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

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1. INTRODUCTION

It has become a tradition for Commission 33 to invite several authors to contribute to the Report. The scope of the Commission is so wide that it is beyond the possibilities of any one individual to do this work without assistance. B. Westerlund contributed Section 2, S. W. McCuskey Sections 3 and 4, T. Elvius the paragraph on high-latitude studies, F. J. Kerr Sections 3, 4 and 5B, J. Einasto Sections 6B and D, and a summary of the current research by Soviet astronomers, K. C. Freeman Sections 6C, E. L. Woltjer Section 6F, and L. Perek Sections 1, 5A, and 6A. Section 6B contains this time a paragraph on the Galactic Corona as seen from the point of view of galactic models, while Section 4 contains a paragraph on the structure of the Galactic Halo.

There are some inevitable overlaps in coverage and some papers are quoted in more than one instance. It is felt, however, that the duplication is minimal and that some papers deserve to be mentioned from different aspects.

A longer version of the Report will be published by the Astronomical Institute of the Czechoslovak Academy of Sciences and will be distributed to all members of Commission 33 and to astronomical institutions.

Several scientific meetings have been held in the period under review which dealt with galactic astronomy: the *IAU Symp.* **58** 'The Formation and Dynamics of Galaxies' (12.012.005) and **60** 'Galactic Radioastronomy' (12.012.026) have been held close to the IAU General Assembly in Australia in 1973, the *IAU Symp.* **62** 'The Stability of the Solar System and of Small Stellar Systems' (12.012.003) has been a part of the Extraordinary IAU General Assembly in Poland in 1973, and the *IAU Symp.* **69** 'Dynamics of Stellar Systems' has been held in France in 1974. Of importance was the Joint Discussion at the 1973 General Assembly 'Kinematics and Ages of Stars Near the Sun' (12.012.014).

Proceedings have been published of the meeting on 'Dynamics of Galaxies and Star Clusters' held in Alma-Ata, U.S.S.R., in 1972 (10.012.034), of the First European Astronomical Meeting, held in Athens, Greece (11.012.010 and .018), of the NATO Advanced Study Institute in Dynamical Astronomy, held in Cortina d'Ampezzo, Italy (10.012.020), of the Third Advanced Course of the Swiss Society for Astronomy and Astrophysics on the 'Dynamical Structure and Evolution of Stellar Systems', held in Saas-Fee, Switzerland in 1973 (10.012.010), of the Symposium 'The Theory of the Structure and Evolution of Galaxies', held in Japan in 1973 (10.012.021). A specialist discussion meeting has been held by the Royal Astronomical Society on Spiral Structure in Galaxies in 1974 (12.011.037), a Conference on Optical Observing Programmes on Galactic Structure and Dynamics (13.012.013) has been held in the Federal Republic of Germany, and a conference on 'Dynamics of Spiral Galaxies' has taken place in Paris in 1974. The Third European Astronomical Meeting on 'Stars and Galaxies from Observational Point of View' has been held in July 1975 in Tbilisi, U.S.S.R.

The *Annual Review of Astronomy and Astrophysics* brought several survey articles of importance: Aarseth and Lecar on Computer Simulations of Stellar Systems, van den Bergh on Stellar Populations in Galaxies, and Verschuur on High-velocity Neutral Hydrogen, all in Volume 13. Volume 14 brings a paper by Burton on The Morphology of Hydrogen and of Other Tracers in the Galaxy.

Oort (09.155.091) has presented a survey of the beginnings of the theory of galactic rotation between 1920 and 1940 and of the evolution from the 'small' Kapteyn Galaxy into the 'large' Shapley Galaxy. A review attempting to place stellar dynamics in relation to other dynamical fields and to describe some of the important techniques and present-day problems has been published by King (11.151.031). A series of articles by Eelsalu (09.155.012; 10.155.067; 11.155.013; 13.155.011 and .012) constitutes a monograph on *Statistical Principles of Galactic Optical Astronomy*.

Clube (11.155.057) has presented an invited paper on 'Stellar Kinematics and Galactic Research Involving Proper Motions' at the *IAU Symp.* **61**. General survey of theories of the third integral have been given by Kuzmin (10.151.082) and by Contopoulos on various occasions (see below).

It is extremely difficult to indicate the main results achieved in galactic astronomy in the past three years and the President of this Commission is not courageous enough to attempt it. What he, however, looks forward to hear discussed at the XVIth General Assembly is the mass of the galactic halo and the reasons for, and against, a fast expansion of the Galaxy.

2. BASIC DATA AND CALIBRATION PROBLEMS

(B. E. Westerlund)

A. *Basic Data*

No attempt will be made here to give a complete summary of all the data of importance for studies of galactic structure that have appeared during the triennium under review.

The *Centre de Données Stellaires* has continued to publish information of importance for problems in galactic research. Since January, 1973, five issues of the Information Bulletin have appeared (09.002.007; 10.002.035; 11.002.024; 11.002.025 and Bull. No. 8, Febr. 75).

Catalogues are described in its *Rapports internes*. A number of star catalogues are available at the *Centre* on magnetic tape (12.041.002).

Catalogues on tape are also compiled elsewhere. Enaliskij *et al.* (12.041.029) have prepared one of 258997 stars. Much astronomical information is available in machine readable form at the U.S. Naval Observatory (12.041.043). The Celescope Catalogue of ultraviolet stellar observations, for 5068 stars, exists in a tape version (10.113.112).

An extensive catalogue giving absolute proper motions has been prepared in Pulkovo Observatory (11.112.006). An initial system of 5590 proper motions has been formed for the AGK 3R on the system of FK4 (12.112.006). Luyten has continued his proper motion surveys of faint stars and published catalogues for a total of 11407 stars (10.112.001; 11.112.013), mainly with motions larger than $0''.18$ annually. An analysis of the available trigonometric parallaxes has been presented by Turon (ESRO SP – 108, March 1975). This volume gives a general review of this topic. Turon and Crézé are investigating the possibilities of correct statistical use of inaccurate trigonometric parallaxes (mean errors $>$ 20%).

Recently published catalogues of stellar data give MK spectral classification published since Jaschek's La Plata Catalogue (12.114.156), a complete list of all known cool carbon stars (11.114.086), MK spectral classification for F and G type stars (11.114.152), spectral types on a uniform system for M dwarf stars (12.114.035), an up-to-date list of Ap and Am stars (*Rev. Mex. Astron. Astrofís.* **1**, 175, 1975) and fundamental data for O type stars (*Rev. Mex. Astron. Astrofís.* **1**, 211, 1975). A catalogue of S-type stars, containing more than 500 entries is available on punched cards or as a computer listing at Ohio State University by Yorka and Wing. The first part of the Michigan Catalogue for the HD stars is being published (Houk and Hartoog, *IAU Symp.* **72**). In the Stockholm spectral survey of the Southern Milky Way a catalogue containing about 3000 stars between $l = 306° - 318°$ has appeared (12.114.020). Henize (in preprint) has prepared a catalogue of 1929 southern emission-line stars. A survey for Hα emission objects reaching 2 to 3 mag. fainter than existing surveys has been conducted at the Vatican Observatory (11.114.087). A catalogue of Hα, Hβ, Hγ and four-colour data for 780 B-type stars has been compiled by Crawford *et al.* (13.113.013). Southern stars embedded in nebulosity have been catalogued by van den Bergh and Herbst (13.132.017).

A uniform survey of clusters in the Southern Milky Way has been carried out by van den Bergh and Hagen (13.153.001). A total of 269 clusters are catalogued. An Atlas of Galactic Globular Clusters, with colour magnitude diagrams on the *UBV* system for 42 objects, has been published (Alcaíno, Univ. Cat. de Chile, 1973).

Sivan has catalogued a number of large-scale regions of faint Hα emission (11.155.044). Contour maps of spatially diffuse, galactic Hα emission have been constructed (12.155.025). Crampton and Georgelin (13.155.043) have mapped the spiral structure by using spectrophotometric and kinematic distances of H II regions. Maršálková has prepared a comparison catalogue of H II regions, listing 698 objects (11.131.515).

Apt has compiled 12 000 radial velocity measures of 3700 stars (11.112.002). The 7th Radcliffe list of radial velocities of southern B-stars contains 164 objects (10.112.003). An extensive programme for the determination of radial velocities of southern planetary nebulae is being undertaken by Acker (1975).

Magnitudes and colours in the *UBV* system, useful in studies of galactic structure, have been published by a number of authors. We mention here only Neckel's photoelectric catalogue (12.113.023) in *B*, *V* of 1030 BD M-type stars.

Similarly, the *uvbyβ* system has been used by many. We note here only the catalogue with homogeneous *uvbyβ* values for 7603 stars (10.113.003). Of interest is an investigation of the various absolute magnitude calibrations in the *uvby* system (12.113.019) and a study of the *uvbyβ* system as a function of the MK spectral classification by Oblak *et al.* (1975).

Observations in infrared and ultraviolet are obtaining more and more importance for galactic studies. The Two-Micron Sky Surveys have attracted continued interest and most of the sources have now been identified (9.114.145; 12.114.114; 12.141.609; 12.141.615; 10.113.053). For other investigations see the Reports of Commisions 25, 44 and 45.

We note that the Internal Report, ROF 72, from the Astronomical Institute at Utrecht gives a number of reports on new ultraviolet observations (11.012.012). The TD 1 Satellite Observations of over 200 stars of types O–A5 (11.113.006) have been used for studying the effects of luminosity on the ultraviolet colours.

A third Uhuru catalogue of X-ray sources has been published (11.142.035) giving a total of 161 sources.

γ-ray observations are entering into the field of galactic structure. It has been proposed that the galactic cosmic rays are preferentially located in the high-matter-density regions of galactic arm segments (11.155.026; 11.143.007; 11.155.058; 12.143.003).

Among the many radio surveys of interest are the continuum survey of the galactic plane at 408 MHz (12.155.030), the 21 cm line radiation surveys (11.157.005, 11.157.006 and Heiles 13.131.513 and 09.157.009, 12.157.007 and 12.157.008) and the 1667 MHz OH absorption survey of the Southern Milky Way (12.131.078). Observations of pulsars, detections of new radio molecular lines and surveys of molecular distribution in our Galaxy as well as work on the radio-recombination lines are left to other reports. We recommend the Proceedings of the *IAU Symp.* **60** (12.012.026) and the volume on Galactic and Extra-Galactic Radio Astronomy (11.003.129) for general reviews of these topics.

A number of radio surveys have covered a major part of the sky or of the Milky Way region. In the 21-cm hydrogen line, three major low-latitude surveys have been published or are in press, all with a velocity resolution of 2 km s^{-1}. The Berkeley Survey covers the region $\ell = 10° - 250°$, $|b| \leqslant 10°$ in a fully-sampled manner, with a partial extension to $|b| = 30°$ (Weaver and Williams 09.157.009; 12.157.007 and 008). The beamwidth is 35′.5. The new Maryland-Green Bank Survey, with a beamwidth of 13′, fully covers the strip $\ell = 11°-235°$, $|b| \leqslant 2°$ (Westerhout and Wendlandt 1975), and the first portion of the New Parkes Survey, with a beamwidth of 15′, provides maps at constant longitude at typical intervals of 1° in ℓ from $\ell = 236°$ to 345° (Kerr *et al.*, 1975).

A 21-cm survey extending to $|b| = 20°$, with $\ell = 15°-225°$ and $\Delta\ell = 2°$, has been published by Burton and Verschuur (10.157.003), and Lindblad (12.157.003) has carried out a set of long constant-longitude scans in the interval $\ell = 339° - 72°$. Garzoli (09.157.008) has published a 21-cm atlas for the region $\ell = 270° - 310°$, $b = -7°$ to $+2°$.

Over a wider latitude range, Tuve and Lundsager (1973) have carried out a major survey, while Heiles and Habing (11.157.005 and 006; Heiles 13.131.513) have extended the Berkeley Survey to cover all the region $|b| > 10°$ and north of declination $-30°$ over the velocity range -92 to $+75$ km s^{-1}.

Cohen (13.157.008) has completed a 21-cm survey of the galactic center region $355° \leqslant \ell \leqslant 10°$, $-5° \leqslant b \leqslant 5°$. The velocity range was -530 to $+530$ km s^{-1}, and the velocity resolution 7.3 km s^{-1}. The data from all the 21-cm surveys are presented in the form of numerous contour maps.

Extensive surveys of H I and OH in dust clouds have been reported by Knapp (11.131.542) and Crutcher (10.131.139) respectively and corresponding surveys of H_2CO by Dieter (10.131.025) and Minn and Greenberg (09.131.010).

Whiteoak and Gardner (13.131.018) have studied H_2CO absorption in the directions of 280 galactic radio sources. Schwartz *et al.* (10.131.223), Scoville and Solomon (1975), and Burton *et al.* (1975) have studied CO emission from directions in and near the galactic plane over a wide range of northern longitudes.

In the radio continuum, general surveys have been carried out by Haslam *et al.* at 408 Mhz (11.157.004), and Milogradov-Turin and Smith at 38 MHz (09.157.001) for the northern sky, and by Alexander and Novaco at 3.93 and 6.55 MHz (12.155.001) for the whole sky. At low latitudes, surveys have been published by Day *et al.* (08.157.008), Green (12.155.030), Felli and Salter (10.157.007), and Jones and Finlay (12.157.010) at frequencies of 2700, 408, 408, and 29.9 MHz respectively.

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B. *Intrinsic Colours and Interstellar Reddening*

Relatively few determinations of intrinsic colours have appeared recently. We refer to '*Multi-colour Photometry and the Theoretical HR Diagrams*' (*Dudley Obs. Rep.* No. 9, 1975) for information on the most recent calibrations of various systems and on the calibrations of intrinsic colours from stellar models.

Systems of stellar intrinsic ultraviolet colours have been established. The OAO-2's Celescope experiment gave $(U_i - V)_0$ colours for B0 to G3 stars (9.113.047). For the B-stars the derived colours agree with those computed from model atmospheres; for A and F stars there is a disagreement (12.113.031). Average values for the extinction law were derived.

Intrinsic colours have been derived for globular clusters as a function of their spectral type, and their interstellar reddening from observations in the *UBVI* system has been discussed (11.154.019).

Pecker (12.155.028) finds it reasonable to expect nearly the same reddening law everywhere in our Galaxy; deviations will reflect mainly the circumstellar distribution of grains and not the interstellar. Sudžius (12.113.053) has re-analysed the Whiteoak and Nandy interstellar reddening laws; certain deviations are found in the former. The Whiteoak reddening curve has also been extended to shorter wavelengths (11.114.100).

The ultraviolet interstellar extinction curve has been studied by a number of observers (9.113.012; 10.113.051; Viotti and Lamers 13.131.092). Large fluctuations in the law may occur from star to star.

An infrared reddening law has been derived from photometry at 2.3, 3.6, 4.9, 8.7, 10 and 11.4 m (12.141.619). An extrapolation of this curve implies $R = 3.40 \pm 0.15$.

For the *UBV* system Olson (13.113.051) has given a relation allowing the calculation of R as a function of $(B-V)_0$ and E_{B-V}, and Gutiérrez-Moreno and Moreno (13.113.058) have determined R as a function of spectral type and reddening.

Fernie (11.122.061) finds for the long-period cepheid RS Pup $R = 2.85 \pm 0.5$. Systematic errors may, however, exist in the methods of finding colour excesses for the long-period cepheids (Schmidt, 13.122.016, and Canavaggia *et al.* 1975).

From the energy distribution of the red star in NGC 6231 it was found that for it the reddening law for Perseus, with $R = 3$, applies; the Scorpius reddening law corresponds otherwise to $R = 3.6$ (11.114.030).

A systematic change of the extinction law with an increase in the ratio of total–to selective absorption and a corresponding increase in the wavelength of maximum polarization was found in the Ophiuchus dark-cloud complex (09.131.164) and confirmed (Vrba *et al.* 13.153.008) in a more extensive investigation. The particle-size distribution may be peaked toward larger sizes. For the same dust cloud $R = 4.2 \pm 0.5$ for the stars associated with nebulosity and $R = 3.3 \pm 0.3$ for the remainder (12.152.001). Also the dark cloud associated with IC 348 shows the same properties (12.153.033). For NGC 6193 a value of $R = 5.6 \pm 0.3$ was derived (12.153.013) and for the small nebulous cluster vB 130 a value of $R = 8.1 \pm 1.2$ (12.153.014).

Crézé and Isobe (13.131.136) find that R is 4 and 1.6 in the spiral arms and inter-arm regions, respectively.

Serkowski *et al.* (13.131.031) conclude from extensive polarimetric-photometric observations in *UBVR* that several well-defined regions in the sky exist where R is larger than 3.

New determinations of the reddening at the galactic poles have appeared. Philip (11.113.039) finds for the South Galactic Pole area $E_{B-V} = 0.02$. Holmberg (12.160.013) has calibrated the galactic absorption by means of galaxies, RR Lyrae stars and globular clusters. He derives a mean value at $|b| = 90°$ of $E_{B-V} = 0.054 \pm 0.004$. In two other investigations, dealing with galaxies and globular clusters, the most reliable data give $R \sim 3$. (Burstein and McDonald 13.154.001, Hartwick 13.131.007). Knapp and Kerr (12.155.038) conclude from H I observations in the direction of 81 globular clusters that the high R values previously obtained at the galactic poles are due to over-estimates of the absorption by galaxy counts.

Finally, we note that also the relation between interstellar X-ray absorption and the optical extinction has been investigated (Gorenstein, 1975; Ryter *et al.* 13.131.087).

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C. *Absolute Magnitudes*

The Hyades cluster continues to attract much interest; for a review I refer to van Altena (11.153.014). He concluded that the best value on its distance modulus is $m - M = +3.21 \pm 0.03$ s.e. Upgren (11.111.001) derived a distance modulus of 3.29 ± 0.18 from parallaxes and proper motions for faint red dwarfs in the cluster region and from RI photometry of 56 stars he found $m - M = 3.22 \pm 0.04$ mag (12.153.025). Hanson (13.153.019) determined new absolute proper motions, referred directly to external galaxies, for over 600 stars in the Hyades region. He carried out a convergent-point analysis and obtained $m - M = 3.42 + 0.21$, independent of all meridian circle proper motion systems. This value, combined with other results gives as most likely value $m - M = 3.29 \pm 0.08$.

By removing the 'Hyades anomaly' (in the $c_1, b-y$ diagram), a distance modulus in reasonable agreement with the results above is found (11.115.011).

DDO intermediate-band photometry has yielded (Janes 13.114.068) a distance modulus for the Hyades of 3.22 mag.

Yoss and Lutz (11.115.007) have made an independent calibration of the zero-point and scale of 562 spectrographic absolute magnitudes through mean-secular parallaxes. No significant systematic errors in either zero-point or scale were found.

McCuskey and McMillan (9.115.005) have determined mean visual absolute magnitudes and dispersions from frequency distributions of apparent magnitude, total proper motion and radial velocity for a number of stellar groups. The values of M_v derived are B8–A0, +0.52; A0, +0.46; F0–F5, +2.13; gC8–K3, +0.08; gM0–M4, −0.86.

Balona and Feast (1975) have used the Hγ luminosity calibration (11.115.002) to derive the zero age main sequence. This is about $0\overset{m}{.}2$ brighter than Blaauw's. A serious discrepancy is noted between the mean astronometric distance modulus of Sco – Cen ($5\overset{m}{.}78$) and the Hγ modulus ($6\overset{m}{.}46$); the former is possibly biased by the cut-off applied to eliminate poor proper motions.

The kinematics of the Mira variables has been used by Foy *et al.* (1975) to calibrate the period-luminosity relation. They find that OH as well as non-OH Mira type variables have the same M_V but differ one magnitude at 1.04 μ.

Mean absolute magnitudes of carbon stars have been determined by Baumert (11.115.012) at 1.04 microns. He found for class N $<M\ (104)> = -4.3$; and for class R -1.7. The non-variable carbon stars have $<M\ (104)> = -1.2$.

Bond determined $M_V = +2$ for the subgiant CH stars (12.114.110).

Certain improvements in the determination of absolute magnitudes for the T Tauri stars are now possible thanks to our knowledge of the large infrared fluxes from these stars (11.115.015; 12.115.003). Problems remain in the determination of the extinction; these stars are affected by interstellar as well as circumstellar reddening and the ratio of total to selective absorption may be large. The derived luminosities indicate that 'normal' T Tauri stars are subgiants. Hemenway (13.122.023) has determined absolute magnitudes for the RR Lyrae stars by the statistical parallax method. For the a-star group the resultant mean light $M_B = 0.63$ mag.

Proper motions have been used to derive mean absolute magnitudes for planetary nebulae (12.133.038); for the optically thin the results agree with Seaton's, for the optically thick $M_n = -2.0$.

Luminosities and motions for several groups of stars have been studied by Eggen: peculiar B-type stars (11.115.016), G-type giants (11.115.006), large-amplitude red variables (Eggen 13.122.009), and the small-amplitude red variables in the old disk population (9.115.010).

Accurate bolometric magnitudes have been determined by broadband infrared photometry for M-type dwarfs (12.115.007). Empirical bolometric corrections for B – F type stars have been determined from ultraviolet observations by the OAO-2 (12.115.016) and TD-1 (11.114.125).

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D. *The Stellar Luminosity Function*

At present our knowledge of the stellar distribution in the solar neighbourhood is approximately consistent with the known stellar motions (12.111.001). Improvements should, however, be possible, in particular when the kinematics of the faint stars is better known. Various investigations have appeared with partly conflicting results. Muzzio (10.115.031) used the method of trigonometric parallaxes on a sample of large proper motion stars to derive the luminosity function for moderately bright and faint stars in the solar neighbourhood. His values for $M_B > 12.5$ are 3 to 4 times smaller than previously derived. Also the total mass is about 4 times smaller.

Veeder (12.118.003) finds from a revision of the masses for some faint double stars an improved mass-luminosity relation for faint main-sequence stars and the total mass density increased to about 0.2 $\mathfrak{M}_\odot \, \mathrm{pc}^{-3}$. Gliese (1975) considers that this value has to be diminished by nearly 0.08 $\mathfrak{M}_\odot \, \mathrm{pc}^{-3}$. He bases his conclusion on his investigations of the supposed existence of a rich population of low-velocity red dwarfs in the solar neighbourhood. His computed results, from Luyten's luminosity function, are in fair agreement with the observed data between m (pg) = 13–15, 17–21. From 15–17 m (pg) too many proper motion stars are observed. The comparison does not contradict the Weistrop function between luminosities $M_V = 10-13$. For the intrinsically fainter stars ($M_V > 13.5$) the observations contradict the extrapolated branch of this function. The number of such objects must be low.

Jahreiss and Wielen (12.155.007) and Wielen (12.115.011) have derived the luminosity function of nearby stars from Gliese's catalogue. It is in good agreement with the results obtained by Luyten from proper motion surveys. The corresponding local stellar mass density is 0.046 $\mathfrak{M}_\odot \, \mathrm{pc}^{-3}$. The local density of halo stars is at least $1 \times 10^{-3} \, \mathfrak{M}_\odot \mathrm{pc}^{-3}$.

Smethells (12.155.013) has searched 1720 square degrees for early M dwarfs to $m_V = 11$ using objective-prism techniques. 186 dwarfs, primarily of types K 7 to M 5, were found. His results indicate higher space densities of the intrinsically faint stars than previous luminosity functions but agree with Weistrop (08.115.017) and Sanduleak (unpublished).

Jôeever (11.155.014) concludes after estimating the mean value and the dispersion for the faint M-stars that the space density of the faint M-stars is too low for explaining the phenomenon of missing mass near the sun. Weistrop (12.155.026) has recalculated the density distribution and luminosity functions for red dwarfs, assuming the presence of unresolved binaries. Previous conclusions concerning the enhanced luminosity function of these stars remain unchanged and arguments in favour of the 'missing mass' in the solar neighbourhood being supplied by faint red dwarfs are strengthened.

Eggen (12.115.015) has analysed 2000 *RI* and 1700 *UBV* observations for K and M dwarfs in the northern and southern spectrophotometric surveys. The astrometric data available permit a distinction between young- and old-disk population stars showing a luminosity law with a steep rise in the members of old-disk stars with decreasing luminosity but for the young-disk objects a flatter distribution of stars. A total density of 0.008 $\mathfrak{M}_\odot \, \mathrm{pc}^{-3}$ in the solar neighbourhood is derived, contributed by main-sequence stars in the range of $M_{\mathrm{bol}} = +6.5$ mag to +8.4 mag. Eggen (10.115.037) has also compared the luminosity functions of the old- and the young-disk population red giants. The sharp dip previously noted at $M_{\mathrm{bol}} = -3$ in the giant branches of the old-disk population groups appears in both luminosity functions.

A galactic anticentre field of 2.32 square degrees with 2400 stars has been studied photometrically in the *RGU* system to $G = 15.5$ by Topaktas (13.155.042). He finds the luminosity function for distances smaller than 0.8 kpc similar to the one for the solar neighbourhood for $0 < M(\mathrm{G}) < 6$.

A new determination of the luminosity function $N(M_V)$ of the zero-age main sequence has been presented by Taff (12.115.012) based on observations of 62 galactic clusters. When $N(M_V)$ is converted to a mass function the result is a power law with an index $p = 2.74 \pm 0.07$ (s.e.).

At Warner and Swasey Observatory the programme for studying the stellar luminosity function continues. Stellar space densities have been determined in various galactic fields for different types of stars (11.155.017; 11.155.039; and 11.155.045). The space distribution of M giants has been studied in the Warner and Swasey luminosity function fields LF 13 (Vleeming and Thé, 1975), LF 14 (13.155.004) and LF 15 (11.155.018).

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3. LOCAL GALACTIC STRUCTURE

A. *General Survey*

This Section of our Report deals with the distributions of stars, interstellar gas and dust, and the surface brightness of the Milky Way in the part of the Galaxy near the Sun. We discuss in Section 4 the overall properties of the Galaxy on the larger scale.

A new general catalogue of cool carbon stars has been prepared by Stephenson (11.114.086). In the southern sky the R stars show a zone of avoidance near the galactic center caused by interstellar absorption; the N stars, although probably of similar absolute magnitude in the blue, are like the OB stars so strongly concentrated near the galactic plane that they do not reveal such a zone of avoidance. Stephenson concludes from this study that with a very high probability all carbon stars showing SiC_2 bands are variable. At present, Stephenson is planning a general catalogue of S stars similar to the carbon star catalogue.

The O and B stars in the local part of the Galaxy have been studied by several investigators. Walborn (10.155.069) has studied the spatial arrangement for some 274 O stars brighter than $m_{pg} = 9$ which together with other data show clear concentrations in Car and Sgr. Stothers and Frogel (11.155.033) have studied in much detail the distribution of O to B 5 stars and have made a spatial separation statistically between the 'Gould Belt' stars and the 'Galactic Belt' stars. Klare and Neckel report from Heidelberg the completion of *UBV* photometry for the 1660 southern OB stars of the Heidelberg catalogue, with Hβ observations following. A catalogue containing *UBV* and Hβ data is expected to be in press by the end of 1975. The observations were carried out at Gamsberg, South West Africa.

Two studies of the relationship between O and B stars and the interstellar medium have been made by Torres-Peimbert *et al.* (12.114.017) and by Cruz-González *et al.* (13.113.008). Sanduleak and Stephenson (10.114.152) have studied the galactic distribution of several classes of strong emission-line objects, noted in their earlier survey of OB stars. Stenholm (13.155.027) has made a new search for faint WR stars and has studied anew the distribution of these objects in the Galaxy. No conspicuous spiral pattern emerges from the distribution of these objects on the galactic plane.

A uniform two-color survey (B and R mag) along the southern Milky Way ($\ell = 250°$ to $360°$; width in $b \sim 12°$) of galactic clusters has been made by van den Bergh and Hagen (13.153.001). The distribution of the open clusters in galactic longitude is much more uniform than is that of very young objects such as OB stars and stars embedded in reflection nebulae.

In the rapidly expanding field of infrared astronomy much of the development during the past three years has been focused on individual objects rather than on large surveys. An up-dating of previous survey data at 10-μm, however, has appeared in the *Catalogue of 10-μm Celestial Objects* by Hall (1974).

Coyne and his colleagues at the Vatican Observatory are continuing a survey for Hα emission objects to a limiting $V = 15$ mag., about two magnitudes fainter than existing surveys (Coyne *et al.* 11.114.087; 1975).

Eggen has continued his detailed studies of stars in the solar neighbourhood. He confirms (08.115.025) from a sample of A0-A2 stars that the young disk population stars occur in only some half dozen groups. By extrapolation of the stellar mass-to-luminosity relation Latyshev (10.065.143) has estimated the lower boundary of the mass distribution function to be $0.025\ m_{\odot}$.

Gyldenkerne reports from the Copenhagen Observatory considerable activity in the observation of bright stars by *uvby* and Hβ photometry. A series of observations of 2771 southern O to G0 stars with $m_V < 6.5$ mag have been completed by Grønbech, Olsen, and Strömgren at ESO. Kinematic data are being obtained for many of these stars. With the same photometric equipment Knude and Strömgren have observed 720 A4-F5 stars in regions at low galactic latitude for a determination of the distribution of interstellar matter near the Sun.

Iwanowska has continued her studies of statistical population indices (SPI). In addition to discussions for the gM and dM stars reported in the 1973 Commission 33 Report, the SPI for dMe stars (1975), for white dwarfs (11.126.011), and for planetary nebulae (11.133.016) have been completed. She reports that a newly constructed 3-dimensional spectral classification scheme by Strobel (1975) and photometrically calibrated objective prism spectra are to be used for statistical studies of the chemical composition of stellar atmospheres in different regions of the Galaxy.

An extension of their 1972 survey for Ly-α absorption from the interstellar hydrogen by ultraviolet photometry from OAO2 has been published by Jenkins and Savage (11.113.001). They estimate the total density of hydrogen (protons, atoms, molecules, etc.) within 1 kpc of the Sun to be about 1.5 atom cm^{-3}. The correlation between N_H and $E(B-V)$ is good and the data indicate that $< N_H$ (total)$/E(B-V) > \sim 7.5 \times 10^{21}$ atom cm^{-2} mag^{-1}. The density ratio of hydrogen to dust is about 170.

The distribution of the neutral hydrogen in the solar vicinity has been discussed by several authors. Lindblad *et al.* (09.155.027) and Weaver (12.155.049) emphasize relationships to Gould's belt and an expanding shell. Fejes and Wesselius (09.155.020) describe a number of strong H I ridges, some of which have not been noticed before. The properties of intermediate-velocity hydrogen have been discussed by Wesselius and Fejes (09.155.021) and Mirabel (10.157.011).

Heiles and Jenkins (12.155.068) have produced striking maps of the 21-cm emission over the whole northern sky, integrated over several different velocity ranges. These indicate very clearly that the dominant structures on a sufficiently large scale are filaments, rather than clouds. Verschuur (11.131.508) has discussed the properties of 200 H I clouds, and he also shows that clouds are often filamentary or parts of filaments. The cloud motions are not as random as usually suggested. Knapp (11.131.542) studied 21-cm self-absorption dips in 88 dense dust clouds, which she showed to be part of the general local system of interstellar matter. Minn and Greenberg (09.131.010) and Crutcher (10.131.139) have studied large samples of dust clouds through formaldehyde and OH absorption, respectively. Tovmassian *et al.* (11.153.003 to 0.007) observed 16 open clusters and found hydrogen associated with a substantial number of them. Grayzeck and Kerr (11.131.532) published an atlas of 21-cm emission profiles in the directions of 43 hot luminous stars and 34 X-ray sources. Daltabuit and Meyer (08.131.025) have summarized the data on the angular distribution of the H I column density in a series of plots.

Falgarone and Lequeux (09.131.141) have studied all available 21-cm absorption data, and find that the equivalent thickness of the interstellar cloud system close to the Sun is 330 pc, and its mean density at $z = 0$ is 0.29 atom cm^{-3}. For the intercloud medium, the corresponding values are 585±100 pc, and 0.155 atom cm^{-3}.

In the radio continuum, the loops and spurs still remain a problem. Spoelstra (08.155.017 and 032; 09.155.024) discusses his observations of linear polarization in the regions of the spurs, and finds that van der Laan's model of a shell expanding into the medium gives a reasonable explanation of the observations. Berkhuijsen (09.155.023) and Vaisberg (12.157.009) favor the supernova remnant interpretation. On the other hand, Kafatos and Morrison (09.155.089) suggest that they may be fossil Strömgren spheres similar to the Gum nebula, while Sofue *et al.* (09.155.067; 12.155.012) find a correlation between the positions of the spurs, of optically obscured regions in the Milky Way, and tangential directions of spiral arms. They propose an explanation in which a nonthermal source extends just above and below the shocked region of a spiral arm. Fejes and Verschuur (09.155.054; 11.155.048) discuss H I observations in the vicinity of the North Polar Spur and Loop III. The clouds appear to show elongations parallel to the magnetic field lines, but not in a way which can be explained by supernova phenomena.

Observations of the linear polarization of the galactic radio emission at 240 and 610 MHz have been presented by Baker and Wilkinson (10.131.003; 11.155.041) for a large part of the northern sky. Kapustin *et al.* (11.157.007) have discussed the linear polarization at 210 MHz.

Two recent reviews have appeared on the characteristics of emission nebulae at radio wavelengths (Terzian 12.132.030). Many papers discuss observations of particular H II regions.

Over 160 planetary nebulae have been detected at radio wavelengths. Surveys have been described by Higgs (09.133.001) Terzian *et al.* (10.133.054; 11.133.008), Cahn and Rubin (11.133.011), Sistla *et al.* (12.133.005) and Milne and Aller (13.133.012), and a review has been published by Thompson (12.133.018). Milne and Aller have compared the radio flux densities with Hβ intensities to obtain optical extinction coefficients, and derive a distance scale. They estimate that the mean optical absorption within the galactic disk is 1.3±0.8 mag kpc^{-1}.

Significant progress has been made on the radio properties of supernova remnants through high-resolution mapping, polarization studies, and the improved calibration of distances through a Σ-d relationship (e.g. Velusamy and Kundu 11.125.024).

B. *Regional Surveys-Low Galactic Latitude*

Local sectional studies of galactic structure both from the optical and the radio observational standpoints form the contents of this section of our report. In general, the results here will refer to galactic latitudes $|b| < 20°$.

I. *The Galactic Center (350° < ℓ < 10°)*

A study by Gschwind (13.155.017) at Basel of a field at $\ell = 1°.1$; $b = 1°.1$ (in the large Sagittarius Cloud) indicates an interstellar absorption probably due to four sheet-like clouds and a space density of late-type giants which appears to reach a maximum at 2–3 kpc from the Sun.

The RR Lyrae variables in Baade's field near NGC 6522 at $\ell = 1°.0$; $b = -3°.9$ have been found by Plaut (10.122.006) to have a maximum space density of 3.2 x 10^3 stars per 10^3 pc^3 at 8.3 kpc from the Sun. Stellar space densities and interstellar absorption in a field at $\ell = 353°$, $b = +3°$ are being investigated at Lund by Ardeberg and Wramdemark. Observations of Sgr A and Sgr B2 in the far infrared (350 μ) by Gezari *et al.* (09.155.009) indicate a rather strong IR source at Sgr B2 which coincides with the region of strong molecule formation. Haug and colleagues at Hamburg are studying the variation of the red-giant star population with z-distance at $\ell = 0°$ by *UBV* photometry.

Simonson and Sancisi (09.157.013) have published profiles and contour maps for the H I at low latitudes for $\ell = 356°-24°$. They discuss correlations with optically-observed bright and dark nebulae. Quirk and Crutcher (09.155.064) suggest that the well-known 'cold cloud' in this direction may be a region of high gas density caused by a shock induced by the gravitational field of the local spiral arm.

Lockman and Gordon (09.131.159) have found H159α recombination-line emission over an extended area around the direction of the center. The lines appear to originate in non-LTE conditions. The proposed interpretation is emission from a cold region lying along the line of sight to the center.

Radio and infrared work on the galactic center region itself will be described in Section IV.

II. *Sct-Aql-Vul (10° < ℓ < 60°)*

Photoelectric photometry of some 400 stars and photographic photometry of more than 3000 stars by the Galaxy machine together with objective prism spectral classifications in a field at $\ell = 40°$, $b = -1°.2$ have been used by Sherwood (12.155.089) to study the galactic structure in this region.

Many radio studies have been made of individual H II regions in this longitude range. Sato and Akabane (11.131.555) have examined 21-cm maps for $\ell = 48°.5-51°.2$, and find a number of absorption features, due to W 51 and other continuum sources. Ariskin *et al.* (09.155.028; 12.157.011) have analyzed the distribution of the background continuum at $\ell = 20°.3-27°.3$ and $\ell = 31°.2$ at various wavelengths.

III. *Cyg-Cep-Cas-Per (60° < ℓ < 150°)*

Voroshilov *et al.* 08.131.123) have investigated the interstellar absorption and the space density of stars at $\ell = 66°$, $b = +1°.2$ in a 1 sq deg field centered on NGC 6834. The space density variation of OB stars shows two groupings at 3 and 4 kpc from the Sun. Space density as a function of distance is also tabulated for other spectral groups. The same authors (Voroshilov *et al.*, 08.131.124) have analyzed in a similar way a field at $\ell = 113°$, $b = +0°5$ centered on the open cluster NGC 7654.

Velghe (1974 has studied the space distributions of giant M stars in Cyg (4 regions with $< \ell > = 75°$, $< b > = +2\overset{\circ}{.}5$). The spatial distributions of the two natural groups M 2–M 4 and M 5–M 10 indicate that in the galactic plane these are about the same, but that the ratio of early M to late M stars increases steadily from $z = 0$ to $z = 0.2$ kpc. At larger z values the reverse takes place. The earlier M stars appear to be concentrated in a flattened disk and in the Cyg spiral complex. The late M stars do not exhibit this tendency. Mavridis and his collaborators have continued their studies of the space distributions of M-, C- and S-stars in selected Milky Way regions. Tsioumis (1974) has completed an analysis for a field at $\ell = 115°$, $b = -5\overset{\circ}{.}4$.

The galactic structure in Cepheus at $\ell = 102°$, $b = -1°$ has been studied by Barbier *et al.* (10.155.021). The space density of OB stars peaks at 2–3 and at 4–5 kpc which the authors interpret as an interarm and the Perseus spiral arm complexes respectively.

Elvius reports that an analysis of the stellar distribution and interstellar absorption in $\ell = 120°$, $b = 0°$ is underway. Photoelectric *UBV* photometry of about 180 stars has been completed. Wramdemark is working on the distribution of faint early-type stars; Sarg is working on the late-type stars.

Investigations by McCuskey (11.155.017) and by Pesch and McCuskey (11.155.021) have been directed toward the elongated space distribution of early-type A stars in Cassiopeia at $\ell = 133°$, $b = -1°$, found previously by McCuskey and Houk (06.155.040). Re-examination of the region shows that uncertainty in the variation in interstellar absorption with distance caused the major part of the elongation; the space density remains high, however, in $r = 200$ to 400 pc from the Sun. McCuskey *et al.* (11.155.045) have obtained *UBV* photoelectric data, MK spectral types and radial velocities of a sample of OB stars in LF5 ($\ell = 129°$, $b = -2°$) to study the distances of these optical spiral arm tracers in this region. The average stellar radial velocity is about 10 km s^{-1} more positive than the average velocity of the neutral hydrogen concentration usually ascribed to the spiral arm.

A search for faint O-B3 stars ($12.0 \leqslant B \leqslant 14.5$) in $135° < \ell < 180°$ near the galactic plane has been conducted by Muzzio and Rydgren (12.113.005). Ten open star clusters in a 25 sq deg field at $\ell = 135°$ have been examined by Moffat and Vogt (09.153.039) to establish the ages and relationships of the clusters to the local galactic structure. Oja reports from Uppsala that their spectral survey of the Milky Way has been extended to a region $132° < \ell < 152°$, $|b| < 3°.2$ by Rydstrom. Analysis of the space distribution of stars and interstellar matter is in progress.

For many years it has been known that the distribution of OB stars along the galactic equator in Per-Cam shows a sharp discontinuity at $\ell = 140°$. The nature of this is being investigated at the Dominion Astrophysical Observatory and University of British Columbia by Aikman, Byl, and Goldberg. Radial velocities of a number of OB stars in the region indicate a systematic difference between the kinematic and the photometric distances, suggesting strongly that the discontinuity is due to interstellar absorption. The Cam OB3 association at $\ell = 146°$ is found by its kinematic distance to be in the Per spiral arm extended. Reddish reports that Dodd at Edinburgh has been studying the region at $\ell = 140°$. Galaxy machine general star counts also exhibit the discontinuity at $\ell = 140°$.

Neutral hydrogen in the Perseus arm has been studied by Bystrova (09.155.059), Gosachinsky (09.155.060), and Verschuur (09.155.026). Verschuur suggests that some of the 21-cm emission apparently associated with the Perseus arm may be coming from a more distant arm. If so, the apparent difference between H I and stellar velocities could be accounted for without requiring streaming motions in the Perseus arm.

Höglund and Gordon (09.131.161) and Minn and Greenberg (1975) have detected giant dust complexes in the Perseus arm through radio observations of H I and molecular lines.

IV. *The Galactic Anticenter* ($150^\circ < \ell < 210^\circ$)

Studies of the galactic structure in this longitude range as well as in other low latitude regions are being continued at the Basel Observatory. Results for two fields have been published recently. In the Auriga field ($\ell = 162^\circ$, $b = -0\overset{\circ}{.}5$) Becker and Fang (09.113.002) have analyzed the colors and distances for some 1743 stars in an area of 0.21 sq deg near NGC 1664. Hersperger (09.113.003) treats in a similar way a field of 0.27 sq deg (2330 stars) at $\ell = 185^\circ$, $b = +1\overset{\circ}{.}7$, near M 35. Topaktas (13.155.042) has recently published a second study near M 35 at $\ell = 186^\circ$, $b = +1\overset{\circ}{.}5$. Fourteen other fields in both northern and southern Milky Way regions are under investigation by *RGU* photometric methods.

At Abastumani several catalogues of stars have been issued. Chuadze (10.113.023) has prepared a catalogue of photographic stellar magnitudes, $B-V$ colors, spectral types and luminosity classes in eight Kapteyn areas (no. 25, 48, 50, 73, 75, 97, 99, and 122). The limit of the survey is $B = 13.0$, the radius of circular areas is $1\overset{\circ}{.}5$. Similar catalogues of stars in two fields in Orion and Andromeda have been prepared by Kazanasmas (10.113.024) and Miskin (10.113.025), respectively. A catalogue of spectral classes of faint stars around NGC 6834 and NGC 7654 was published by Kuznetsov (10.114.046); the limiting magnitude is $15\overset{m}{.}0$.

A second finding list of faint blue stars in the anticenter region of the Galaxy has been published by Rubin et al. (12.155.086). Andrews (13.113.053) has published a useful catalogue of photometric and astronomic data for 4117 stars in the Orion nebula aggregate ($\ell = 208^\circ$, $b = -19^\circ$).

V. *Pup-Vel-Car-Cru* ($210^\circ < \ell < 300^\circ$).

This section of the Milky Way and that covering galactic longitudes $\ell = 300^\circ$ to 350 have been intensively studied in the triennium under review. Bok *et al.* (10.155.074) have summarized in detail their studies. Individual contributions for the regions in $210^\circ < \ell < 300^\circ$ are: (a) McCarthy and Miller (12.113.049) have searched for and found 95 new stars of spectral type B 3 and earlier and as faint as $V \sim 15.6$ mag in five regions in Puppis. These have been confirmed as OB stars by use of transmission grating spectra. A plot of spiral tracers (young clusters, H II regions and the OB stars beyond 4 kpc) suggests a distant spiral feature in the Puppis direction which may be a third-quadrant extension of the Perseus arm; (b) Miller (10.113.043) has found three very distant (5–8 kpc) early-type clusters or associations in Vela and in Carina.

A region in Canis Major ($220^\circ < \ell < 227^\circ$, $-4\overset{\circ}{.}5 < b < +1^\circ$) has been investigated by Claria (12.155.043). Moore and FitzGerald (10.155.066) have studied a field in Vela ($\ell = 277^\circ$, $b = 0^\circ$). The space density of O to B 3 stars and the B 5 to A 0 supergiants decreases rapidly with distance from the Sun. A very high concentration of B 8–A 0 stars appears at $r = 500$–600 pc. This is one of the highest space densities of A stars thus far known.

The distribution in space of giant M stars and of carbon stars in Puppis ($\ell = 246^\circ$, $b = -0\overset{\circ}{.}6$) has been analyzed by Kirton and FitzGerald (11.155.038).

Havlen (12.152.004) has made extensive Hβ and *UBV* photometric observations of OB stars in Pup OB2 ($\ell = 245\overset{\circ}{.}7$, $b = +0\overset{\circ}{.}5$) and confirms that the distance modulus is 13.1. No evidence for stellar concentrations more distant than Pup OB2 were found. At present, Havlen is obtaining image-tube spectra for classification purposes of the stars already observed and for several fainter ones to $B \sim 14$ mag. Velghe has completed a study based on revised photoelectric data for 196 OB stars in Vela ($263^\circ < \ell < 273^\circ$, $-5^\circ < b < +2^\circ$). The data confirm the probable presence of a spiral feature at $\ell \sim 268^\circ$ stretching to distances of more than 5 kpc from the Sun, outside the known Car spiral complex. In a parallel study Denoyelle (1974) has found an apparent link between the Vel feature at $\ell = 268^\circ$ (noted above) and the Car spiral arm, around $\ell = 275^\circ$, at a distance of 2–4 kpc from the Sun.

The Carina-Crux section of the Milky Way continues to receive much attention. Lynga and Wramdemark (10.133.056) have established in the galactic plane faint star sequences (to $V \sim 17.5$ mag) in three regions ($\ell = 280^\circ$, 289°, and 298°) for a study of the early-type stellar distribution and the distribution of interstellar matter. Wramdemark (1975) has completed an investigation of faint early-type stars at $\ell = 290°$ in two fields ($b = 0°$ and $b \sim -1°$). He finds that the OB stars at $r > 5$–7 kpc in the galactic plane are more numerous than at $b \sim -1°$, while nearer the Sun the reserve is true. An investigation of the stellar aggregate surrounding HD 101205 ($\ell = 295°$, $b = -2°$) by Ardeberg, Maurice and Rickard by observations at ESO indicates that the aggregate is extremely young and consists of O and early B stars. Its distance is 2.5 kpc and the number of binary stars appears to be high (Ardeberg and Maurice, 1975).

Progress on the Stockholm Spectral Survey of the Southern Milky Way continues. Catalogues by Sundman *et al.* (12.114.020), by Nordstrom (1975) and Lodén *et al.* (1975) have appeared or will appear soon; others are in preparation. A statistical investigation of the surface and space distributions of 13 000 stars in $\ell = 280°$–$319°$ has been carried out by Sundman (1974).

Several investigations of the stellar space distribution in the Warner and Swasey Observatory LF regions in the southern sky (*Trans. IAU* XIII, p. 687, 1967) are in progress. Vleeming (13.155.004) has recently completed an analysis of the distribution of giant M stars in LF 14 ($\ell = 298°$, $b = +1\overset{\circ}{.}4$). In a later paper Vleeming and Thé (1975) give a detailed discussion of the results for LF 13 ($\ell = 281°$, $b = +3\overset{\circ}{.}0$) and for the M star distributions in several other fields.

The surface and space distributions of main sequence B 8–A 3 stars and of gG 8–K 2 stars to $V \sim 13$ mag along the Carina section of the Milky Way ($\ell = 270°$ to $305°$, $b = -5°$) are being studied by McCuskey and colleagues at the Warner and Swasey Observatory.

Garzoli and Mirabel (10.155.039) have studied 21-cm data for $\ell = 288°$–$310°$, $b = -7°$ to $+2°$, a region where the galactic plane is strongly bent towards negative longitudes. The principal structure is a spiral arm with a pitch angle of 10° and made up of several concentrations.

Humpreys and Kerr (12.155.078) find a significant difference between the motions of young stars and hydrogen in the Carina spiral feature near $\ell = 290°$. They discuss several possible interpretations, and suggest that a shock front may be involved.

VI. *Cen-Cir-Nor-Sco ($300° < \ell < 350°$)*

Interest in the region of the Coal Sack continues. Muzzio *et al.* (12.155.033) have searched five small areas at $\ell = 302\overset{\circ}{.}4$, $b = -0\overset{\circ}{.}2$ for faint OB stars to a limiting mag $V \sim 14.5$. They found 11 previously known and 15 new OB stars. There is a possible clustering (six stars) of OB stars near the compact cluster Hogg 15. In two papers Weaver (11.113.023; 11.131.066) has discussed his *UBV* photometry of Hα emission objects and of suspected flare stars in the Coal Sack region. Hidajat and Kuncoro (12.122.125) have recently used multiple-image photographic techniques to detect five flare stars in the Coal Sack area. Kerr *et al.* (11.131.541) report a negative result in a search for neutral hydrogen in the Coal Sack.

Lynga and Stenholm (11.114.024) have found ten WR stars in $\ell = 302°$–$312°$ which have very low color excesses. They calculate distances ranging from 2 to 20 kpc for these objects and hence, conclude that the line of sight here coincides with a 'galactic window'. Lynga is now observing radial velocities for some luminous stars in this field.

A search for faint OB stars by multiple-image plates and transmission grating techniques for a field in Centaurus at $\ell = 307\overset{\circ}{.}1$, $b = -1\overset{\circ}{.}3$, has been made by McCarthy and Miller (09.113.017). There appears to be no obvious concentration of OB stars indicative of a spiral arm feature in this galactic longitude. A similar search by McGruder (11.113.012) by *UBV* photometry on a massive scale has been done photographically through the use of the Galaxy machine at Edinburgh. In an analysis of the space distribution of OB stars along the Cir-Nor section of the Milky Way Oyen (08.155.034) has found at $\ell = 325°$ a density maximum at $r = 1.3$ kpc from the Sun and suggests that these stars are concentrated in the Sgr spiral arm. Muzzio and McCarthy (10.113.086) have found by *UBV* photometry at $\ell = 328°$, $b = 0\overset{\circ}{.}8$, some 125 stars with derived spectral types B 3 and earlier of which 11 were previously known. Preliminary space density analyses for the stars earlier than B 2 indicate maxima at $r = 2.5$ kpc and at $r > 5$ kpc which may be associated with the Sgr and Nor-Sct galactic spiral features. Muzzio (12.155.027) has made a similar search for faint OB stars in the Norma region in three areas at galactic longitudes $\ell = 325°$ to $335°$ near the galactic plane. Havlen (09.155.079) has continued his *UBV* and Hβ stars in the Ara region $\ell = 335°$ to $339°$, $b = -2°$ to $+1°$.

The space distribution of giant M stars in LF 15 at $\ell = 330°$, $b = -2\overset{\circ}{.}2$ has been studied by Thé *et al.* (11.155.018). A space density maximum for M 2–M 4 stars may possibly be connected with the Sgr spiral arm, although the distance seems too large. For the late M stars there is no evidence of association with the spiral structure.

C. *High Latitude Optical Studies*

This section of our Report is concerned with optical studies of the stellar population in galactic latitudes $|b| > 20°$. Large-scale properties of the galactic halo will be discussed in Section IVD.

One of the current unsolved problems of local galactic structure near the Sun and perpendicular to the galactic plane is that of the space density of late-type dwarf stars. This has an important bearing on the mass density near the Sun and, hence, on the discrepancy between the total mass estimated from stars, gas, dust, etc. and that required by the dynamical theory of stellar motions – the so-called 'missing mass problem'. Using star counts as a function of color and apparent V magnitude at the NGP, Weistrop (08.115.017) obtained the space distribution of red dwarf stars perpendicular to the galactic plane at the Sun's position. She derived a steep, negative density gradient perpendicular to the galactic plane and a red dwarf disk population near the Sun at least five times as large as formerly supposed. The large increase in the stellar luminosity function demanded by this has been seriously questioned. Weistrop (1975) has recently reexamined the evidence and finds from a preliminary analysis that the density of the reddest stars is not nearly as great as originally proposed. Currently, a thorough investigation of the red dwarfs near the NGP is underway.

Others are actively working on this problem. Luyten (1975) has determined proper motions for 1900 faint stars ($m_{pg} \sim 21$ mag) to $0\overset{''}{.}090\ \mathrm{yr}^{-1}$ in four Palomar regions at high galactic latitude, and motions down to $0\overset{''}{.}045\ \mathrm{yr}^{-1}$ for 2250 stars in one region. From these and color data he finds no evidence for the existence of large numbers of M dwarf stars with little or no proper motion. Gliese reports recent calculations based on the Luyten and the Weistrop luminosity functions, and on Luyten's proper motion data and concludes that the observations contradict the extrapolation of Weistrop's luminosity function for $M_V > 13.5$. He concludes that the number of such objects must be low. In consequence, the value of the local mass density given by Veeder (12.118.003) (about $0.2\,M_\odot\,\mathrm{pc}^{-3}$) should be decreased by $0.08\,M_\odot\,\mathrm{pc}^{-3}$. Gliese (12.112.002) pointed out some of these discrepancies earlier, as did Luyten (13.112.010) Sanduleak at the Warner and Swasey Observatory has ready for publication a list of 273 suspected faint late-type M dwarf stars at the NGP. He is planning to survey several other northern high-latitude regions for suspected M dwarfs with $V \sim 16$ mag, beginning with objective prism identifications.

Gliese (11.155.030) has evaluated the frequency of red dwarf stars in the region of the South Galactic Pole (SGP). In a more recent survey of the SGP Thé and Staller (12.155.071) have identified M stars to a limiting $m_{pg} \sim 16$. By use of proper motion data, where available, they segregate the dM stars and find an average space density which is significantly lower than that at the NGP. This result, however, has been questioned by Dolan (13.155.028). This discrepancy has led Pesch at the Warner and Swasey Observatory to undertake a new and complete objective prism survey of the SGP for M stars comparable in depth ($V \sim 16$ mag) to that done by Sanduleak in 1964 at the NGP. This is now underway; data are being obtained at CTIO.

Murray reports from the Royal Greenwich Observatory that a large scale proper motion and photometric program to $B \sim 16$ mag in Sa 51, 54, 57, 71, 82, 94, and 107 is underway. Final proper motions for 300 stars in SA 57 near the NGP have been derived and a discussion of kinematics, mean parallaxes and the stellar density distribution is nearly complete. A survey for determination of trigonometric parallaxes of faint stars near the SGP is also being started.

Eggen (1975a, b) has continued his observational studies of population samples at the galactic poles. Luminosity functions for 'old disk population', 'halo population', and M-type dwarf stars have been derived. He derives an upper limit of $9 \times 10^{-4}\,M_\odot\,\mathrm{pc}^{-3}$ for the mass density of the halo population near the Sun.

A survey for early dM stars based upon objective prism spectra has been made by Smethells (12.155.013) over an area of 1720 sq deg of the southern sky at intermediate galactic latitudes. Jôeveer (11.155.015, and .016) has also estimated the galactic mass density near the Sun from long-period cepheids.

M. Schmidt (1975) finds from the luminosity function of high-velocity stars that the local mass density of halo stars heavier than 0.1 solar masses is 1.7×10^{-4} solar masses per cubic parsec which corresponds to a mass of the halo ten times less than the massive halo proposed by Ostriker and Peebles.

The density and velocity distribution of K-giants near the galactic poles was studied by Balakirev (1975). For stars with $|b| > 84°$, excluding intermediate disk population stars, he obtained for the Kuzmin constant $C = 76$ km s^{-1} kpc^{-1}, which corresponds to $\rho = 0.11\ M_\odot\ \mathrm{pc}^{-3}$.

At Abastumani Observatory two catalogues of stars were published (Tchipashvili 10.113.021, Zaytseva 10.113.022). For more than 10 000 stars brighter than $12^m.5$ near the North Galactic Pole photovisual magnitudes and spectral classes were derived; for many stars $B-V$ colors and luminosity classes were also found.

Some years ago a joint Abastumani-Tartu program was initiated for the study of stars of various metal content near the North Galactic Pole. The technique of three-dimensional quantitative spectral classification of F 5–G 5 stars from objective prism plates was worked out by Malyuto (12.114.155). Of the 98 stars classified so far, 8 are metal deficient.

Space density gradients for the halo and disk populations have been published by Schaltenbrand (12.113.014) for SA94 ($\ell = 176°$, $b = -49°$). Becker reports that new results of this program at Basel are available for SA 82, SA 107, and in the directions of M 3, M 5, M 13, and NGC 4147; measurements in a field 20° away from the galactic center (NGC 6171) are in progress. A search for white objects at high galactic latitudes is underway at Basel. Results are available for SA 51, 54, 57, 82, and the region of M 5; measurements in SA 107 and the NGC 6171 field are in progress.

The distribution in space of the common stars in Selected Areas at intermediate and high galactic latitudes has been studied by Borzov (10.155.029). A reexamination of his earlier (Upgren 62, 14435) analysis of the stellar population at the NGP has been made by Upgren and Lü (12.155.014) to identify more definitively the giant and dwarf stars. They conclude that their new separation into luminosity groups agrees with the original, and so would the space density analyses.

Elvius reports from Lund that large-scale studies of stellar space density and interstellar absorption by himself and Ardeberg are continuing. Emphasis is on SA 92, 164, 165, 188, 200, and 205. Sarg is investigating the late-type giant stars in two fields in the southern sky at $\ell = 185°$, $b = -43°$ and $\ell = 228°$, $b = -50°$. From Uppsala Oja indicates that an investigation by Erikssson of the SGP region by *UBV* photoelectric and *BV* photographic photometry is well advanced. A discussion of the interstellar reddening and the stellar space densities is nearly complete. Gyldenkerne and Hansen at Copenhagen, in collaboration with Griffin and Radford at Cambridge, are making g, n, k, m, f photometry of about 600 NGP stars of G and K spectral type for which radial velocities have been measured, as a contribution to the evaluation of the galactic K_z component. Strömgren (Copenhagen) and Mavridis (Thessaloniki) have in progress a photographic photometric search for Extreme Population II stars to a limiting mag 15.5 in the galactic polar caps.

Several photometric investigations relative to the galactic structure at intermediate and high galactic latitudes should be mentioned. Philip and Relyea (10.113.107) and Philip (11.113.039) have observed by *uvby* and Hβ photometry all stars of spectral type A 5 and earlier to a limiting mag ∿14.5 in a 34 sq deg area centered at the SGP. Two related studies by *UBV*, *uvby* and Hβ photometry have been published by Drilling (09.113.018) and by Drilling and Pesch (09.113.019) for areas 3HLF4 ($\ell = 0°$, $b = -45°$) and 4HLF4 ($\ell = 180°$, $b = -45°$). These data are to serve for calibration of more extensive spectral class and photometric data being compiled at the Dudley Observatory by Philip and his coworkers.

One interesting result of the past three years is the observation of the far ultraviolet brightness of the NGP and SGP regions from the spacecraft Apollo 17. Henry *et al.* (12.155.085) have reported that spectrometer scans between 1180 and 1680 Å, after due correction for a variety of non-stellar radiations, yielded a residual intensity of less than 250 photons cm^{-2} s^{-1} $Å^{-1}$ st^{-1} at 1400 Å. They interpret this as the light of B stars in the galactic plane scattered by high galactic latitude interstellar dust.

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4. OVERALL STRUCTURE OF THE GALAXY

In this section, we discuss the larger-scale features of the Galaxy, revealed largely by radio observing methods, coupled to some extent with the optical.

A. *Spiral Structure*

An interesting and comprehensive review of current knowledge concerning the structure of the stellar constituents of the Galaxy has been published by Eggen *et al.* (09.155.100). The progress of neutral hydrogen studies of galactic structure has been reviewed by Kerr (10.155.026), Burton (11.155.012) and Lindblad (12.151.021).

Deriving the distribution of the neutral hydrogen throughout the Galaxy requires an understanding of the velocity patterns, because only kinematic distances are available. The kinematic aspects of the spiral structure problem are discussed in Section 5B. Recent work on the hydrogen distribution has depended on the density-wave theory. For example, Simonson (1975) has produced a spiral structure model based on the available 21-cm data and the density-wave theory. He derives a basically two-armed pattern, which becomes multi-armed outside the Sun's distance from the center. The pitch angle is 6°–8° in the inner part, increasing to 16° in the outer sections. Yuan has also developed a spiral model from density-wave considerations. Rohlfs (12.155.029) has derived a new interpretation for the Perseus arm through a separation of the cloud and intercloud components in the observations for that region. Wielen (13.151.035) has discussed the implications of the density-wave theory on future programs of optical observations of spiral structure and kinematics of the Galaxy.

A new view of the outer structure of the Galaxy has been presented by Verschuur (09.155.005; 10.155.005; .020 and .048) and Davies (08.155.006). They suggest that most of the high-velocity H I clouds at intermediate and high galactic latitudes, as well as the highest-velocity clouds which lie near the plane, are parts of distant spiral arms. The lack of earlier recognition of these arms in galactic plane surveys is due to the arms being extremely nonuniform and well out of the plane. Hulsbosch and Oort (09.155.006) have criticized this approach.

The galactic spiral arms in the disk have been outlined by Georgelin (13.155.020) and Crampton and Georgelin (13.155.043). They have combined their optical observations of H II regions (using distances of exciting stars and $H\alpha$ radial velocities) with radio observations ($H109\alpha$ radial velocities). The optical detection of very distant H II regions has permitted a good overlap between the radio and optical data. They obtain a four-armed spiral pattern of 12° inclination, whose tangential longitudes agree well with flux maxima in the radio continuum and at 21 cm.

The distribution of carbon monoxide in the galactic plane has been studied by Schwartz *et al.* (10.131.223), Scoville and Solomon (1975, and Burton *et al.* (1975) through observations of the 2.6-mm line. Molecular clouds emitting in this line are plentiful over the inner region of the Galaxy, and the technique is a good one for tracing out the higher-density regions. The greatest number of these clouds is found in the nucleus and at $R \sim 5.5$ kpc, a distribution similar to radio H II regions and γ-ray emission, but different from that of H I. Clearly, most of the interstellar medium in the interior part of the Galaxy is molecular H_2.

The relationship between high-energy γ-radiation and galactic structural features (particularly with arm segments) has been discussed by Fichtel *et al.* (1975). The γ-radiation appears to result from cosmic-ray interactions with interstellar matter. The relation between CO and γ-ray observations, cosmic rays, and the thickness of the galactic disk has been discussed by Wentzel *et al.* (1975), who conclude that the cosmic-ray density increases with distributed gas density.

Green (12.155.030) has derived a spiral pattern from her radio continuum survey of the galactic plane at 408 MHz, using the method of continuum 'steps', originally due to Mills. She tried a variety of equiangular spirals, obtaining the best fit to the data with a 14° quadruple spiral or a 9° two-armed spiral. From an analysis of 150-MHz continuum observations, Price (11.155.055) finds that the nonthermal emission has two major components, a base disk and a spiral component, of about equal brightness. He suggests that the Sun is located near the inner edge of a nonthermal spiral feature. Kodaira (11.125.072) and Clark *et al.* (10.125.031) have studied the distribution of supernova remnants in the Galaxy; the latter find some similarities with the HI distribution. Minn and Greenberg (09.155.049) have compared the kinematic and spatial distributions of optical and radio spiral tracers.

The galactic spiral features revealed by the spatial positions of 110 young open star clusters have been pictured by Moffat and Vogt (09.155.015; 13.155.029). They find that: (a) all spiral tracers indicate clearly a gap in the local arm at $\ell = 235°$ between 1.6 and 2.5 kpc from the Sun; (b) beyond this gap there is an indication either that the local arm might extend to 4 kpc from the Sun, or that these young clusters are a part of an outer arm (+II); (c) some young clusters have been detected out to 6 kpc in the galactic anticenter direction, in contrast to a lack of such clusters toward the inner galactic region ($\ell = 270° - 0° - 90°$); (d) an extension of the Car arm to at least 8 kpc from the Sun. The suggestion of a spiral feature at $R \sim 15$ kpc from the galactic center in this galactic longitude ($\ell = 235° – 245°$) is documented by Moffat and FitzGerald (12.155.011) and FitzGerald and Moffat (12.153.005).

Schmidt-Kaler and Schlosser (09.155.069, 10.155.059) have investigated the fine structure of the spiral arms toward the galactic center from the Sun based upon surface photometry of the Southern Milky Way. In galactic longitudes $\ell = 300°$ to 0° to 20° the spiral tracers appear to have inclinations of 10° −12° to the galactic plane, which the authors describe as a 'shingle like' pattern. The 'shingles' are typically of length about 1 kpc and width 50 pc. The main body of the Galaxy is estimated to extend to $R = 18$ kpc; its absolute magnitude is estimated to be $M_{pg} = -19.9$; its color index is about 0.60.

In a new discussion of the space density distribution of O stars, Walborn (10.155.069) finds evidence for a concentration in the Car-Sgr region with a decided gap of 1 kpc between this complex and the local arm. Stothers (10.117.025) has investigated the spatial distribution relative to spiral structure of those supergiant and early-type high-luminosity objects which are possible components of binary systems. Radial velocities derived from the interstellar calcium lines for 68 O and B stars in $\ell = 285° - 0° - 29°$ near the galactic plane have been used by Chu-Kit (09.155.003) to outline the spiral features in the Galaxy.

A review of the galactic spiral structure in the Norma region, $\ell = 320°$ to $340°$ and $b = -5°$ to $+5°$, has been made by Rydgren (12.155.032). Some evidence exists for a connecting link in Centaurus between the Sgr and Car arms but the evidence is conflicting; there appear to be a number of OB associations and H II regions in the gap between the Sgr and Nor-Sct arms; few, if any, primary optical spiral tracers are evident in the region of the Nor-Sct arm as outlined by Kerr.

R-associations are assuming importance as delineators of spiral structure. A series of papers by van den Bergh and Herbst (13.132.017), and by Herbst (13.122.018) indicate that: (a) a local spiral complex extends from Cyg through the Sun's position and toward $\ell = 265°$; (b) a sharp break occurs in the distribution in $\ell = 270°$ to $280°$ where no R-associations appear; (c) a good delineation of the Car complex extends from $\ell = 280°$ to $\ell = 0°$, and appears to join the Sgr spiral feature. A proposed model is presented for continuous spiral arms with pitch angle 13°; average width 750 pc; average separation of arm centers 1250 pc; average width of gap between the local and the (–I) arm 500 pc.

The controversy concerning the physical reality of stellar rings continues. Several papers bearing on the question have appeared in the triennium under review. Isserstedt and Schmidt-Kaler (09.153.033) conclude that the stellar ring near the open cluster Cr 107 is of doubtful reality. More recently, Isserstedt (11.113.010) has examined by UBV photometry the UV color excesses for 20 stars having MK spectral classes and 14 stars having measured radial velocities in the Aquila ring. He concludes that the Aquila ring is probably real.

Kolesnik *et al.* (10.152.001) and Voroshilov *et al.* (12.152.002) have concluded that Stellar Ring 58 at $\ell = 134°$, $b = 1.^\circ 7$ is a fortuitous grouping, not a spatial grouping, of stars. Vidal and Bern (10.152.007) have examined the observational data in detail for seven rings and conclude that the rings do not serve as spiral arm tracers in the large.

Uranova (10.152.003 and .004) has published two new lists of stellar rings. If the rings had their linear diameters at 7 pc, as assumed by Isserstedt, then they were located predominantly in the space between known spiral arms. Detailed photometric, spectroscopic and statistical study has led her to the conclusion that stellar rings are not real physical formations but consist of stars at different distances from the Sun.

Rickard (11.131.021) has observed interstellar calcium for 168 southern stars, and has distinguished several large gas features. Beintema (1975) has discussed similar observations of 149 stars in Orion, Scorpius and Lacerta.

B. *The Galactic Disk*

In this section, we consider items which refer to the disk in general, with no special connection with spiral structure.

Quiroga (11.155.011) has studied 21-cm line intensities at the tangential points in the inner parts of the Galaxy, and reports a corrugation effect in the neutral hydrogen with an average wavelength of 2 kpc and amplitude of 70 pc. Jackson and Kellman (11.155.047) have redetermined the half-thickness of the neutral hydrogen layer over the range $1.4 < R < 16.8$ kpc. They discuss the relation between this quantity and the sum of the gas, magnetic, and cosmic-ray pressures.

Knapp and Kerr (12.155.038) have derived the gas-to-dust ratio in the galactic disk from observations in the directions of 81 globular clusters, by comparing H I column densities with reddening data. They find no variation with galactic latitude, contrary to the conclusion drawn when the dust content is determined from the absorption, as indicated by galaxy counts. Seki (10.131.094) and Knapp (13.155.016) have studied regional variations of the gas-to-dust ratio over the sky. The relationship between OH, formaldehyde, and interstellar extinction has been discussed by Turner and Heiles (12.131.167). They find that the OH abundance is independent of extinction.

Extended regions of faint Hα emission have been studied by Reynolds *et al.* (10.131.140) and Sivan (11.155.044). There appears to be an ionized component of the interstellar gas which is distributed throughout the three nearby spiral arms. Radio recombination-line emission from the diffuse gas in the galactic ridge has been discussed by Gordon *et al.* (08.157.004;

08.155.048), Matthews *et al.* (10.157.008), and Jackson and Kerr (13.157.002), with differing results on the deduced electron temperature and the degree of clumpiness of the gas. An extensive catalogue of H II regions in the Galaxy has been published by Marsalkova (11.131.515).

Hopper and Disney (12.131.034) have studied a sample of 392 elongated, highly absorbing dust clouds to see whether their major axes exhibited preferential directions in the Galaxy. The authors conclude that the clouds are flattened sheets parallel to the galactic plane.

A possible relation between the spectral indices and the z-distribution of supernova remnants has been studied by Becker and Kundu (13.125.004). They find that for 93 objects $\langle |z| \rangle$ varies from about 175 pc for remnants with flat spectra ($-0.25 \leqslant \alpha < 0$) to about 60 pc for those with steep spectra ($-0.65 \leqslant \alpha \leqslant 0.56$).

The spectral index for the galactic background radiation has been determined over various frequency ranges between 130 kHz and 15.5 GHz by Brown (09.157.005), Sironi (11.157.001), Webster (11.157.002), Keen (09.157.006), and Hirabayashi (11.155.071). Berkhuijsen (09.142.108) discusses a possible correlation between extended soft X-ray emission from the region of the anticenter and some features in the radio continuum radiation.

Vallee and Kronberg (10.156.003) have derived a model for the local magnetic field from radio source rotation-measure data, together with radio and optical polarization results. They obtain a longitudinal magnetic field which is perturbed by an anomaly centered at northern latitudes. Manchester (11.156.002) has used rotation measures for 38 pulsars, and obtains a longitudinal field of 2.2 μG toward $\ell = 94° \pm 11°$, together with superposed irregularities of comparable field strength. Wilkinson and Smith (11.156.003) confirm from polarization data that a considerable random field component exists, together with a system of magnetic fields showing large-scale order.

Borzov (10.155.029) studied the density distribution in the vertical direction for the stars of late spectral types. He came to the conclusion that the density of stars near the Sun is higher than adopted earlier. Vorontsov-Velyaminov *et al.* (10.133.022) carried out spectrophotometry of planetary nebulae in the galactic center direction. The conclusion is drawn that planetaries near the center of the Galaxy differ from planetaries in the galactic disk. Physical characteristics of planetary nebulae of both groups have been studied by Kostyakova (11.133.020).

C. *The Galactic Nucleus*

In this section we discuss structural information about the nuclear region; kinematic studies are summarized in Section 5B. The galactic center (especially Sgr B2) is the principal place in the Galaxy where new molecules have been studied and their physics and chemistry investigated. This work is described in the reports of Commissions 34 and 40.

An important study by Oort and Plaut (13.155.051) of the space distribution of RR Lyr variables toward the galactic center leads to a new value $R_0 = 8.7 \pm 0.6$ (m.e.) kpc. The space density distributions appear to be almost spherical out to a distance of 5 kpc from the galactic center. The authors show convincingly that $R_0 = 8.7$ kpc can be reconciled satisfactorily with kinematic data on galactic rotation. For the present, however, they recommend adherence to $R_0 = 10$ kpc and $\Theta_0 = 250$ km s^{-1} now used as galactic parameters except in special cases where more accuracy may be desirable.

Counts of very faint stars (limiting $V \sim 21$ mag) in a galactic window at $\ell = 0°$, $b = -8°$ by van den Bergh (11.155.009), and corresponding UBV photometry, have shown a very steep rise at $V = 19$ which is interpreted as the large body of main sequence stars populating the nucleus. Van den Bergh estimates $R_0 = 9$ as the distance from the Sun to the galactic center. The interstellar reddening was evaluated as $E_{B-V} = 0.27 \pm 0.30$ mag. In a succeeding study van den Bergh and Herbst (11.155.046) obtained 9.2±2.2 kpc for R_0 .

Schmidt-Kaler and Schlosser (10.155.059) have photographed the Southern Milky Way in the $UBVR$ system with a wide-angle camera. On the assumption that $R_0 = 10$ kpc the authors find from the red photometry isophotes that the nucleus extends 2.9 kpc ±0.3 in the galactic plane and 1.7 kpc ±0.2 perpendicular to the galactic plane. The flattening of the nuclear region, the relative dimensions of the nucleus, and a main body of radius 18 kpc agree well with averages for Sb I–II galaxies.

In the radio continuum, much work has been done on fine structure in the central source Sgr A. Studies with resolutions of 2–4′ have been reported by Dulk and Slee (11.141.048) at 160 MHz, Rougoor *et al.* (12.057.002) at 1418 MHz, Sandqvist (12.157.001) at 1420 and 1667 MHz, and Whiteoak and Gardner (09.157.004) at 5 GHz. Arc second resolutions or better have been used by Kapitzky and Dent (11.155.008) and Balick *et al.* (12.155.023 and .077). Much fine structure has been observed, with components directionally coincident with IR sources thought to be at the center; the radiation therefore probably arises from hot dense gas very near the center.

Ariskin *et al.* (12.155.042) have proposed a model of the large-scale distribution of the ionized medium in the central region from their 21-cm observations. Jones (11.155.003) discusses recent high-resolution observations over a very wide frequency range, and obtains a nonthermal spectral index for Sgr A, which he suggests is a supernova remnant.

Sanders and Wrixon (10.155.004) discuss their 21-cm observations of the nuclear disk. From model studies, they conclude that the gas density in the inner 500 pc must increase inward in a form similar to the star density, and that an upper limit of 10^8 $M_{\odot}$ may be placed on any condensed object at the center. Cohen (13.157.008) in his 21-cm survey of the galactic center region, has detected six new high-velocity emission features, all lying out of the galactic plane. Saraber and Shane (12.131.544) have studied a high-velocity (-213 km s^{-1}) H I object at $\ell = 8°$, $b = -4°$, which they interpret as a cloud ejected from the nucleus. Several papers discussing the kinematics of nuclear-region hydrogen with outward radial velocities are reported in Section 5B.

The distribution of CO in the central region has been discussed by Solomon *et al.* (08.155.052; 11.155.004) Sanders *et al.* (11.155.054), and Liszt *et al.* (13.155.041). The distribution of CO corresponds well with those of formaldehyde and of the 100-μm sources. The dust grains and the gas appear to be colocated, and nearly in thermal equilibrium.

The observations of formaldehyde absorption by Scoville and Solomon (09.155.013) indicate that the group of dense, low-positive-velocity clouds does not continue beyond $\ell = 2°$ and that the negative-velocity clouds are part of an arm structure within 300 pc of the galactic center and having a total mass of $\sim 10^6$ $M_{\odot}$. Whiteoak *et al.* (12.131.153) have presented an aperture-synthesis map of formaldehyde aborption in Sgr A with a 20″ x 40″ beam.

Lekht *et al.* (12.131.021) carried out a study at Nançay of OH at 1667 MHz near the galactic center. Six clouds were found and their possible structure discussed. Lipovka (13.157.001; 1975) has found two deep minima of 4-cm continuum radiation at 500 pc from the center. Soboleva (12.141.090) has determined the polarization of Sgr A at 4 cm wavelength.

Recombination-line emission from H II regions near the center has been reported by Matthews *et al.* (10.157.009) and Pauls *et al.* (12.131.504). Mezger (11.155.072) has suggested that the dominant features of the galactic nucleus are: (a) a dense star cluster containing about 10^{10} $M_{\odot}$ and a rapidly rotating gaseous disk, both extending to $R \sim 800$ pc from the center; and (b) the central source Sgr A, consisting of an extended H II region in which are embedded strong infrared sources.

Infrared maps of the galactic nucleus at $\lambda = 3.5$, 5.0, 10.5, and 21 μm with a resolution of 5.5 arc sec by Rieke and Low (10.155.036; 10.155.023) show five discrete sources resolved from the diffuse background, which in turn is separated into three components. Rocket observations of the galactic center in the infrared at $\lambda = 5$, 13, 20, and 100 μ are reported by Soifer and Houck (10.155.055). They suggest that the nucleus of the Galaxy is a giant H II region with thermal emission from dust producing the strong infrared sources.

D. *The Galactic Halo*

Oort and Plaut (13.155.051) have determined the space density gradient of RR Lyr stars along the direction of the galactic axis of rotation. Densities ν_m around the maxima of the observed frequency in general vary as z^{-3}.

An extensive study by *UBV* photometry of the colors and distances of globular clusters has been published by Kukarkin and Rusev (07.154.004). The distances are systematically smaller than those previously accepted. One can deduce from the data presented a value $R_0 = 8.5$ kpc, in good agreement with that found by Oort and Plaut (1975). A study of all available integrated *UBV* colors and spectral types for globular clusters has been made by Burstein and McDonald (13.154.002) to see whether these parameters can be used to obtain an accurate value of interstellar reddening in the halo.

Knapp *et al.* (10.154.022) and Conklin (1975) have carried out sensitive searches for neutral hydrogen in globular clusters with negative results. The upper limits in several cases are below a solar mass. Erkes and Philip (13.154.007) have reported a similar negative result for ionized hydrogen. Several groups are engaged in theoretical work to consider these low upper limits in relation to the amount of gas to be expected due to mass loss from stars.

The nature and distance of the high-velocity hydrogen clouds have long been uncertain. The most interesting recent development in this field has been the discovery by Mathewson *et al.* (11.159.004; 12.131.543) that a long filament of H I extends from the Magellanic Clouds over a large part of the galactic sky. This feature, 'the Magellanic Stream', seems to contain a large part of the high-velocity hydrogen, and may have been produced by a tidal interaction between the Clouds and the Galaxy. A possible extension of the Stream in the northern sky is discussed by Cohen and Davies (13.159.005).

A large general study of the properties of high-velocity clouds has been described by Hulsbosch (13.131.126). He shows that the clouds occur mainly in complexes consisting of bright cores embedded in weak extended envelopes, and suggests as the most probable explanation that infall of extragalactic matter accelerates galactic hydrogen clouds high up in the halo. From high-resolution observations, Giovanelli *et al.* (10.131.091) also show that the high-velocity gas has a hierarchial structure, with small bright condensations embedded in larger regions of low emissivity. Wesselius (09.155.022) has studied intermediate-velocity gas in one high-latitude region, and suggests there has been recent interaction between this gas and the low-velocity gas.

Silk and Siluk (09.131.039) report a correlation between the maximum hydrogen column density and the corresponding radial velocity. Suchkov *et al.* (12.131.526) discuss an origin for the high-velocity gas in the passage of the spiral shock through interstellar gas.

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5. KINEMATICS

A. *Stars*

I. *Galactic Rotation*

Proper motions and radial velocities of FK4/FK4 Sup stars of the disk population have been analysed by Fricke and Tsioumis (1975) in the distance intervals 70 to 300 pc to 1300 pc. It appears that (1) stars assumed to be members of the Gould Belt by Lesh do not deviate as a whole from galactic rotation, the motions of the nearby stars younger than 4×10^7 yr, however, deviate strongly from galactic rotation and form a local irregularity in the general velocity field; (a) the significant K term, found in the solar neighbourhood in agreement with Lesh's results, is most likely to be explained by the occurrence of nearby groups of stars with diverging group motions. The investigation is at present being extended by Tsioumis to all stars in Lesh's lists of Gould Belt stars.

After the final version of the AGK3 has become available, a rediscussion of the AGK3 proper motions has been made by Asteriadis, and the Lick proper motions measured with respect to galaxies and the comparison with AGK3 have been reanalysed by du Mont. Asteriadis has found that the final version of the AGK3 yields a correction to Newcomb's lunisolar precession in full agreement with the value derived by Fricke in 1967 on the basis of the FK4. The precessional correction Δk agrees with the value derived by Dieckvoss in 1967, and the values of Oort's constants agree with the generally adopted values. From the Lick proper motions du Mont has derived values of Oort's constant in satisfactory agreement with results obtained by Vasilevskis and Klemola in 1971; the correction to lunisolar precession is in fair agreement with Fricke's value, and Δk agrees satisfactorily with the result from AGK3.

Solar motion solutions were made by Hemenway (13.122.023) using velocity data of RR Lyrae stars. Their absolute magnitudes were found from statistical parallaxes of these stars grouped by period and metal type. The resultant mean light visual absolute magnitude of a-type group leads to a value of 9.3 kpc for the distance to the galactic centre. Van den Bergh and Herbst (11.155.046) report a value of 9.2 ± 2.2 kpc from distant RR Lyrae stars in the nuclear bulge. Rybicky *et al.* (12.55.084) deduced a value of 9.0 kpc using the observed values of Oort constants A and B, the local surface mass density and a single selected point from 21-cm rotation curve data. Barkhatova *et al.* (09.155.061) has used Weaver's method to derive a distance of 8.0 ± 0.4 kpc from radial velocities of 46 galactic clusters.

Isobe (12.155.074) derived a local velocity of rotation of 275 ± 20 km s^{-1} from Eggen's high-velocity stars. The mean error of 20 km s^{-1} may not be representing the external error because of the small number of stars. Woltjer finds a velocity of 200 to 225 km s^{-1} from a discussion of the motions of globular clusters (1975). Karimova and Pavlovskaya (10.155.006) found that the law of rotation in the neighbourhood of the Sun is the same for different groups, such as Cepheids and globular clusters, and that the angular velocity varies from 4 to 25 km s^{-1} kpc^{-1} for extreme population I to the halo population.

A discussion of recent determinations of R_0 and A have yielded according to Lohmann (11.155.006) the mass of the galaxy of 1.92×10^{11} solar masses.

An analysis of motions of galactic clusters to second-order terms has led Taff and Littleton (08.155.046) to a value of $A = 14.2$ km s^{-1} kpc^{-1}. The observing data were unsufficient for a definitive calculation of the second order constants. Crézé (09.155.004) tried to eliminate errors of stellar distances and found that the solar motion exceeds 20 km s^{-1}, that A is at least 16 ± 0.5 km s^{-1} kpc^{-1}, and that R_0 cannot be larger than 9 kpc. This study took into account the existence of a spiral density wave in order to arrive at unbiased estimates. Gomez and Mennesier are continuing this line of thought. Also considering second order terms, Barkhatova and Danilov (09.155.062, 10.151.048) found substantial differences in the values of A and K for young and old galactic clusters.

Balona and Feast (11.155.042) found, using OB stars, $R_0 = 9.0\ (+1.9, -1.3)$ kpc and $A =$ 16.8 km s^{-1} kpc^{-1}. Cruz-Gonzales (12.155.002), using a fixed value of $A = 15$ km s^{-1} kpc^{-1}, derived from nearby stars $B = -10.7$ km s^{-1} kpc^{-1}, $R_0 = +8.9 \pm 0.5$ kpc, a rotation velocity of 228 ± 24 km s^{-1}, and values of the mass density gradient. Fatchikhin (09.111.007) has used proper motions of 14600 stars with photographic magnitudes between 14.6 and 15.5 to derive solar apex co-ordinates and the constants of galactic rotation.

Clube (09.155.042, 11.153.034) applied a general model describing first-order variations in the velocity field with respect to distance in the wide solar neighbourhood to the analysis of absolute proper motions of faint stars and found the Lindblad-Oort model inappropriate to the motions of nearby stars. If applied to more distant stars, the following values are obtained $A \leq 16.1 \pm 5.0$ km s^{-1} kpc^{-1}. $B = -25.6 \pm 5.0$ km s^{-1} kpc^{-1}. These results are interpreted as implying a distance to the centre of 7 kpc. The velocity field also indicates a local expansion of the solar neighbourhood from the centre at about 75 ± 27 km s^{-1}. This expansion is supported by Clube by other evidence. The expansion of the galaxy will be probably a controversial subject. No significant expansion is reported by M. W. Ovenden from an analysis of radial velocities of O and B stars, Cepheids and galactic clusters. Feitzinger (1974) finds a K-term only with young stars which lose the excess velocity after they have left the spiral arm.

The space distribution and z-motions of population I Cepheids has been studied by Jôeveer (11.155.015) and a value of 80 km s^{-1} kpc^{-1} has been derived for the local dynamical parameter C corresponding to a galactic mass density near the Sun of 0.115 solar masses per cubic parsec.

II. *Velocity Distribution*

Vandervoort (13.155.006) has extended the equations of stellar hydrodynamics to include equations involving third and fourth-order moments of the stellar velocity distribution, and he has analyzed the way in which measurements of the higher moments can be used with the extended system of hydrodynamic equations in order to study the local structure of the Galaxy. Erickson (13.155.007) has determined the higher moments for a sample of nearby stars. He has shown that their values are consistent with the axial symmetry of the Galaxy, and he has estimated the local curvature in the law of galactic rotation, the local scale height of the Galaxy and the ratio of the constants of galactic rotation.

Radzievsky and Medvedeva (10.155.007) have shown, from a discussion of proper motions, that the Sun belongs to a moving group with a centre at a distance of a few hundred parsec. The kinematical properties of the Hyades-Praesepe moving group were determined by Nezhinskij and Osipkov (13.153.003). Moving groups and star streams have been studied by Hopman (08.155.042).

Relations between parameters of distribution of stellar absolute and apparent magnitudes, proper motions and tangential velocities were studied by Jôeveer (10.155.068). The correlation between kinematical properties and age was discussed by Einasto (10.155.051). The dependence of the velocity dispersions on age of nearby stars was examined by Byl (12.155.031). The results could be accounted for if the spiral arms had dissolved and reformed a number of times.

Thackeray (13.112.007) has compiled a list of galactic objects with radial velocities greater than 250 km s^{-1}. Most objects are probably in retrograde orbits. Toomre and Greenstein have been re-examining the dynamical implications of some of the highest-velocity stars (with regard to the centre). Individual high-velocity stars have been measured by Kilkenny (11.112.003), Lippincott (1975), and the detection of a proper motion of a pulsar has been reported by Manchester *et al.* (11.141.330) which implies a rather high transverse velocity.

Havnes (08.112.014) has reported an increase of average space velocity of early type stars with increasing rotational velocity. Balakirev (10.155.008) has found the value of $A = 12.5 \pm 0.6$ km s^{-1} kpc^{-1} from radial velocities of O and B stars. Shatsova (12.155.036 and .037) has found the OB stars rotating with $A = 15$ km s^{-1} kpc^{-1} and slightly expanding, and Abhyankar (12.155.088) has studied the variation of the galactic force law. Thuan (13.131.116) has studied the ionization of the intercloud medium by runaway O-B stars. Karimova and Pavlovskaya (13.155.013) redetermined proper motions of B supergiants and calculated their velocity ellipsoid.

Velocities of pecular and normal A and B stars have been studied by Eggen (08.115.025, 11.115.016). Mayor (11.151.031) studied the age and kinematics of A and F dwarfs. He showed that it is not justifiable to include stellar subpopulations whose velocity dispersions are too low in calculations of the tangential component of the solar motion. A new value of the solar motion is proposed. Wright (10.155.033) has used radial velocities of A stars to calculate the z-component of the attraction. Karimova and Pavlovskaya (in press) determined elements of orbits for different stellar populations. The orbits of Ap and Am stars are almost circular. Clegg and Bell (10.155.001) studied the correlation of metal abundances with galactic orbits of F and G dwarfs.

The luminosities and space motions of high-luminosity red stars near the Sun were discussed by Eggen (09.155.099, 10.113.027, 10.115.037, 11.115.006). One of the results is an indication of a continuous star formation over most of the life of the Galaxy. Gomez (11.155.028) derived velocity ellipsoids of well defined samples of the main sequence stars and of sub-giants. He found third order moments of little significance. Dessureau and Upgren (1975) have studied the velocity distribution of G and K stars and revised their density distributions. A stable and realistic model has been obtained with three distributions (09.155.078).

The velocity dispersion of M stars in the Southern galactic cap has been determined by Jones (08.155.055) and low-velocity red dwarfs in the vicinity of the North galactic pole have been studied by Gliese (12.112.002). The incidence of wide pairs of about 60% among K and M dwarfs has been found by Lü and Upgren (09.117.006). Upgren also calculated space motions of about 150 K3-M2 dwarfs and determined the solar motion. About half of the late-type dwarfs in the solar neighbourhood belong to the young-disk population and half to the old-disk population with halo stars accounting for only a few percent of the total number. Upgren also found that the velocity ellipsoid of old-disk stars is considerably larger than that of young-disk stars and that the vertex deviation is larger for the latter group. Karimova and Pavlovskaya (10.155.070, 11.155.051) have determined velocity ellipsoids for various populations of stars and for nearby stars. Correction for observational selection has been found to be most important for red dwarfs. Shatsova *et al.* (10.155.071) have computed velocity dispersion of the GKM dwarfs, Jahreiss (11.155.053) has discussed kinematics and age of nearby stars, and Rius Jordan (1975) has presented a three dimensional analysis of the velocity field in the neighbourhood of the Sun. Shatsova (12.151.030) has determined dynamic parameters of the phase-density of stars from Planck's distribution law.

Wielen (11.122.017) derived space motion of 45 classical Cepheids closer than one kiloparsec and found their velocity dispersions. Distant Cepheids were investigated by Grayczek (10.122.135) who found reasonable agreement with the H I motions in the region, indicating that both stars and gas share similar kinematics. Large scale regional motions in the distant spiral feature in the Crux-Centaurus region are indicated. Motions of Mira Ceti variables have been studied by Gotska (10.155.028) and by Foy *et al.* (1975). It appears that the relation of velocity dispersion versus age agrees with the idea of gradual flattening of the galaxy, as proposed by theories of a collisional collapse. Karimova, Kukarkin and Pavlovskaya (in press) determined elements of orbits for 109 RR Lyrae stars and attributed some of the stars to the halo and disk populations.

Cudworth (12.133.038) measured new proper motions of 51 planetary nebulae and used them in statistical parallax calculations. The distance scale thus calibrated for optically thin nebulae agrees with that of Seaton. A distance for the centre exceeding 8 kpc is indicated. Melnick and Harwit (13.133.016) find a correlation between the orientation of elliptical planetaries and the direction of the galactic equator. According to Cudworth (1975) this correlation cannot be due to compression along the direction of motion through the ambient interstellar medium. Barkhatova and Pavlovskaya (in press) computed elements of orbits of 50 galactic clusters.

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B. *Interstellar Matter*

I. *Large-Scale Motions*

The interpretation of 21-cm observations of galactic spiral structure in terms of the density-wave theory has been reviewed by Burton (11.155.012) and Lindblad (12.151.021). They discuss the observable kinematic characteristics of the neutral hydrogen, and stress the importance of understanding the velocity field before the structural pattern can be derived. Tuve and Lundsager (1973) find no evidence in their observations for spiral arms outlined by density variations, and present the extreme view that the conventionally-discussed arms exist in velocity space only. Rohlfs (12.155.029) has used an operational definition to separate H I clouds from the intercloud medium. The latter can then be examined for large-scale velocity field effects. When the method is applied in the Cassiopeia region, density-wave streaming motions can be seen.

Most authors now discuss the observations in terms of the density-wave theory, but Piddington (09.151.011 and .028) argues that elongated H I features do not coincide with stellar spiral arms, and he considers a magnetic theory may be more appropriate. In any case, it is necessary to include an X-factor of star formation.

Lohmann (11.155.006) has applied the tangential-point method to the data of the 21-cm survey by Weaver and Williams (09.157.009), and obtained a value of 145.7 km s^{-1} for the product AR_0. For comparison, recent individual measurements of A and R_0 yield a value of 138.5 for the product.

Manabe and Miyamoto (13.155.019) have shown that the large scale north-south asymmetry in the galactic rotation curves obtained from observations of neutral hydrogen can be explained as a consequence of non-circular galactic rotation caused by a central bar-like structure and a radial motion of the local standard of rest.

Tosa and Sofue (11.155.043; 12.155.073) discuss rising and falling motions of H I gas above the Perseus arm, on the basis of a systematic variation of radial velocity with galactic latitude. The motions are interpreted in terms of vertical motion of gas ejected from the spiral arm. On the other hand, Yuan and Wallace (10.155.034) consider that these 'rolling motions' are only apparent, being caused by the combined effect of the bending of the galactic plane and the differential rotation. Ariskin (09.131.012) presents evidence for large expanding H I regions in the Sagittarius and Scutum arms, possibly produced by type III supernova explosions 10^7 yr ago.

Several studies have been made of the kinematics and structure in the local region. Burton and Bania (12.155.004) studied a large number of supergiants, associations and H II regions, and compared the kinematics of these optical tracers with that of the neutral hydrogen. The resulting differences are consistent with the predictions of the density-wave theory, the maximum correlation being obtained with rotation curves which are different from the Schmidt curve. Minn and Greenberg (09.155.049) also find differences between the kinematics of stars and gas, which can be explained on the basis of the density-wave theory.

Lindblad *et al.* (09.155.027) and Weaver (12.155.049) have discussed relationships between a component of the local H I gas and Gould's belt. Lindblad *et al.* and Grape (1975) describe the motion of this local component in terms of a shell or cloud expanding in the field of differential rotation. The best-fit model has an expansion age of about 50 x 10^6 yr, and the initial expansion velocity distribution has a maximum at 4 km s^{-1}. Burton and Bania (12.155.005) suggest that some of the kinematic behavior of the low-latitude local hydrogen may be explained without invoking a separate sybsystem. They compute model line profiles for an observer immersed in a flow pattern of the type predicted by the linear density-wave theory. Henderson (09.155.087) considers a plane-parallel approximation and finds a 'shearing' effect in which the gas above and below the plane has a slightly different velocity from the gas closer to the plane.

Quirk and Crutcher (09.155.064) and Humphreys and Kerr (12.155.078) have found evidence for density-wave shocks in the local arm and the Carina arm respectively.

Chu-Kit (09.155.003) and Rickard (11.131.021) have published extensive studies of the kinematics of interstellar calcium. Minn and Greenberg (09.131.010) have studied the kinematics of 80 dark clouds through observations of 4830-MHz formaldehyde absorption.

II. *Central Region*

Motions in the central region have been studied through observational surveys in the neutral hydrogen, formaldehyde and carbon monoxide lines. Sanders and Wrixon (10.155.004) find that the random or turbulent velocity dispersion of the H I in the inner 500 pc is not large enough to account for the observed distribution of gas perpendicular to the plane. Also, the gas kinematics and distribution in the inner 300 pc are nonaxisymmetric in the sense of there being a deficiency of neutral hydrogen with high rotational velocities at positive longitudes.

Scoville and Solomon (09.155.013) and Whiteoak (12.131.202) have studied the motions of formaldehyde clouds near the center. Whiteoak interprets the kinematics of these clouds in terms of an outward expansion from the nucleus. A preliminary survey in the 2.6 mm line of CO by Solomon *et al.* (08.155.052) shows a large spatial extent and velocity range. Sanders and Wrixon (11.155.054) found three distinct CO features in directions near $\ell = 0°$, $b = 0°$, with non-circular velocities of -35, -53 and $+165$ km s^{-1}, the last of which had not been previously detected in H I or H_2CO. In a later survey, Liszt, Sanders and Burton (13.155.041) have reported preliminary results of a fine-scale CO survey of the Sgr-A molecular-cloud complex. No evidence was found for galactic rotation being a dominant factor in the motion of CO within a few arcmin of the center, nor was evidence found for a rapidly rotating disk of gas at the core of the Galaxy.

Sandqvist (09.155.016; 12.157.001) has published the detailed results of his observations of a series of lunar occultations of the galactic center region in lines of H I, OH and H_2CO. In his discussion, special attention was given to the $+40$ km s^{-1} feature, which he considers to be a rotating cloud of gas that is located physically close to the center.

Sanders and Prendergast (11.155.019) have carried out hydrodynamical calculations to simulate the effects of an energetic explosion in the galactic center. They obtain a radially oscillating ring of cold gas, with the oscillation persisting for a time longer than the initial expansion time of the hot gas. This oscillating ring may be related to the observed 3-kpc arm. Kaifu *et al.* (11.155.007) report evidence for an almost complete ring of neutral hydrogen similar to the 270-pc expanding ring which they determined from earlier OH and H_2CO data. Their interpretation is based on a shock-wave model of the expanding ring.

On the other hand, Simonson and Mader (10.155.019) propose that the H I motions in the region $R = 1-5$ kpc can be approximately represented by a disk in differential rotation without the need for a general field of expanding motions. Their rotation curve for this region indicates a more uniform distribution of mass in the inner region than in many previous models. The second approximation to the motions includes an elliptical dispersion ring which represents the 3-kpc arm and the $+70$ km s^{-1} feature. Peters (12.155.083; 13.155.010) has also presented a model for the H I motions in which no energetic explosion is required. Some of the observed features are considered to be due to bar-like perturbations in the gravitational field.

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6. DYNAMICS

A. *Stellar Orbits – Third Integral*

Relaxation effects of the passage of a particle through the vicinity of a prolate homogeneous ellipsoid were studied by Ogorodnikov (08.151.023). Korchagin and Marochnik (10.155.055) investigated the case of a test star moving in a gaseous disk.

General properties of integrals of motion in stellar systems have been considered by Osipkov (09.151.050, 13.151.028). Properties of models of galaxies with a gravitational potential admitting a third integral of motion have been studied by Osipkov (10.151.063, 11.151.005, 1975) and Rodionov (1974, 1975). Osipkov (10.151.064) also proposed a method for the construction of a formal third integral in resonance cases.

The theory of cases admitting a third integral was further developed by Agekjan (11.042.003, 12.151.041) and Agekjan and Yakimov (10.151.002) and the case of a quasi-Newtonian potential by Agekjan and Vyuga (10.151.022) and Vyuga (13.151.045).

Stodółkiewicz (11.151.051) has shown that the family of dynamical systems with symmetry towards a plane and an axis and possessing local third integrals is identical with the family systems defined earlier (see Report 1973). Further, (12.151.031) he has shown that there exists a family of transformations of the third integral, kinetic energy and co-ordinates, such that the equation for the third integral is invariable. He also discussed (12.151.045, 1975) the symmetry conditions of the third integral in systems with a plane of symmetry.

Relative motion in a meridional plane can be described by methods developed for the problem of two fixed centres according to Ivanov and Kajsin (08.151.035). Malasidze also investigated orbits with zero angular momentum (10.151.060, 12.151.007) and found the shape of the area filled out by an open meridional orbit in case of a potential admitting a quadratic third integral.

Andrle (09.151.030, 12.151.006) has continued his investigations of a third integral for a biquadratic potential. Higher approximations were treated in resonance cases.

Contopoulos (1975a, 1975b) reviewed the properties of conservative dynamical systems of two or more degrees of freedom. The transition from integrable to ergodic systems is described in detail. Non-integrability is due to the interaction of two, or more, resonances. Then infinite types of islands of various orders appear on a surface of section, while the asymptotic curves from unstable invariant points intersect along homoclinic and heteroclinic points producing an apparent dissolution of the invariant curves. A threshold energy is defined separating near integrable systems from near ergodic ones. The possibility of real ergodicity for sufficiently high energies is discussed. In the case of many degress of freedom distinction is to be made between integrable, ergodic and intermediate cases. Individual results are given in (1973) (10.012.010, 11.151.046). The applications of the problems of integrals of motion have been discussed by Contopoulos in (1975b) and current work is being continued with Karanicolas and Michaelides.

Measure preserving mappings have been used by Froeschle and Scheidecker (10.151.040 = 12.151.017) for studying the disappearance of isolating integrals in dynamical systems with more than two degrees of freedom. Rannou (11.042.021) has considered discrete mappings operating on integers for the study of systems with two degrees of freedom.

A third isolating integral has been found by Berry (09.151.006) in an investigation of the dynamics of a galaxy with an axisymmetric time-dependent mass distribution but a non-axisymmetric kinematics. Properties of quadratic integrals of motion and stellar orbits in systems without an axial symmetry have been studied by Kuzmin (10.151.056).

An epicyclic theory of stellar orbits near the Lindblad resonances of a spiral galaxy has been developed by Vandervoort (09.151.020, 1975a, b). The epicyclic theory reproduces, at least qualitatively, the resonance phenomena exhibited by numerical solutions of the exact equations of motion. Further work has consisted of a survey of resonance phenomena and of comparisons of analytic and numerical solutions of the epicyclic equations (Vandervoort and Monet 1975). In work now in progress, Monet is testing the epicyclic approximation by comparing numerical solutions of the epicyclic and exact equations of motion. Vandervoort has formulated a theory of the equilibrium of a stellar disk in the resonance regions. Self-consistent models of the resonance regions will be constructed. In related work, solutions for periodic orbits derived from the epicyclic theory have been adapted to the solution of the hydrodynamic equations governing the steady flow of a gaseous disk in the resonance regions. The epicyclic approach has been used also by Berman (1975) who has found resonant periodic orbits near the inner Lindblad resonance, and by Ray (08.155.060) who has deduced from the sizes of the epicycles that mixing of stars takes place in larger volumes as we go away from the centre.

Mayer and Martinet (10.155.015) have presented an extensive study of periodic and quasi-periodic orbits in the Schmidt model of the Galaxy. Martinet (11.155.032) has found asymptotic orbits of the homoclinic and heteroclinic type for peculiar initial conditions, typical of extreme Population II objects, and examined the relation between such orbits and the semi-ergodicity. Martinet and Mayer (1975) have studied orbits in the neighbourhood of the Sun and of inner regions, in particular the conditions for the existence of a third integral. Similar applications to the halo are planned. Mayer and Gomez (1975) have explained the persistence of old stellar groups as a consequence of successive approaches of stars of common origin in terms of the isolating integral of motion. The study of periodic orbits in the Schmidt model by Palouš and Perek (13.155.015) was aimed at the solar neighbourhood and the results have been presented in terms of velocity components making thus possible a direct comparison with observations. The complicated boundary of the ergodic region has been outlined.

House and Innanen (13.155.001) have integrated orbits of over 10 000 stars in a steady-state model of the Galaxy. The mean velocities and dispersions of stars have been calculated as functions of time. The quantities show a strong time-dependence with oscillations of a period of 10^8 yr.

Galactic orbits have been frequently used to determine the birthplace of stars. Martin and Downes (08.065.015) have found possible sites of star formation in Sgr B2. Kalnajs (09.151.008) has found that the given uncertainty in stellar ages makes it necessary to use a large number of stars for the detection of a significant correlation between the velocity and age. An analysis of galactic orbit calculations by Innanen *et al.* (10.155.010) for a sample of moderately young stars has confirmed an earlier conclusion that stars are not formed preferentially at extreme distances from the galactic plane. Keenan and Innanen (11.154.024) have computed the orbit of the old open cluster NGC 2420 and have explained its eccentricity as the result of a gravitational perturbation during an encounter with one of the Magellanic Clouds. For birthplaces of Cepheids see also 6C.

Under the assumption that the size of a globular cluster is limited by the tidal force field of the Galaxy, Peterson (11.154.018) has computed the perigalacticon distances for 41 clusters and has studied the distribution of orbital eccentricities. Lauberts (11.151.002) has studied the orbits of satellites moving in the gravitational field of the Galaxy. Keenan and Innanen (13.151.011) have presented a numerical investigation of tidal effects on spherical stellar systems and have found that star clusters rotating in a retrograde sense are more stable in a tidal field. Sasaki and Toshiaki are investigating the cone of avoidance around the rotation axis in the distribution of globular clusters by calculating orbits of test particles in the Schmidt model. The test particles initially in the cone of avoidance stay there for about 25% of total time and, as a result, the density in the cone of avoidance is considerably rarefied compared to that outside the cone.

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B. *Models of the Galaxy*

I. *The Corona of the Galaxy*

Gunn (12.162.049), Einasto *et al.* (12.158.022) and Ostriker *et al.* (12.158.107) suggested on the basis of the study of relative motions of companions of our Galaxy and of other giant galaxies that giant galaxies are surrounded by a corona of invisible matter having a mass of the order $10^{12} - 10^{13}\ M_\odot$. These mass estimates have been questioned by Burbidge (13.158.023), who argued that companion galaxies studied may form random samples of field galaxies. Einasto *et al.* (13.158.108) demonstrated, however, that companions of giant galaxies form systems with distinct spatial, morphological and dynamical structure and it is very unlikely that random samples of galaxies could be so well organized.

From dynamical arguments the mass of the corona of our Galaxy amounts $1 \times 10^{12}\ M_\odot$ (Jôeveer *et al.*, 1975), its harmonic mean radius is 100 kpc (Einasto *et al.*, 1975b). The density of the corona follows an inverse square law (12.158.107), its shape is practically spherical.

Komberg and Novikov (13.158.071), Dorschner *et al.* (1975), and Chernin *et al.* (1975) demonstrated that the corona cannot contain presently large amounts of gas. The mass to luminosity ratio of the corona is very high (12.158.187, Freeman *et al.*, 13.158.105). This indicates that the corona may consist of very low mass stars (Jaaniste and Saar, 1975; Schmidt, 1975).

The presence of the corona causes dynamical friction which will destroy the Magellanic Clouds within 2–4 billion years (Tremaine, 1975). This process leads to the increase of the luminosity of giant galaxies, located in the centres of systems of companion galaxies (Ostriker and Tremaine, 1975).

II. *Mass Distribution Models*

A mass distribution model of the Galaxy, based on all available new data on the structure of galactic populations (including the corona) was constructed by Einasto *et al.* (1975a, b). In this model the following principal galactic constants were used: $R_0 = 8.5$ kpc, $V = 225$ km s^{-1}, $A = 16.0$ and $B = 10.5$ km. s^{-1} kpc^{-1}, $\rho_0 = 0.10\,\mathfrak{M}_\odot\,\mathrm{pc}^{-3}$. Evidence that the distance of the Sun from the centre of the Galaxy is smaller than the currently adopted value $R_0 = 10$ kpc is given by Oort and Plaut (13.155.051) and others (11.155.009, 11.155.042), arguments favouring the adopted density are given in Section 3. Another detailed model of the Galaxy was calculated by Innanen (10.155.012) for the conventional system of galactic constants. Simple mass distribution models were also presented by Saha (12.155.087) and Wielen (1975).

Kinematic models based on the density wave theory were presented by Basu and Roy (09.155.048) and Burton and Bania (12.155.004, 12.155.005). A kinematic model for describing the velocity parameters of galactic subsystems was developed by Peralta (11.155.073).

Hunter (11.151.010, 1975a) has constructed self-consistent models of collisionless stellar systems with a gravitational potential which is a quadratic function of the spatial coordinates. Aoki (09.151.001) and Hunter (1975b) have given methods for calculating distribution functions for collisionless stellar systems with known mass distribution. Models of highly flattened systems were considered by Kuzmin and Chumak (1975). Methods of constructing models of disk-like galaxies with a velocity distribution which is a function of the energy and angular momentum were presented by Miyamoto (11.151.007, 1975) and Kutuzov (1975). Rodionov (1975) has constructed a model which allows for the presence of the third integral of motion. Aikawa (10.151.010) and Miyamoto and Nagai (1975) demonstrated that the mass distribution expressions used by Brandt are identical with those used by Toomre and Kuzmin.

Ballabh (10.151.028, 11.151.008) found expressions for calculating the potential energy of interacting spheroidal galaxies. Ahmad (11.151.019) discussed a class of equilibrium solutions of the Vlassov equation for self-gravitating stellar systems in the form of Jacobi polynomials.

Nordsieck (10.151.011) demonstrated that the existence of a spheroidal subsystem in spiral galaxies does not affect considerably the angular momentum. Einasto (12.151.026) indicated that the mass of spheroidal component of spirals is considerably larger than usually believed which increases the fraction of mass with low angular momentum. Genkin and Genkina (08.158.113, 10.158.048) derived the distribution of galaxies according to their angular momentum.

Kuzmin and Veltmann (10.151.058, 10.151.083) discussed generalized isochronous models of spherical stellar system in phase description. Nezhinskij (1975) proved that spherical envelopes of central mass configurations must have an isothermal density law. Antonov, Naumova and Ogorodnikov (10.154.002, 10.151.050) developed a method of determining the masses of globular clusters based on the estimation of the perturbation of the density of the field of nearby stars.

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C. *Spiral Structure*

I. *Reviews and Conferences*

IAU Symp. **58** (12.012.005) included reviews by Contopoulos and Lindblad of recent developments in spiral structure theory. Contopoulos and Lynden-Bell lectured on spiral structure theory at the 1973 Saas-Fee course (10.012.010). Proceedings of the 1974 CNRS symposium on the 'Dynamics of Spiral Galaxies' (L. Weliachew (ed.)) held in Paris should appear soon. The Alma-Ata conference 'Dynamics of Galaxies and Star Clusters' (10.012.034) included several papers on spiral structure. Reviews of spiral structure theory, from different viewpoints, were given by Contopoulos (11.151.040), Marochnik and Suchkov (11.151.049), Kalnajs (11.151.018), Kaplan and Pikel'ner (12.151.025), Piddington (11.151.017) and Wielen (12.151.018).

II. *Particle Orbit Studies*

The important role of the resonance regions in spiral structure theory can be illustrated by studying the properties of particle orbits near these regions. Numerical experiments by Barbanis show that trapped orbits near particle resonance in spirals form density maxima at the maxima of the spiral potential. Contopoulos (09.151.033) developed a theory to account for these nonlinear effects: in the rotating frame of reference, there are two stable equilibrium points at the potential maxima, and particles are trapped in librating orbits around these points. More orbits have been calculated by Mertzanides, to compare their forms and invariant curves with Contopoulos's theory. Contopoulos (1975) has used an action-angle Hamiltonian formalism to explain the properties of orbits near the inner Lindblad resonance in spiral galaxies. Vandervoort (09.151.020) studied the epicyclic theory of orbits near the Lindblad resonances, and obtained integrals of the motion in a form suitable for extending the density wave theory into the resonance regions. Further work (11.151.013) shows that properties of the resonant orbits discriminate between leading and trailing spiral patterns in a way which may vitiate the anti-spiral theorem for stellar disks.

III. *Origin and Maintenance of Spiral Structure*

Mark stressed the need for wave amplifiers to overcome dissipative processes. He suggests (i) exchanges of angular momentum between density waves and some stellar subsystem of galaxies, and (ii) exchanges of angular momentum between waves inside and outside corotation, as processes leading to wave amplification. Mark (12.151.035, 1976) also showed that, provided there is not also a rapid temporal decay in amplitude, the short waves decay spatially in the direction of their group propagation, and that this decay process can be described physically in terms of detailed balance of energy and angular momentum. Dekker (12.151.004) derived an expression for the growth rate of density waves in flat galaxies, and explains this physically in terms of angular momentum or energy exchange between resonant stars and the wave: growing waves occur only for a limited range of pattern speeds. Lynden-Bell (11.151.041) discussed the fundamental role of the large-scale angular momentum transport for spiral structure. Korchagin, Marochnik, Mishurov and Suchkov (09.155.093, 11.151.049, 13.158.018; 1975) Feldman and Lin (09.151.056) and Simon (12.151.005) all investigated the generation of spiral structure by a rotating bar-like structure in the central regions of galaxies. Maksumov (11.151.042) considered how stellar drift motions associated with differential rotation could cause the excitation of spiral waves. Kato (09.151.032) examined the excitation of spiral density waves in a rotating star-gas disk by a kind of two-stream instability due to gases flowing relative to a rotating stellar disk. Kato also argued that density waves can be maintained against the damping due to galactic shocks by nonadiabatic processes in the gas of the galactic disk. Mishurov and Suchkov (12.151.027) found the conditions for the stability of shock spiral waves. They (1975) also report that multi-armed structures of spiral galaxies can be explained by the presence of different stellar populations with different rotational velocities. Biermann (09.151.009) and Kato (11.151.057) discussed the role of star formation for driving density waves, and Piddington (09.151.011) argued from empirical grounds that star formation should be included in the density wave analysis.

Antonov (10.151.068) indicated that the density wave theory has some serious difficulties: initial conditions adopted may be unrealistic, the duration of the period of strong instability may be too short for forming spiral arms, and there are no signs of mutual interference at points of encounter of different arms. Hunter (09.151.034) used ray methods of geometrical optics to calculate patterns of waves produced by localised sources in galactic disks. Athanassoula-Georgala's thesis discussed several topics in spiral structure theory. Evangelides derived a dispersion relation for density waves propagating at an arbitrary angle in a rotating galaxy. Roy (12.155.003) calculated the density, potential and velocity perturbations associated with a density wave, assuming that the pattern speed depends on the distance from the galactic center. Robe (13.151.019) used the linearised hydrodynamical equations for the oscillations of cold cylindrical stellar systems to show the existence of an unstable growing mode in the form of a quite open trailing spiral. Ptitsyna (12.151.038) argued that magneto-sonic waves may be responsible for different forms of the grand design of galaxies.

IV. *Gas Flows and Shocks*

Shu, Milione and Roberts (10.151.006) showed that the density response of interstellar gas to a spiral potential is quite nonlinear even if the perturbation to the potential is small. Galactic shocks arise if the strength of the spiral field exceeds a critical value. Baker and Barker (12.155.072) investigated the interaction of interstellar gas with stellar density wave packets; they showed that shocks develop even if the gravitational perturbation is aperiodic and transient. A time-dependent calculation of gas flow in a tightly would spiral density wave was made by Woodward (13.151.002). For large enough wave amplitude, shocks form within one or two transits of gas through the spiral pattern. Tosa (09.155.066) calculated the steady gas flow through spiral arms, allowing the thickness of the gas disk to vary: two shocks were found. Saaf (11.151.036) derived approximate solutions for the structure of the gaseous component in a thin disk galaxy with spiral structure stationary in a rotating frame. Roberts (12.151.024) discussed the strength of the galactic shock wave and the degree of development of spiral structure. Quirk and Crutcher (09.155.064) suggested that the cold cloud of Riegel and Crutcher may be a high gas density region caused by a shock induced by the local spiral arm. Mishurov and Suchkov report that galactic shocks can be unstable. They find the stability criteria and propose that spiral structure secondary features may form through these instabilities. Kuzmin and Chumak (10.151.072) discussed density waves in a gas disk. Hydrodynamical calculations were made by Sanders and Prendergast (11.155.019) to simulate the effect of an explosion at the galactic center. They found that a radially oscillating ring of cold gas forms in the plane and persists for some time longer than the initial expansion time of the hot gas.

V. *Rolling Motions*

The rolling motions observed in the outer spiral arms of the Galaxy were interpreted by Yuan and Wallace (10.155.034) as only apparent motions caused by the combined effect of bending of the galactic plane and differential rotation. They constructed theoretical galactic latitude – velocity contour diagrams for direct comparison with observation. On the other hand, Tosa and Sofue (11.155.043) examined in detail the systematic variation of gas velocity with galactic latitude, with special regard to the Perseus arm: they interpreted these variations as the vertical motion of gas ejected from the spiral arm, with z-velocities of about 90 km s^{-1}, and then falling freely back to the galactic plane. Further work by Sofue and Tosa (12.155.073) showed that the duration of the gas ejection is about 3.10^7 yr.

VI. *Observational Aspects of the Density Wave Theory*

There is still a need for unambiguous observational tests of the density wave concept. Kalnajs (09.151.008) argued that star migration studied have not yet revealed the presence of a spiral density wave, although the results of these studies may be compatible with the density wave theory. Burton (09.155.031) emphasised that the several components of a spiral arm may in many cases be characterised better kinematically than spatially; for external galaxies, the kinematic data is again most crucial for observational confrontation of the gravitational density wave theory. Piddington (09.151.028) compared the prediction of hydromagnetic and gravitational spiral structure theories. Both predict dust, young star and old star arms separated as observed. The differences lie in the surface density and velocity distributions of cool gas.

The observed kinematics and spatial distributions of young stars can be compared in detail with the predictions of the theory. Contopoulos and Grosbøl (1975) calculated ages and space velocities for 430 stars younger than 3×10^8 yr near the Sun. Birthplaces were determined, using a spiral potential. This lead to an estimated pattern speed $\Omega_p = 14$ km s^{-1} kpc^{-1}, but this value is sensitive to the adopted chemical composition of the stars. Wielen (09.151.036) derived birthplaces of 19 nearby classical cepheids: these are mostly in agreement with the predictions of Lin's theory. He is presently investigating the places of formation of some nearby open clusters. Crézé and Mennessier (10.151.005, 10.155.060, 1974) have fitted the theory to the observed velocities of young stars, in order to estimate the free parameters of spiral waves. The results are inconsistent with those estimated from large scale spiral structure, suggesting that the Lin theory may be unsuitable for understanding the kinematics of young stars near the Sun. Wielen and Schwerdtfeger report their investigation of the age dependence of the spatial distribution and velocity dispersion of stars in spiral galaxies, through orbit calculations. Wielen (13.151.035) concluded that the commonly adopted model of the density wave in our Galaxy does not predict any measurable drift of the spiral arms with stellar age in the region around $R = 10$ kpc, because the newborn stars move, on average, along the spiral shock front for about 7×10^7 yr.

Roberts, Roberts and Shu (13.151.008) have devised a categorisation of spirals by two parameters: the total mass to characteristic dimension ratio and the degree of concentration of the mass to the center. From the theory, these govern the strength of galactic shocks and the geometry of the spiral pattern. Mikhailovsky and Fridman (09.151.003) attempted to explain the splitting of spiral arms into red, yellow and blue stars on the basis of the displacement of density waves in the galactic disk. Basu (09.155.048) determined the mass of the galaxy as 2×10^{11} solar masses from a simple relation derived from the density wave model. Burton and Bania (12.155.005) calculated local low-latitude H I profiles for a flow pattern of the sort predicted by the linear density wave theory. They show characteristics of the observed H I kinematics which have previously been interpreted in terms of a separate subsystem. Simonson (09.155.035) constructed T_b (l, V) maps from Yuan's theoretical density wave pattern, with the Sun's position in the pattern shifted in phase from one model to the next.

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D. *Stability and Evolution*

A review of dynamical processes during the early evolution of galaxies was given by Freeman (12.155.034). Theoretical calculations of these processes were performed by Larson (11.151.009, 12.158.009), Larson and Tinsley (12.158.065), Antonov *et al.* (1975). The short time-scale of the early evolution was confirmed by Hartwick and Hesser (12.154.023).

The effects of supernovae explosions and photoionization by massive stars on the gas content of the protogalaxies were shown to be important by Tinsley (09.161.003), Larson (11.151.009), Suchkov and Shchekibov (1975c) and Schwarz *et al.* (1975).

The problems of phase mixing were considered by Byl and Ovenden (10.155.024), Osipkov (08.151.001, 09.151.014, 1975) and Antonov *et al.* (10.151.051). Clube (in press) regards the Galaxy as a rapidly expanding system with ejections from a rotating nucleus. The dynamical evolution of dense stellar system was studied by Saslaw (09.151.017), Tremaine (1975), Tremaine *et al.* (13.158.028). The role of dynamical friction was considered by Baranov and Batrakov (11.151.029, 12.151.016), and of tidal interaction by Lauberts (11.151.052). The influence of irregular forces in the evolution of stellar system was studied by Kuzmin (10.151.057), Antonov and Baranov (12.151.001), Antonov and Nuritdinov (12.151.032). In particular, it was shown that the Jean's critical wavelength does not depend on the irregular forces.

Dynamical theories for the forming of the galactic halo were proposed by Clutton-Brock (09.151.043) and Innanen and Keenan (10.155.027).

Dynamical evolution of star clusters was considered by Kaliberda and Petrovskaya (09.151.015), Kaliberda (08.153.019), Danilov (09.151.040), V'yuga *et al.* (1975). The influence of 'gravitational shocks' in clusters was studied by Spitzer and Chevalier (10.151.004). The general problems of stability of spherical clusters were discussed by Ipser (12.151.033), and clusters with an isothermal density law were shown to be stable by Synakh *et al.* (09.151.047).

Full attention was given to the problem of star formation. The star formation rate was concluded to follow the Schmidt law by Madore *et al.* (12.158.020), Tosa and Hamajima (1975), Hamajima and Tosa (1975), but to depend mainly on the infall of intergalactic gas by Quirk and Tinsley (09.065.010). Talbot (11.158.121), Truran (10.155.037), Black and Kullman (11.065.010), Piddington (12.065.106) and Ostriker *et al.* (11.065.055) have studied this problem.

Theoretical possibilities to explain the star formation were studied by Doroshkevich and

Kolesnik (1975) for the first-generation stars, Zasov (1975), Suchkov and Shchekinov (1975d, e) and Kaplan and Pikelner (12.151.025).

An extensive series of papers on the physical and chemical evolution of galaxies has been published by Tinsley and collaborators (08.151.004, 08.065.096, 10.065.105, 11.158.110, 12.158.065, 11.065.003, 09.065.010). Tinsley (12.065.095; 13.061.038; 13.065.026; 1975), Audouze and Tinsley (12.155.024), Tinsley and Cameron (12.155.053) have followed in detail the distribution of elements in the solar neighbourhood. A detailed theory of the physical and chemical evolution of galaxies has been elaborated by Talbott and Arnett (10.158.103, 10.065.106, 11.158.121). For active galaxies such a theory was proposed by Ohnishi (10.158.085, 11. 155. 036, 11.155.050).

On the problems of stability and equilibrium of stellar systems comprehensive reviews have been published by Antonov (1975), Fridman (1975) and Zeldovich et al. (1972). The behaviour and stability of the one-dimensional water-bag model was studied by Cuperman and Harter (08.151.027), Cuperman and Tzur (09.151.013), Doremus and Bauman (11.151.032), Doremus and Feix (10.151.045). The stability of spherical systems was studied by Shukhman (09.151.041), Antonov (10.151.067), Fridman and Shuckhman (07.151.002), Polyachenko and Shuckhman (09.151.004, 10.151.001). The stability criteria were considered also by Chumak (10.151.077), Genkin and Genkina (10.151.070), Lodén and Rickman (12.151.012) and Nezhinskij (08.158.062, 12.151.046, 12.042.044, 12.062.068).

The stability of disks was studied by Clutton-Brock (09.151.044, 09.151.038), Genkin and Safronov (13.151.013). The problem of large-scale instabilities in cold disks has been considered by Ostriker and Peebles (11.065.055), Miller (11.151.061), Morozov *et al.* (1975a). The instabilities due to differential rotation have been studied by Maksumov (10.151.059, 1974a, b, c).

For infinitely long rotating cylinders temperature-gradient instabilities were shown to arouse by Polyachenko and Shukhman (09.061.036) and Bisnovaty-Kogan and Mikhailovsky (09.151.024). Large-scale instabilities have shown to exist by Antonov (09.061.023), Antonov and Nezhinskij (09.151.052). Differentially rotating cylinders were considered by Chumak and Chumak (1974).

The instabilities arousing in gas layers were studied by Tassoul and Dedic (09.061.042, Jeans instability), Shu (11.155.056, Parker instability), Mouschovias *et al.* (11.151.048), magnetic Rayleigh-Taylor instability). Suchkov and Shchekinov considered the role of thermal and gravitational instabilities for star formation, especially in spiral shock waves (12.131.526, 1975a, b). Morozov *et al.* (1975) demonstrated that the Kelvin-Helmholtz instability in a gravitating medium may have a large increment.

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E. *Computer Simulations*

Reviews of numerical experiments in stellar dynamics were given by Aarseth (11.151.020) and Aarseth and Lecar (1975).

Hohl (10.151.009) used an initially stationary and stable disk of stars with a stellar mass spectrum to confirm that the models used for earlier largescale N-body calculations were indeed collisionless. Hohl (11.151.056) investigated the stabilising effect of a fixed galactic halo component on the bar-making instability and found that bar formation in the disk is suppressed if the disk mass does not exceed about 40% of the total galactic mass. Hockney and Brownrigg (11.151.035) compared their 3-dimensional computer model of a fully selfconsistent disk galaxy of finite thickness with 2-dimensional models, and showed that the lifetime of spiral formations is significantly longer in their model, which allows motion out of the galactic plane.

Aarseth, Henon and Wielen (12.151.044) showed that N-body and Monte Carlo methods for studying the evolution of the spatial structure of star clusters give rather similar results. Quirk (09.151.025) reported further work on his program to simulate spiral structure in galaxies. Keenan, Innanen and House (09.151.018) calculated galactic orbits and tidal radii for M 67, NGC 188 and ω Cen, in the Schmidt and Innanen galactic models. Ahmad and Cohen (09.151.012) studied numerically the probability distribution of random forces in gravitational systems; their results are in good agreement with the theory of Chandrasekhar and von Neumann. Eneev, Kozlov and Sunyaev (09.151.002) use numerical calculations to determine the main effects on a galaxy associated with the passage of a massive body in a number of characteristic hyperbolic orbits with respect to the galaxy.

Agekjan and Martynova (09.042.055) added to the Szebehely classification of the stages of three bodies a new stage 'triple encounter' and give quantitative criteria for the determination of the stage. Agekjan and Anosova (12.117.013) investigated the influence of the shape of the initial configuration of triple stars to the disruption time of the systems. The whole space of possible configurations is divided into a certain number of regions; within these regions the disruption time is a smooth function of location, but on the boundaries this time sharply changes. Petrovskaya and Yakimov (1975) studied the multiple encounters of stars. Methods of constructing models of stellar systems by numerical experiments were discussed by Yakimov (09.151.053).

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F. *Magnetic Fields, Pulsars, X-Ray and γ-Ray Sources*

The structure of the local galactic magnetic field was studied by several authors on the basis of rotation measures for pulsars and other radio sources and of polarization measurements at radio and optical wavelengths [(Kaiser (09.156.001), Osborne *et al.* (09.156.003), Vallée and Kronberg (10.156.003), Manchester (11.156.002), Wilkinson and Smith (11.156.003)]. It appears that systematic and random magnetic fields have comparable strength. For the former Manchester (11.156.002) obtains $2.2 \pm 0.4\ \mu$G directed towards $= 94° \pm 11°$. A possible cellular structure for the galactic field was discussed by Michel and Yahil (09.158.028), with comments by Parker and by Michel (11.158.002).

Instabilities in the galactic gas disk involving magnetic fields and cosmic rays were studied by Shu (11.155.056) who concluded that shear and rotation cannot stabilize the Parker instabilities – at least in the absence of dissipation – and by Zweibel and Kulsrud (1975) with comments by Parker (1975). An equilibrium model for the disk with arches of magnetic field lines rising above the disk was constructed by Mouschovias (12.131.039; 13.131.127). The interaction of a galactic density wave with a magnetic field was studied by Saha (12.156.004) on the basis of a 3-dimensional perturbation calculation. A mechanism for the formation of galactic magnetic fields based on the field amplification in spiral shocks was proposed by Mishurov *et al.* (13.156.002) and by Peftiev and Suchkov (1975).

The controversy of dynamo or primordial origin of galactic magnetic fields has been summarized and the characteristics of the fields and their interactions with the gas and cosmic rays discussed by Piddington (1975).

A listing of X-ray sources is provided in the Third Uhuru Catalog (Giacconi *et al.* (11.142.035) which contains 161 objects. About half are probably galactic. In the galactic disk sources are mainly identified with supernova remnants and binaries consisting usually but not always of an OB star with a compact companion. In the galactic halo variable X-ray sources have been identified with globular clusters NGC 1851, 6441, 6624, 7078, and probably NGC 6640 (Clark *et al.,* 1975); (Markert *et al., Nature*, in press). Several other sources in the galactic nuclear bulge may be of the same type (Canizares, 1975). Possibly the cluster sources are associated with binaries formed in stellar encounters (Clark, 1975) (Fabian *et al.*, 1975). Efremov *et al.* (1975) suggested that X-ray sources in the galaxy belong to two different populations, the young population (example Cyg X-1) and the old disk population (Her X-1). Our knowledge of galactic gamma-rays was much increased by data from the SAS-2 satellite (Fichtel *et al.,* 13.061.039). The longitude distribution of the galactic disk emission shows a strong enhancement within 40° from the galactic center. The distribution is very similar to that of CO emission and therefore of dense interstellar gas regions. Most gamma-rays are probably due to collisions of cosmic rays with interstellar gas nuclei and inference on the distribution of cosmic rays may be made (Stecker *et al.,* 1975). The relation between these observations and dynamical models of the galactic disk has been discussed with contradictory results by Wentzel *et al.* (1975) and by Mouschovias (1975b).

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