.073). The galactic structure was examined in a faint object survey in a field in Aquarius by Tritton, Morton and collaborators (38.155.008, 39.114.015, 41.155.083). A photometric survey of two high-galactic-latitude fields has been carried out by Friel and Cudworth (41.155.088). Observed magnitudes and colour distributions have been compared with star-count predictions from the Bahcall-Soneira galaxy model.

Three fields of the galactic bulge have been analyzed by Rodgers *et al.* (42.155.038) using star counts, colour distributions and colour-luminosity arrays. For these star counts more than 120,000 photographic stellar images were used.

Reed and Fitzgerald have determined the distribution of B5 to M5 stars to $V \simeq 12.5$ in the direction of Puppis (38.115.034/035). Dubyago (37.113.053) carried out *UBV* photographic measurements of 2200 stars in Cygnus (37.113.053) and Frogel *et al.* (38.113.007) *RIJHK* photometry of K and early M-giants in Baade's window.

Late-type dwarfs have been the subject of different studies. Robertson has carried out an objective prism survey for late M dwarfs (38.114.013); Upgren and Lu have presented broadband *BVRI* photometry for nearby K and M stars (42.113.031). Hartwick *et al.* (38.114.121) have been able to separate a true halo population of M stars. The authors have obtained an upper limit to the relative density of halo to disk stars at $M_v \simeq 14$ and argue that the faint halo M stars are unlikely candidates for the solution of the "missing mass" problem in the Galaxy. Reid and Gilmore (37.115.004) have presented new optical and infrared photometry of a large sample of very low mass dwarfs.

UBV photometry was carried out by Sandage and Kowal (41.113.053) for 1690 high-proper-motion stars which provided a finding list for potential high-velocity stars of various metallicity values. Using the variation of the tangential velocity maximum with galactic longitude, the authors estimate the rotation of the subdwarf system to be V_{rot} (halo) $\sim 0 \pm 50$ km.s^{-1}. On the same subject, see the work done by Carney and Latham (1987) on some 900 G stars, including *UBV* photometry and radial velocities. *UBV* photoelectric photometry has been carried out by Oja (40.113.003) for about 700 stars near the North Galactic Pole. Vilnius photometric measurements of stars near the North Galactic Pole has been published by Bartasiūtė and H_β photometry of A and F stars in the direction of the South Galactic Pole by Andersen and Jensen (39.113.005). New spectral types have been determined by Lee (37.114.105) for high-proper-motion stars. Nikolaev *et al.* (40.002.139) have published mean light curves and $B-V$ and $U-B$ colours for 210 RR Lyrae-type stars of the galactic plane.

In order to study the distribution of interstellar matter in the solar neighbourhood and to investigate ages, abundances and kinematics of F type stars, Olsen and Perry have done H_β photometry of 2699 A5 to G0 population I stars. Large and kinematically unbiased samples of F-type stars (38.113.028) and G and K type stars (42.113.032) have been studied by Eggen; four colours, H_β and *RI* photometry have also been published. Golay et al. (39.155.059, 41.155.068) did a first analysis on the UV survey of the galactic plane (2000 Å) in a balloon-borne experiment. The second catalogue of stellar UV-excess objects searched with the Kiso Schmidt Telescope has been presented by Kondo *et al.* (38.113.055).

Positions and infrared photometry of 338 sources have been published from the Valinhos 2.2 μm survey of the South Galactic Plane by Epchtein *et al.* (40.002.003).

2.2 Intrinsic Colours, Interstellar Reddening and Absolute Magnitudes

IAU Symposium no. 111 has been devoted to "Calibration of fundamental stellar quantities" (40.114.092). Equally of interest for stellar classification are "Spectroscopic and photometric classification of population II" (42.012.106) and "The MK process and stellar classification" (42.012.033).

Among detailed studies we can mention that on H_γ luminosity calibration for spectral types O to early A of luminosity classes V–III by Millward and Walker (39.115.003) and for A and B supergiants (39.115.006) and (42.114.160). Effective temperatures and angular diameters of non-supergiant O9–G8 stars have been determined by Moressi and Malaguini (39.114.090); see also (42.115.001). Absolute magnitude and T_{eff} of B-type stars have been derived from 13-colour photometry by Conconi and Mantegayya (40.113.043). Balona and Shobbrook have carried out re-calibration of the luminosities of early-type stars (38.115.011) (see also 38.115.016); they discussed in particular the effect of the calibration on the zero-point of the cepheid luminosity scale. Effective temperature scales for B-type stars in relation with *UBV* and Geneva photometry is discussed by Cramer (37.113.017). The Effective Temperature Scale of O to F stars has been analysed by Theodossiou (39.114.089). Pastori and Malaspina have applied the visual surface brightness scale for B5–F5 main sequence stars, (38.115.001) and Shulov the luminosity of OB stars from photometry in the $uvby\beta$ system (42.115.004).

F-type stars have been calibrated by McNamara and Powell (41.114.008) and by Saxner and Hammarbäck (40.113.047). Moon and Dworetsky have published grids for the determination of effective temperature and surface opacity of B, A and F stars using $uvby\beta$ photometry. The infra-red flux method has been used by Leggett *et al.* (41.115.007) to obtain effective temperatures, diameters and luminosities of 22 bright stars.

Calibrations of G and K type stars have been discussed by Olsen (38.113.014), Frisk and Bell (40.114.088), Wing *et al.* (40.114.092) and Ardeberg and Lindgren (40.113.036); population II giants by Geisler (42.113.027); M supergiants by Elias *et al.* (39.115.004) and by Abramyan (38.115.005); M giants by Mennessier and Grenon (40.114.090); OH/IR sources by Feast (39.115.014); supergiants in open clusters by Keenan and Pitts (39.115.022); normal stars by Grenier *et al.* (39.115.009); red dwarfs by Gliese (39.115.021) and by Thé *et al.* (37.113.019); the Barnes-Evans relation by Eaton and Poe (38.115.012); stars in the *uvgr* system by Kent (39.113.013); absolute magnitudes of K and M giants by Mikami (41.115.003).

The existence of tight linear correlation between the stellar absolute magnitude M_v and the MgII k-line emission has been confirmed using IUE high-resolution spectra, by Parthasarathy (40.115.014).

Buser and Kurucz have treated some of the basic problems involved in the synthetic colour calculations and discussed the theoretical calibration of *UBV* photometry (40.113.037).

The Malmquist correction has been derived using different shapes of the luminosity function by Jaschek and Gomez (1985). Space density of B5 to A5 stars and extinction was analyzed by Burns *et al.* (37.155.012) in a direction $(l, b) = (253°, -7°)$. The distribution of OB stars and absorbing matter in the region around P Cyg (38.155.026) as well as in the direction of Per OB1 (38.114.130) has been discussed by Garibdzhanyan *et al.* Kunde, (41.113.003) using $uvby\beta$ photometry, has obtained the local dust distribution in the direction $(l, b) = (359°, +24.5°)$.

The catalogue of Savage *et al.* (1985) containing UV interstellar extinction excesses for 1415 stars exists in machine-readable version (42.002.063).

2.3 Stellar Luminosity Function

The search for brown dwarfs in relation with the missing mass in the solar neighbourhood is always a topic in the forefront of astrophysics. The proceedings of the workshop on "Astrophysics of brown dwarfs" (42.012.099) give a general idea of the state of current research in this field. The crucial role played by the luminosity function in galactic structure modelling using star counts has been analyzed by Bahcall (42.155.031). This author gives in particular a list of the more important questions which can be answered by future observations.

A *RI* survey for low-luminosity M-dwarfs from deep UK Schmidt plates has been analyzed by Hawkins (42.155.-081). The resulting luminosity function shows a decrease in space density in the range $M_R = 12 - 15$ after which the space density rises again. The author explains this subsequent rise as the reappearance of a population of non-hydrogen burning "brown dwarfs" in degenerate cooling phase. This result gives new hope that the missing mass in the solar neighbourhood resides in faint stars after all. On the contrary, the analysis done by Boeshaar and Tyson (39.155.096) on faint red star counts does not support the hypothesis that the missing mass of the disk is constituted of very low mass stars near the hydrogen-burning limit. Studies of the disk main-sequence luminosity function using photometric and kinematic absolute magnitude calibration methods result in significantly different estimates of the number density of very faint ($M_v > +14$) dwarfs. Reid (37.115.003) has investigated biases affecting the latter method. The stellar distribution in apparent V magnitude and $B - V$ colour has been determined for complete samples toward $(l, b) = (0°, -9°)$ and $(37°, -51°)$. From these data Gilmore *et al.* (39.155.062) derive the form of the stellar luminosity function in the solar neighbourhood. The low-mass stellar luminosity function obtained shows a broad maximum near $M_v \sim +13$ and a decline for less luminous stars. The conclusion of the authors being that missing mass in the solar neighbourhood cannot be explained by unusual low-mass luminous

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stars. Luyten has continued this survey for proper motions of faint stars on Schmidt plates and finds evidence that the frequency of such proper motions decreases with galactic latitude and this appears to become more prominent for fainter stars. This may mean that eventually we may have to use different luminosity functions for different galactic latitudes.

From the luminosity function of main-sequence nearby stars, D'Antona and Mazzitelli have derived the Initial Mass Function between 0.1 and 1 $\mathcal{M}_\odot$ (42.155.001). The local mass density of halo stars has been discussed by Lee (41.155.110) and Dawson (41.155.092/.106). The initial mass function for massive stars in the Galaxy and the Magellanic Clouds has been determined by Humphreys and McElroy. The authors find no observational evidence that the slope of the massive IMF differs from the normal IMF for the solar neighbourhood or that it varies with galactocentric distance. Observational constraints on the form of the high-mass stellar IMF have been reviewed by Scalo (41.155.121). There is no convincing evidence for any systematic variations of the shape of the high-mass IMF.

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3. Stellar Studies of Local Galactic Structure

This subsection reports results on the existence and nature of the possible unseen matter near the Sun, the local density of disc and halo stars, the respective luminosity functions and the local distributions of some special type objects. It summarizes work relating to the space density of stars of different types in the plane of the Galaxy and dealing with photometric stellar studies in the Milky Way fields of strong interstellar extinction. It also reviews galactic models relevant to the local structure.

3.1 The Volume Closest to the Sun

The existence and nature of unseen matter in the solar neighbourhood received much attention in the past triennium; the subject remains controversial.

Bahcall (38.155.084) determined the total amount of matter in the vicinity of the Sun by comparing the observed distributions of K giants with the predictions of detailed Galaxy models. Hartwick *et al.* (38.114.121) studied a sample of 65 faint cool stars from the LHS catalog. Strömgren (39.155.020) discussed the determination of the galactic force K_z and the local mass density. Boeshaar and Tyson (39.155.096) searched for faint red stars out to 40–100 pc from the Sun. A survey of low luminosity M-dwarfs from deep UK Schmidt plates has been described by Hawkins (42.155.081).

The local density of disc and halo stars, and the respective luminosity functions were investigated on different kinematically selected new samples. Eggen (42.113.032) discussed the distributions of abundances and space motions based on four-colour, H_β, and (R, I) photometry for some 5000 stars in four kinematically unbiased samples. He computed (1987) the luminosity and abundance distributions based on a catalog of *VRI* photometry of stars with $V > 15.1$ and annual proper motion $> 0.5''$. Sandage and Kowal (41.113.053) gave *UBV* photometry for 1690 high-proper-motion stars, providing a finding list for potential high-velocity stars of various metallicities. Sandage (1987) determined the disk and halo densities at the galactic plane from star counts at the galactic poles. From a kinematically unbiased sample of halo stars, S.G. Lee (41.155.165) estimated the local mass density of halo dwarfs. The luminosity function of the main-sequence galactic halo population was derived from the LHS catalog by Dawson (42.155.106).

Westin (38.155.063) studied the distribution of early type stars and the orientation and extent of the Gould's Belt. A population of super-metal-rich stars was searched by Grenon (39.155.165). He estimated the age and space density of the SMR subpopulation.