here that Burbidge and Hoyle (**20**) have suggested that the galactic halo may be a highly transient phenomenon. Belton and Brandt (**21**) have discussed the interpretation of the rotation curve of our Galaxy obtained from 21 cm observations. They indicate that there must be an excess of unknown matter in the Galaxy, distributed like halo Population II objects, if the data from $K(z)$ are to be brought into line with 21 cm results. They suggest the presence of large numbers of intrinsically faint stars with high velocity dispersions perpendicular to the galactic plane.

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VII. STELLAR MOTIONS

Theory

Filin (**1**) found that random errors of the distances and radial velocities do not affect the reliability of the Camm function. A method for the determination of the vertex from proper motion was proposed by Rudnicki (**2**). Strömberg's formula for the asymmetric shift of the centroids was modified by Einasto (**3**). The new formula fits better the observations and leads to the rotational velocity of the Sun of 250 km sec^{-1}. Przybylski (**4**) has suggested a simple method of computing galactic components of stellar velocities by means of a Cracovian formula avoiding an intermediate computation of galactic co-ordinates. A table of nine direction cosines for the conversion of the observed velocity components into galactic components is being prepared by Perek.

Neutral Hydrogen

The outflow of neutral hydrogen from the galactic nucleus raises the question of whether it is replenished by some inward motions. Pariskij (**5**) found that only ionized gas can flow inwards. The velocity is about 10 km sec^{-1} and the radius of the area is 1 to 1·5 kpc.

A new reduction of the Leiden hydrogen observations was made by Agekian and Klosovskaya (**6**) using the Camm function and adjusting the whole profiles, not only the maximum values. The Leiden results were confirmed within 2·5 km sec^{-1} kpc^{-1} in the angular velocity.

General kinematics of the local gas system was investigated by Helfer (**7**). The contributions of the interstellar hydrogen to the radial velocities were developed into a double Fourier series. Various explanations of the deviations of these expressions from circular motions are offered. The observed deformations of the gas disk were explained by Lozinskaya and Kardashev (**8**) by the gas-dynamic interaction between the Galaxy and the intergalactic medium.

A possible large scale circulation of the neutral hydrogen in the Galaxy follows from the radio observations by McGee and Murray (**9**) and by McGee *et al* (**10**, **11**). In the solar vicinity hydrogen is flowing outwards at a mean radial velocity of +6 km sec^{-1} near the direction of the galactic centre and anticentre. It is flowing inwards from above and below in high galactic latitudes at a mean velocity of −6 km sec^{-1}.

The increase of the neutral hydrogen densities at the positions of the OB associations and a better agreement of the motion of the neutral hydrogen with Weaver's galactic rotation curve than with Schmidt's was established by Kaftan-Kassim (**12**).

A good correlation of optical radial velocities from interstellar lines with the radio data was found by Howard and Wentzel (**13**). Thus large scale motions of neutral hydrogen and ionized calcium are identical. Field and Fletcher (**14**) obtained a strong correlation between the distribution of O and B stars, cepheids and neutral hydrogen independent of the assumed model of the Galaxy. Rubin *et al* (**15**) found a qualitative agreement between radial velocities of O to B5 stars within 3 kpc of the Sun and the 21 cm profiles. The distance of the Sun from the centre must be larger than 8·2 kpc. The mean circular velocity is about 15% above the radio model at 6 kpc from the centre. At 8 kpc both curves coincide. Beyond 8·5 kpc the stellar curve is flat and does not decrease as is expected for Keplerian orbits. The radial velocity component agrees well with the expansion observed for interstellar hydrogen.

Early-Type Stars

Mirzoyan (**16**) has discussed the motions of O to B 0·5 stars brighter than 10th magnitude. He derives a value of the constant A of 11 to 12 km sec^{-1} kpc^{-1}. A determination of A and B from proper motions of the O and B stars is in progress by Wayman. The K-term was investigated in detail by Missana *et al* (**17**) under the assumption that all O to B3 stars belong to associations. A catalogue of 280 B stars was compiled by Eggen (**18**). He found that all nearby B stars possibly form a large association of more than 1 kpc in the galactic plane and less than 100 pc in the z-direction. The velocity distribution shows a gradient of 40 km sec^{-1} kpc^{-1} in the radial direction away from the galactic centre. Karpowicz (**19**) and Moerdijk (**20**) found that at least one of a number of independent groups formed by the B stars takes part in the rotation of the local system. Blaauw (**21**) pointed out that the Scorpio-Centaurus, Orion and Perseus associations actually form the Gould belt. Important observational material, in particular for the Scorpio-Centaurus association, was accumulated by Buscombe and Morris (**22**), Morris (**23**), Petrie (**24**), Buscombe (**25**) and Buscombe and Morris Kennedy (**26**). Bonneau (**27**) has investigated residual radial velocities of O and B stars and of A0 to A2 super-giants. The velocity decreases in the anticentre region from + 4·5 km sec^{-1} at the Sun at the rate of 6·5 km sec^{-1} kpc^{-1}.

A value of the constant A of 17 km sec^{-1} kpc^{-1} has been derived from B and super-giant A stars by Boulon (**28**).

Thackeray (**29**) has compiled the third list of Radcliffe radial velocities of southern B stars and he has investigated the galactic structure in three southern regions of special interest. He

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has further found that the Norma direction is favourable to resolution of interstellar Ca II lines into two components which suggest the presence of two spiral arms. An analysis of B star radial velocities is in progress by Thackeray, Shuttleworth and Feast. A value of the constant A close to 15 km sec^{-1} kpc^{-1} is indicated. The curve of angular velocities and the variation of the K-term with spectral type have been studied.

Pilowski (**30**) has attempted to give a consistent explanation of the observed local velocity distribution and he has noted that stars which flow into the solar vicinity from spiral arms are characterized by their position in the velocity diagram. Their relative velocities and the distances of the spiral arms lead to the determination of the age of the groups (A stars and red giants).

A preliminary analysis of the radial velocity and absolute magnitude data on 570 B stars by Petrie (**31**) has yielded the following results on galactic motions and distribution up to 1·6 kpc from the Sun: The distribution does not indicate strongly any spiral structure and does not appear to be closely correlated with the denser hydrogen clouds as delineated by the 21 cm surveys. Oort's constant A is found to be $+17{\cdot}9 \pm 1{\cdot}2$ km sec^{-1} kpc^{-1}. This value depends on the H-beta distance scale. A negative K-term is found. The Ca II velocities yield roughly one half that given by stellar velocities and hence the Ca II is approximately uniformly distributed. A few local deviations from the circular model velocities are found suggesting motions of groups of stars. The random motions are not correlated with galactocentric distance but show some correlation with absolute magnitude.

Field Stars

An extended material of space velocities for 3483 stars with accurately determined proper motion and radial velocity was prepared by Eggen (**32**). Two further catalogues containing 6000 stars with less accurate data are in preparation.

Frequency curves of radial velocities of faint stars in Selected Area 19 were studied by Duflot (**33**). The B, A and F stars clustered around zero velocity. Only a few stars have large negative velocities; these are situated in the Perseus arm. The curve for G and K stars is irregular and has a maximum at -70 km sec^{-1}.

The analysis of McCormick proper motions by Emoto (**34**) shows a decrease of the rotational velocity with increasing distance from the galactic plane. The distances and radial velocities of several hundred stars have been determined by Boulon (**35**). The presence of the Orion spiral arm of about 550 pc thickness has been revealed in the solar vicinity. It appears that the value of the K-term is very sensitive to the distribution of the stars entering the solution on the celestial sphere.

The relation between ages and kinematics of G and K stars was investigated by Gyldenkerne. Young giant stars which evolved from A type stars show the vertex deviation of the A stars while those which evolved from the main sequence F and G stars do not show the deviation. The result of many years' work by Rootsmäe on the connection between the kinematical characteristics of various types of stars and their ages are summarized in his posthumous article (**35a**).

The distribution of tangential velocities received considerable attention. Einasto (**36**) found that groups with various velocity dispersions exhibit the same frequency curve of the logarithms of tangential velocities which is only shifted along the axis of abscissae. According to Shatsova (**37**) the distribution of the logarithms of the tangential velocities is normal. An extended material of tangential velocities of 1300 stars served to Lodén (**38**) for the determination of the solar motion and of the velocity ellipsoid.

The radial velocities have been used by Pavlovskaya (**38a**) to study the solar motion with respect to stars of different spectral types and luminosity classes. Pavlovskaya (**38b**) and

Karimova (**38c**) have studied the velocity distribution in the transversal and radial directions to the galactic centre.

With the completion of the Fourth Fundamental Catalogue by Fricke and Kopff (**39**) a new fundamental system of proper motions, deviating noticeably from previous systems, is available. Fricke is at present investigating the effects of the differences between systems of proper motion on the determination of precessional corrections and of the constant *B*. The FK4 removes the deficiencies of the GC system only in the magnitude range of the FK4 stars (down to about 7·5 mag.). There remains a magnitude equation in the proper motions of fainter stars. An effective removal of the magnitude effects in the southern sky can only be reached after the completion of the Southern Reference Star programme. Fricke suggests that in investigations of proper motions no averages of different systems should be taken since this practice obscures the influence of the systems on the quantities to be determined.

Special Groups of Stars

Gaska (**40**) found differences between the solar motion of population I and population II F, G and K giants. A difference in the motions of M stars with and without emission lines was pointed out by Jul Kim (**41**). Comparing stars with negative and positive CN anomaly, Yoss (**42**) found that the latter have a larger velocity dispersion. Ikauniecks (**43**) investigated constant and variable red giants stars. Variables have larger mean absolute radial velocities and a steeper gradient of the density in space.

Several investigations of carbon stars (Karpowicz *et al* (**44**), Rudnicki (**45**, **46**)) lead to the conclusion that the parameters of the velocity ellipsoid are functions of the distance from the galactic plane, or more generally, the velocity ellipsoids of physically uniform subsystems of stars are functions of the space co-ordinates.

New southern subdwarfs were identified by Przybylski (**47**) and by Deeming (**48**). Deeming reported a solar motion with regard to the subdwarfs of 131 $\pm$ 27 km sec^{-1} in the direction of rotation. It appears that the dispersion in the z-velocities increases with increasing UV excess. Takayanagi (**49**) found that the axes of the velocity ellipsoid of subdwarfs exceed by factors of 5 to 10 the values for nearby stars. The space density is of the order of 0·0002 solar masses per cubic parsec.

New southern high velocity stars were announced by Buscombe and Morris (**50**) and by Fehrenbach and Duflot (**51**). A large number of G and K stars with high negative velocities in Selected Area 19 is reported by Duflot (**52**). The correlation between the orbital eccentricity and the position in the H-R diagram was discussed by Michalowska and Smak (**53**). A discussion of the characteristics of high velocity stars was presented by Vanderlinden and Broucke (**54**) and by Liu (**55**). Their H-R diagram was discussed by van den Bergh (**56**). A theory explaining the origin of runaway stars was proposed by Zwicky (**57**). In the vicinity of a supernova outburst the interstellar matter had been swept away and thus the attraction decreased. Hence stars which had high enough velocities became free to escape.

Variable Stars

A comparison of the Camm function of cepheids with that of neutral hydrogen gave $R_0 =$ 8·3 kpc (Sinzi, (**58**)). Takase (**59**, **60**) derived a higher value of $R_0 = 11$ kpc, an angular velocity at the Sun of 31 km sec^{-1} kpc^{-1} and the constant $A = 14{\cdot}1$ km sec^{-1} kpc^{-1}. A criterion of population I and II cepheids based on loops formed in a two-colour diagram was proposed by Mianes (**61**). Kraft and Schmidt (**62**) used recent photo-electric data and found that most cepheids within 1500 pc are located on the side of the Sun toward the centre. Only long-period cepheids show indications of spiral structure. Taking $R_0 = 10$ kpc, the value of $A = 15$ km sec^{-1} kpc^{-1} was derived.

Kinman and Wirtanen (**63**) presented preliminary results of an RR Lyrae star survey with the Lick 20-inch astrograph. Faint RR Lyrae stars down to 18 mag. were detected, which are at a distance of about 25 kpc. Plaut and Soudan (**64**) redetermined the density distribution of RR Lyrae stars and studied the correlation of the density gradient and velocities with the period. Z. Kordylewski reports on an investigation of the acceleration of the space motion of the Sun from changes of periods of variable stars.

Feast (**65**) has combined radial velocity determinations for southern long-period variables with northern data and investigated galactic motions of Me variables. He found no *K*-term and no vertex deviation. The axes of the velocity ellipsoid in the galactic plane differ less than for extreme population I objects. The high value of the density gradient leads to a high value of the velocity of rotation of 270 km sec^{-1}. With increasing R the density gradient becomes less steep. The mean height above the galactic plane varies from 1500 at short periods to about 100 pc at long periods. The derived value of $A = 8$ km sec^{-1} kpc^{-1} is considerably smaller than that of extreme population I objects but it is in agreement with the derived velocity ellipsoid. Plaut (**66**) noted that the average period of long-period variables decreases if we approach the galactic centre, and he determined systematic velocities, average peculiar velocities and density gradients of several groups of variable stars.

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VIII. GALACTIC DYNAMICS

Theoretical problems of galactic dynamics received much attention. The centre of interest was the question of the number of independent integrals of motion, in particular the form and properties of the third integral.

Lynden-Bell (1) has pointed out that only the obvious integrals of energy and angular momentum have been considered while there are five integrals in all. He has considered the role of the neglected integrals and showed that certain classes of integrals should indeed be omitted. He further (2) has devised a method for the discovery of models for unrelaxed, self-gravitating, axially-symmetrical, steady-state stellar systems and developed (3) the dynamical theory without the aid of the restrictive ellipsoidal hypothesis. For many forms of the potential the local integrals were derived and tabulated. Idlis (4) has shown that there exist three and only three independent integrals and (5) offered a new proof of the symmetry with regard to the equatorial plane of a system with a continuous phase density and with the third integral quadratic in velocities. Dynamics of a non-steady-state galaxy with a potential allowing the

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