# 33. COMMISSION DE LA STRUCTURE ET DE LA DYNAMIQUE DU SYSTEME GALACTIQUE

## Report of Meetings, 26 August and 1 September, 1964

PRESIDENT: B. J. Bok.

SECRETARY: G. Contopoulos.

### REPORT ON THE IAU SYMPOSIUM NO. 25

*L. Perek* presented the following report on the IAU Symposium no. 25: 'The Theory of Orbits in the Solar System and in Stellar Systems' held in Thessaloniki, Greece, 17–22 August 1964 (Prepared by *G. Contopoulos* and *L. Perek*).

The papers presented at the Symposium, which are of special interest for Commission 33, may be divided into four parts:

1. *Stability questions and general properties of stellar systems.*

*D. Lynden-Bell* investigated the conditions for the collisionless stability of stellar systems. He worked in analogy with problems of stability of gaseous masses.

A sufficient condition for stability was found by means of an operator similar to Schrödinger's operator.

This condition does not depend on the motions but only on the density distribution. A necessary condition probably depends also on the motions.

*V. Szebehely* studied the stability of spiral orbits in potentials of the form

$$V = \frac{ce^{a\phi}}{r^n}$$

If $a = 0$, $n = 1$, this is a Newtonian potential. If $a \neq 0$ there exists a spiral flow. The spiral orbits are unstable if they spiral out and stable or unstable if they spiral in, depending on the values of $a$ and $n$.

*K. Prendergast* calculated orbits of stars in a barred spiral. He found that stars with high velocity escape from the system. Stars with intermediate velocities move along the bar and at the same time oscillate perpendicularly to it, until they reach the end of the bar; then they describe almost circular orbits around the axis of rotation, being eventually recaptured by this or the other end of the bar. Thus the $\Theta$-form galaxies may be explained. Low velocity stars either remain always near the origin or escape from the ends of the bar forming trailing arms. Prendergast studied also the hydrodynamics of the barred spirals. He found a circulation in the bar in the direction of rotation. A stationary shockwave is formed, which explains the existence of some dark lanes in barred spirals.

*F. Nahon* studied the forms of the potentials that admit orbits with constant measure of velocity. In some cases spiral orbits appear.

2. *Papers related to the third integral.*

As it has been remarked the third integral has the interesting property that in general it is neither an integral (in the usual sense) nor the third! Therefore it has been suggested to call it Contopoulos function.

*G. Contopoulos* gave an explanation of different kinds of orbits in the potential field

$$V = \tfrac{1}{2}(A\,x^2 + B\,y^2) - \epsilon\, x\, y^2.$$



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In general the orbits are boxes, i.e. they fill curvilinear parallelograms inside the curve of zero velocity. But if $\sqrt{A}/\sqrt{B}$ is very near a rational value $n/m$ and the initial conditions are within a specific narrow range the orbits are tubes, i.e. they fill a narrow strip around a periodic orbit.

Further Contopoulos considered, together with Woltjer, orbits in non-smooth potentials, in the form of waves or hills superimposed over a smooth potential. For small values of the perturbation the third integral seems to be isolating, while for larger perturbations it becomes quasi-isolating and finally ergodic.

*B. Barbanis* studied the topology of the third integral. He described a surface on which the orbits lie and which explains many of the characteristics of the orbits in different potential fields.

*A. Ollongren* gave examples of box and tube orbits in a model of the Galaxy representing Schmidt's (1956) potential. In the inclination diagram (inclination of the orbit when it crosses the plane of symmetry, versus the radial distance) the box orbits are represented by simple curves reaching the axis $\varpi$, while the tube orbits are represented by sets of closed curves around a set of points corresponding to a periodic orbit.

The orbits can be considered as distorted Lissajous figures with a variable ratio of frequencies.

*G. Hori* studied orbits in a separable potential that also approximates Schmidt's model. In this case the third integral is given in closed form and all orbits are boxes.

*L. Perek* and *D. M. Peterson* studied orbits in another potential field representing our Galaxy. They found that for small initial velocities (less than 280 km $s^{-1}$ at the centre) the orbits fill boxes inside the curve of zero velocity. This is an indication, but not a proof, for the existence of an isolating third integral.

However, if the velocities are large, the orbits have not a well-defined boundary, and eventually they fill the whole space inside the curve of zero velocity. We can say that if the orbits of stars are confined inside the galactic disk, a third isolating integral is at least a good approximation, while if a star or a cluster goes rather far from the main body of the Galaxy it is not restricted by a third isolating integral.

It seems therefore that the third integral is important in most problems of galactic dynamics.

Further the third integral applies also to other problems. Contopoulos used it to explain the non-ergodic character of the non-linear coupled oscillators studied by Fermi, Pasta, and Ulam.

*M. Hénon* calculated orbits in the restricted three-body problem and found again results that indicate the existence of an isolating integral besides the Jacobi integral for some values of the initial conditions. For other values of the initial conditions the integral becomes quasi-isolating or ergodic.

*V. Szebehely* mentioned similar work done with *G. Bozis* at Yale. They used regularized co-ordinates and found invariant curves on a surface of section even in the case of collision orbits.

On the other hand, *A. Deprit* found the third integral in the form of a series in the neighbourhood of the triangular points in the restricted three-body problem.

### 3. *Papers concerning the actual Galaxy.*

*M. Schmidt* proposed a new model of the Galaxy which is based on densities observed in the vicinity of the Sun, on the velocity and density distribution in the $z$-direction, on the distribution and motion of the neutral hydrogen in the galactic plane between the centre and the Sun, on a distance of the Sun from the centre of 10 kpc, and on the values of Oort constants, $A = 15$ km $s^{-1}$ $kpc^{-1}$, $B = -10$ km $s^{-1}$ $kpc^{-1}$. The mass distribution is represented by two

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heterogeneous spheroids with equidensity surfaces in the form of similar spheroids with an axial ratio 1:20.

For $R$ up to 9·73 kpc

$$\rho = 3{\cdot}93\, R^{-1} - 0{\cdot}025\, R;$$

for $R$ exceeding 9·73 kpc

$$\rho = 1450\, R^{-4}.$$

A mass point of $0{\cdot}07 \times 10^{11}$ solar masses is added in the centre, which, together with the masses of the two heterogeneous spheroids, 0·82 and $0{\cdot}93 \times 10^{11}$ respectively, leads to a total mass of the Galaxy of $1{\cdot}8 \times 10^{11}$ solar masses. The velocity of escape at the Sun is 380 km $s^{-1}$.

*Sir Richard Woolley* reported about an investigation of the motion of the globular cluster $\omega$ Cen. Two proper motion plates taken with 57 years interval served Murray to derive proper motions of 5000 stars. This together with other data leads to a retrograde galactic orbit for that cluster. The orbit has the form of open rosettes and the cluster attains only moderate heights above the galactic plane.

The same kind of work is being planned for other clusters, e.g. NGC 6397, 6522, and 47 Tuc.

*P. Steffey* traced the galactic orbits of supergiant stars backwards and tried to find in what stellar associations they originated. The time involved is 10 to 20 million years. $\alpha$ Lep and $\alpha$ Car have been traced to II Sco, $\alpha$ and $\beta$ Ori with some ambiguity to I Ori and the high-latitude supergiants 89 Her and $\rho$ Leo to the layer of associations along the galactic plane.

4. *Clusters and small stellar systems.*

Numerical integrations of $n$-body systems brought many interesting results.

*R. H. Miller* studied the irreversibility in stellar dynamical systems by comparing the simultaneous evolution of two similar systems. He was led to the conclusion that $n$-body systems with inverse square law forces behave as tightly coupled systems.

*I. R. King* stressed the fact that a cluster is limited in size by tidal forces imposed by the Galaxy. The escape rate from the cluster has been found to be very sensitive to the central concentration and to correspond to a decay time-constant of 1 to $3 \times 10^{10}$ years. Low-mass stars escape only a little faster than average-mass stars, because the low-mass stars show a preference for the low-density outer parts of the cluster.

*S. Aarseth* made $n$-body calculations for $n = 100$ and found a pronounced mass-segregation, both in the density and energy distribution, giving thus rise to the formation of a very dense nucleus of heavy particles. Equipartition of energy does not take place.

*S. von Hörner* found that the virial theorem still holds for clusters even after a long time. Starting with a uniform density he found that after a long time the density became inversely proportional to $r$ or $r^2$ near the centre, to $r^3$ further off, and to $r^4$ in the outer parts. The velocity distribution became similar to the Maxwellian distribution after a while but differed from it substantially after a long time.

*S. Ulam* considered the collisions at the centre of a system of high density. He found numerically that after some collisions have taken place the rate of collisions is speeded up and finally a collapse of the whole system may occur.

*P. Bouvier* discussed the relation between an anisotropic velocity distribution and the density distribution in spherical systems.

A different character had the contribution by *V. Abalakin.* He considered periodic orbits inside a heterogeneous three-axial ellipsoid only slightly differing from a sphere. As compared with a spherical system the number of free parameters of periodic orbits is reduced from 5 or 4 to 2 or 1.

SCIENTIFIC DISCUSSION

After Dr Perek's report *D. S. Evans* remarked, in connection with Schmidt's paper, that in his work on subdwarfs he has found a velocity of escape from our Galaxy of 380 km $s^{-1}$.

*P. Goldreich* and *D. Lynden-Bell* gave a report on their paper 'Spiral Arms as Gravitational Instabilities'. There are two effects that stabilize a stratified, self-gravitating rotating disk of gas: Pressure, in the case of perturbations of small wavelengths, and rotation, in the case of large wavelengths. However, there is an intermediate range of unstable wavelengths. If we have uniform rotation the sheet may break up into separate masses. If we have differential rotation we may have axially symmetric instabilities and formation of concentric rings, or shear instabilities that give rise to trailing spiral arms. The latter effect is more important. It occurs even if the density is sufficiently low, so that no axisymmetric instabilities occur. This paper will be published in *Monthly Notices RAS*.

*I. R. King* reported on the work of Mrs E. S. Avner 'Gravitational Effects of the Magellanic Clouds on the Galaxy'. Many think that the masses of the Magellanic Clouds are too small to explain the manner in which the central plane of the Galaxy curls toward the edges; the calculated deviation is only 1 pc in one revolution of a star. Mrs Avner, however, calculating the secular effects of the Magellanic Clouds, found much larger deviations. In 1 to $2 \times 10^9$ years, the deviation is one-half to one-third of that of the observed. After that time the form of the Galaxy becomes very complicated. The fact that the deviation is most marked in the direction of the Clouds is only coincidental.

*A. G. Velghe* distributed his paper 'A Study of O- and B-Type Stars in Vela from $l^{II} = 262°$ to $l^{I} = 273°$ along the Galactic Equator'. An abstract of this paper will be published soon in *Vistas in Astronomy*, Vol. VI; the full text will appear in the '*Annales de l'Observatoire Royal de Belgique*'.

*J. Graham* and *G. Lyngå* distributed their paper on 'OB Stars in Carina'.

The paper of *L. Plaut* on 'Galactic Coordinates of 15504 Variable Stars', published by the U.S.S.R. Academy of Sciences, Moscow, 1963, was also distributed.

*F. Nahon's proposal*

*F. Nahon* proposed that Commission 33 be divided into two Commissions, one devoted to Galactic Structure and the other to Galactic Dynamics, because of the large increase in the number of members and participants in the sessions of Commission 33.

Many members (*Bok*, *Oort*, *Ambartsumian*, *Lindblad*, etc.) remarked that the contact among theoreticians and observers is important, therefore such a division is not desirable.

*Bok* said that a separation may prove necessary in the long run, therefore Nahon's proposal will be on the Agenda during the next General Assembly.

*L. N. Mavridis' suggestion*

*L. N. Mavridis* suggested that a new kind of central Clearing House be formed; this should have the complete catalogues of spectral types and photometric data, and should distribute copies in card form on request. *Bok* remarked that this suggestion has been made in the past; e.g. Commission 25 made this suggestion six years ago. There are now a number of people working in this direction.

*C. O. R. Jaschek* has the proofs of a catalogue that will appear soon.

*E. D. Hoffleit* announced that a card catalogue for the brighter stars has been prepared at Yale and will soon become available. Other people working in similar projects are *R. H. Stoy*, *A. S. Sharov*, *W. Buscombe* and *W. P. Bidelman*. *Bok* suggested that Mavridis contact them and report to Commission 33.

*G. Westerhout* distributed mineographed 'Conversion Charts for New Galactic Coordinates'. These charts finish the task of Sub-Commission 33*b*. They will be printed in a convenient size to fit in the back of the Lund Tables. About 5–20 copies will be sent to each observatory on the IAU mailing list. More copies can be obtained by writing to the author, c/o Dept. of Physics and Astronomy, University of Maryland, College Park, Maryland, U.S.A.

*The President* announced the dissolution of Sub-Commission 33*b* after completion of its task. Commission 33 unanimously thanked the members of Sub-Commission 33*b* for their fine work.

*M. McCarthy*, *F. C. Bertiau* and *Mrs J. Burley* announced that the Vatican Observatory will publish a list of Galactic Coordinates for the stars in Wilson's Catalogue of Radial Velocities.

*K. F. Ogorodnikov* presented the paper of *J. Einasto* and *S. A. Kutuzov* 'On the System of Galactic Parameters', *Tartu astr. Obs. Teated*, no. 11, 1964.

The authors gave a set of galactic constants derived from observations and calculations agreeing generally with the values favoured in the Report. However, they suggested a value of 0·0910 pc$^{-3}$ for the derived density in the galactic plane near the Sun. *Bok* remarked that he would be happy if observations give $\rho = 0{\cdot}091$, because then we shall not have to explain any excess mass near the Sun, but he expressed doubts about the lower value.

*R. M. Petrie* spoke on a new calibration of the absolute magnitudes of the OB stars as derived from H$\gamma$ intensities. Using the distances of the O9 – B8 stars of the Victoria programme he found the following values for $A$ and $K$:

| $\bar{r}$ | Stellar Velocities O9 – B8 | | | Interstellar Velocities O9 – B3 | | |
|---|---|---|---|---|---|---|
| | $A$ | $K$ | $n$ | $A$ | $K$ | $n$ |
| kpc | km s$^{-1}$ kpc$^{-1}$ | km s$^{-1}$ | | km s$^{-1}$ kpc$^{-1}$ | km s$^{-1}$ | |
| 0·56 | 20·2 ± 1·4 | −0·9 ± 0·6 | 258 | 7·5 ± 1·0 | −1·5 ± 0·4 | 127 |
| 1·05 | 13·1 ± 1·1 | −1·6 ± 0·8 | 186 | 9·5 ± 0·7 | +0·2 ± 0·5 | 133 |
| 1·65 | 14·7 ± 0·8 | −3·6 ± 1·0 | 147 | 8·6 ± 0·5 | −1·5 ± 0·6 | 125 |
| 2·35 | 17·0 ± 1·1 | +4·9 ± 2·2 | 77 | 7·5 ± 0·5 | +1·1 ± 1·0 | 64 |

The mean value of $A$ is equal to 15·6 from stellar velocities and equal to 16·6 from interstellar calcium lines. The mean value of $K$ is not significantly different from zero. The variation among different groups is probably due to random motions and sporadic motions.

*C. Jaschek* asked which solar velocity was used.

*Petrie* replied that for stars of distance $< 400$ pc and interstellar lines from clouds at distances $< 500$ pc the solar motion found was very nearly equal to the standard one.

*A. Blaauw* remarked that the distance moduli are given with an accuracy of $\pm 0^{m}{\cdot}1$. He checked, with *J. Borgman*, the distance modulus of *h*, χ Persei, using an assumed value for the modulus of the II Sco Association and found the same value as Petrie.

*A. D. Thackeray* summarized results relating to constants of the Galaxy obtained by *M. W. Feast* in a new extensive analysis of radial velocities of OB stars at all longitudes. Statistical corrections to MK distances were applied, which become large at great distances ($r > 4$ kpc). The total number of stars analysed was nearly six times that of the cepheids used by Kraft and Schmidt. The greater number of B stars gives increased weight relative to the cepheids, which more than offsets greater uncertainties in the distances of the B stars.

A new analysis of the solar motion led to results between the basic and standard values. This was required in view of the sensitivity of $R_0$ to the solar motion when derived from the shift of the node in the galactic rotation curve.

The derived $\omega(R)$ curve for $\Delta R = \pm 3$ kpc agrees closely with the Sydney 21 cm curve, especially when the corrected distances are used.

The most important results of this discussion were

$A = 14{\cdot}3 \pm 0{\cdot}8$ (based on corrected distances)
(or $15{\cdot}0 \pm 0{\cdot}8$, based on uncorrected distances),
and $R_0 = 9{\cdot}9 \pm 0{\cdot}9$ kpc from 24 stars with
$\Delta R = \pm 1$ and $r > 3$ kpc (corrected).

*Bok* asked if there is any correction of the opposite sign for near-by stars.

*Thackeray* replied that for small distances the statistical correction is in the sense of increasing the observed distances by a small amount.

*V. Rubin:* 'Motions of early-type stars in the anticentre'.

Radial velocities of twenty-eight O6–B3 stars in the anticentre region of the Galaxy have been obtained with the Meinel spectrograph attached to the 36-inch reflector of Kitt Peak Observatory, in order to see if these stars show significant motions toward or away from the centre of the Galaxy. The distances, $R$, of the stars from the centre of the Galaxy range from $11{\cdot}0 < R < 14{\cdot}2$ kpc; the longitude range is from $136° \leqslant l^{II} \leqslant 193°$. The Schmidt rotation curve, scaled to $V_0 = 250$ km s$^{-1}$, $R_0 = 10$ kpc, has been used in the calculations. Results indicate:

(1) Twenty-three stars show no significant radial motion.
For eighteen stars, $|\Pi| \leqslant 10$ km s$^{-1}$.
(2) Only five stars have $|\Pi| \geqslant 20$ km s$^{-1}$; $+31$, $+45$, $-54$, $+71$ and $-84$ km s$^{-1}$.
(3) The observed velocities have been projected to determine the circular velocities about the centre of the Galaxy for the eleven stars with $l^{II} < 156°$, assuming circular orbits. The computed circular velocities agree well with the scaled rotation curve of Schmidt.

*C. Jaschek* asked how many of these stars are spectroscopic binaries.

*Rubin* replied that one half of them are definitely not.

*W. J. Luyten* spoke about the correction of relative to absolute proper motions. In general one measures the motion of a particular object relative to comparison stars of about the same apparent magnitude. To correct these motions to absolute values most people use corrections like those of Parenago's Tables. The most crucial item is the mean secular parallaxes of the stars. We need also the 'best' value of the solar motion and the differential galactic rotation. *A. N. Deutsch*, *W. J. Luyten* and *C. A. Murray* will try to modernize Parenago's Tables until finally improved values from the Galaxy proper motion programme are derived.

*C. A. Murray* spoke on recent work done by S. V. M. Clube and himself at Herstmonceux to relate the galactic distance scale to that of the Cepheid variables. On the simple circular velocity model, the radio observations of 21 cm radial velocities give the differential radial velocity, $f(u)$, as a function of $u = R_0/R$. This function depends only on the interpretation of the radio data and not on $V_0$. The radial velocity of an object at heliocentric distance $r$ in the

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galactic plane is $\sim u\,f(u)$ sin $l$. For the cepheids distances according to Kraft and Schmidt (*Ap. J.*, **137**, 249, 1963) have been adopted and the radial velocity dispersion for various assumed values of $R_0$ has been computed. Preliminary calculations indicate that the minimum dispersion confirms a value of $R_0$ near 10 kpc. This value has low weight on account of the small sample included. Similar results were obtained when a general radial motion was included in the assumed model. An increase of the statistical precision is expected by including B-stars in the solution.

*King* remarked that from 80 stars, even if all had unit weight, the dispersion will have a statistical mean error of 2/3 km $s^{-1}$. This seems to embrace the values for the entire critical range in $R_0$.

*Murray* replied that indeed the sample was too small. His purpose was to indicate the method rather than present a final result.

*J. H. Oort* described briefly the reasons which had led to the proposal printed in *IAU Information Bulletin* no. 11 (September 1963) to use the same standard values for the distance $R_0$ of the Sun from the galactic centre, for the constants $A$ and $B$ of differential rotation and for the rotation curve for $R > R_0$ in all reductions of observations of the 21 cm line.

He pointed out that because of the uncertainty in the determination of these quantities there was a danger that different groups would adopt different values for these constants and that thereby undesirable confusion might arise. It would then also become difficult to compare the results obtained by these different groups.

An extensive discussion of all available data has been given by *M. Schmidt*. This will appear in Volume V of *Stars and Stellar Systems*.

The following data have been considered in proposing the standard values for $R_0$, $A$ and $B$ indicated below.

$R_0$

Direct determination from RR Lyrae-type variables near the galactic centre. Adopting $M_B = +0{\cdot}5$, *H. C. Arp* derives $R_0 = 9{\cdot}9$ kpc.

$A$

Recent determinations from radial velocities and distances of galactic clusters and cepheids lead to an average value of $A$ of approximately 15 km $s^{-1}$ $kpc^{-1}$. The distance scale is derived by fitting main sequences of galactic clusters and is ultimately based on the distances of the Hyades. If the secular parallax of cepheids is used, a considerably larger value of $A$ (of about 19) is found, but this is considered to be more uncertain.

*Product* $AR_0$

This can be derived from 21 cm line observations without reference to any other observations. The values found range from 135 to 150 km $s^{-1}$.

$B$

The only direct way of determining this constant is by means of proper motions. However, such determinations are very uncertain for two reasons. Firstly, because at present they can only be based on bright stars, for which the motions can be directly referred to a fundamental system; these stars are confined to a relatively small region, and are likely to be influenced by local deviations from the circular velocity. Secondly, the angular velocity of rotation is so small that even for these bright stars it is badly influenced by the remaining uncertainties in the fundamental system of proper motions. For these reasons the direct determinations of $B$ have not been used in fixing the value of $B$.

$\sqrt{-B/(A-B)}$

If the system is in a steady state this expression is equal to the ratio, $b/a$, of the transverse axis of the velocity ellipsoid (in the galactic plane) to the radial axis. Values for this ratio

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range between about 0·7 and 0·5, corresponding with a range between 0·96 and 0·33 for the ratio $-B/A$. The smaller values for this ratio might be due to local streamings, such as are causing the well-known deviation of the vertex. The ratio $-B/A$ can also be determined from the mass-density gradient, as indicated by M. Schmidt. This leads to $-B/A = 0{\cdot}67$.

On the basis of these considerations it is suggested to use the following round values for the constants discussed:

| *Constants used up to present* | *Proposed new values* |
|---|---|
| $R_0 = 8{\cdot}2$ kpc | $R_0 = 10$ kpc |
| $\theta_0 = 216$ km s$^{-1}$ | $\theta_0 = 250$ km s$^{-1}$ |
| $A = 19{\cdot}5$ km s$^{-1}$ kpc$^{-1}$ | $A = 15$ km s$^{-1}$ kpc$^{-1}$ |
| $B = -6{\cdot}9$ km s$^{-1}$ kpc$^{-1}$ | $B = -10$ km s$^{-1}$ kpc$^{-1}$ |

It is further proposed to use the following values for the velocity of rotation for distances beyond $R_0$

| $R$ | $\Theta_c(R)$ | $R$ | $\Theta_c(R)$ |
|---|---|---|---|
| 10 | 250·0 km s$^{-1}$ | 14 | 225·7 km s$^{-1}$ |
| 11 | 244·4 | 15 | 219·7 |
| 12 | 238·2 | 17·5 | 206·1 |
| 13 | 231·9 | 20 | 194·2 |

The values were computed by Schmidt from a very simple model for the density distribution in the Galactic System adjusted to a mass density of 0·145 in the neighbourhood of the Sun and to the values of $R_0$, $\Theta_0$, $A$ and $B$ quoted above. The circular velocities in Schmidt's model were represented by the following interpolation formula, from which also the velocities in the table were computed:

$$\Theta_c = 885{\cdot}44\, R^{-\frac{1}{2}} - 30\,000\, R^{-3};$$

$\Theta_c$ is in km s$^{-1}$, $R$ in kpc.

It was felt that the determination of rotation velocities in the part well *within* $R_0$ could best be left to the groups studying these regions and that there is neither a possibility nor a need for a general concordance about this part of the rotation curve, as long as it is adjusted to the above values of $R_0$ and $A$ near the Sun.

### *General Discussion on the Constants of the Galaxy*

*Bidelman:* There are a number of stars that will have retrograde orbits if one assumes a circular velocity as low as 250 km s$^{-1}$. I recently found an object that has a velocity in the direction opposite to that of galactic rotation of at least 320 km s$^{-1}$ relative to the local centroid. Does this worry any one?

*Schmidt:* There will always be some retrograde orbits.

*Bidelman:* Not so many if one assumes a higher circular velocity.

*Van den Bergh* mentioned the work of *K. Innanen* of the University of Western Ontario, who found smaller values for $V_0$, around $V_0 = 200$ km s$^{-1}$; but he commented that these values are not yet final.

### *Motions and Chemical Characteristics of the Stars*

*R. Cayrel:* 'On the meaning of the correlation between kinematical properties and chemical composition of stars'.

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In the last three years considerable advances have been made toward a better understanding of the kinematical properties of stars in terms of their physical characteristics, such as their age and their initial chemical composition.

These advances have been made possible because of the increase in the number of stars thoroughly analysed (Cf. IAU Symposium no. 26) and because of the number of accurate space velocities which have been recently obtained (Eggen, 1962, 1964). A third important factor for progress has been the calibration of photometric indices ($\delta(U - B)$, Strömgren $m_1$ index, etc.) on the basis of high-dispersion work (Wallerstein, 1962).

It is now clear that all stars with metal deficiency exceeding a factor of 5 are stars with very eccentric orbits and small angular momentum with respect to the galactic centre, and conversely (Eggen, Lynden-Bell, Sandage, 1962).

The situation for stars with no or smaller metal deficiency is not so sharply defined. Pagel (1964) has remarked that really all stars with orbital eccentricities between 0·35 and 0·5 are mildly metal poor, whereas stars with orbital eccentricities smaller than 0·35 may be either normal or mildly metal poor.

The fact that most of the heavy elements have been synthesized in a very short period of time contemporary with the formation of the halo population is very stimulating and suggests that the physics of star formation were in the early stages very different from those at the present conditions.

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Pagel, B. E. J. Communication at the IAU Symposium no. 24, 1964.
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*O. J. Eggen* spoke on the 'Observed correlations between the kinematical properties and the chemical composition for G-type dwarfs and for orbiting visual binaries'; his paper will appear in the October 1964 issue of the *Astronomical Journal*.

## COMMITTEE OF 'SELECTED AREAS'

### Report of Meeting, 26 August 1964

CHAIRMAN: T. Elvius

SECRETARY: S. van den Bergh

### *Draft Report*

The Draft Report, as presented, was accepted with some minor corrections.

Concerning the form of future reports B. J. Bok suggested that no radical change be made. It is valuable to have access to reports which keep together information on actual activities within the Selected Area plan and bibliographic references to such work. It was agreed that in the future the reports should include references to work performed also within other schemes than the Kapteyn Plan for systematic investigations of galactic structure by combined efforts, *cf.* the proposal by Kharadze under desiderata in the Report to the meeting (*Trans. IAU*, **12A**, p. 553).

*Committee of 'Selected Areas'*

Kharadze's above-mentioned proposal was further discussed. There was a general agreement that the scope of the Committee should be extended to include co-ordination of work within fields for galactic research supplementing the Kapteyn Plan.

It was announced by Bok, President of Commission 33, that for the next period the Selected Area Committee should consist of T. Elvius (chairman), Kharadze, McCuskey and Plaut.

*Discussion of current and future work*

*Photometry.* A discussion arose as how to obtain, without a tremendous amount of work, good magnitudes and colours of faint stars in wide fields. Bok suggested that objective gratings be applied for photographic extension of scales when photoelectric determinations will be too time-consuming. He also advocated the use of long-focus wide-field reflectors (e.g. Ritchey-Chrétien type) for crowded areas. To obtain good colour indices he recommended measurement of image-pairs exposed in different colour regions and located close together on the plate. At Mount Stromlo the following plate-filter combinations had been used with advantage,

for $U - B$: 103a-O plates with GG 13 for $B$ and UG 2 for $U$

„ $B - V$: 103a-D „ „ GG 14 „ $V$ „ GG 13 + Wr 47 for $B$

For stars of type A0 the $U$ exposures have to be four times the $B$ exposures to obtain equal images.

Elvius pointed out that in order to get good photographic photometry over wide-field plates it is necessary to supplement the usual photoelectric sequence at the centre by standards also in the outer parts of the plates. He also suggested that photoelectric photometry in Selected Areas be placed on the ESO programme.

W. Becker demonstrated that the *RGU* system separates stars with ultra-violet excess in range $0{\cdot}8 < B - V < 1{\cdot}0$, when such separation is not discernible with *UBV* photometry. Results down to $V$ abt. 19 magn. were shown for SA 51 ($l^{II} = 189°$, $b^{II} = +21°$), where population variations with level over the galactic plane were revealed. Such features will be investigated in the run of the Basel programme for Selected Areas situated in a plane through the galactic poles, centre and anticentre.

Information was obtained that E. Rybka has hopes that the same instrumental equipment as has been used at the Crimean Observatory for Selected Area photometry, will be transferred to the U.S.S.R. station in Chile.

*Proper motions.* Oort urged that the proper motions in the Kapteyn Selected Areas be improved, and expressed the hope that the London Observatory continuation of the Radcliffe proper motion work should be carried on.

Supplementary information on the Bonn-Vienna programme, mentioned in the Report, was given by Hopmann. Abraham referred to the possible continued proper-motion determinations for southern Selected Areas by means of the 'Yale-Columbia-refractor' which will remain in Australia as the property of the Mount Stromlo Observatory.