

30. COMMISSION DES VITESSES RADIALES STELLAIRES

PRÉSIDENT: M. A. D. Thackeray.

MEMBRES: MM. Edmondson, D. S. Evans, Fehrenbach, Gollnow, Gratton, Heard, Herbig, Joy, McLaughlin, Mlle Ruth Northcott, MM. Pearce, Petrie, Sahade, Sanford, Shajn †, Struve, Taffara, Weaver, O. C. Wilson, R. E. Wilson.

30a. SOUS-COMMISSION DES VITESSES RADIALES FONDAMENTALES

PRÉSIDENT: M. J. A. Pearce.

MEMBRES: MM. Neubauer †, D. S. Evans, Gratton, Heard.

30b. SOUS-COMMISSION DES LONGUEURS D'ONDE

PRÉSIDENT: M. R. M. Petrie.

MEMBRES: MM. Struve, Weaver.

30c. SOUS-COMMISSION POUR L'OBSERVATION DES ÉTOILES DOUBLES SPECTROSCOPIQUES

PRÉSIDENT: M. D. B. McLaughlin.

MEMBRES: MM. Pearce, Shajn †, Struve, O. C. Wilson.

Two momentous developments in the field of radial velocities in recent years have been the publication of R. E. Wilson's *General Catalogue of Stellar Radial Velocities* (*Carnegie Inst. Washington Publ.* no. 601, 1953) and the successful application of radio techniques to observations of the motions of interstellar hydrogen gas through observations at 21 cm. wave-length. For details of the latter work the reports of Commissions 40 and 33 should be consulted. The technique has brought to light in a short time motions of the gas in distant portions of our Galaxy and in the Magellanic Clouds, which could only have been studied spectroscopically, if at all, by the expenditure of great labour. However, the new information relating to gas to some extent supplements the old data derived from classical spectroscopy and it has by no means diminished the need for observations of individual stars, particularly stars belonging to certain physical groups. Data concerning the relative motions of stars and the interstellar gas have assumed a new importance in recent years.

A vote of thanks to Dr R. E. Wilson was passed by the commission at its meeting at Rome in 1952 when a sample proof of his *General Catalogue* was laid on the table. The *Catalogue*, containing velocities of 15,106 objects in our Galaxy, represents the labours of radial velocity workers over more than half a century, summarized in a form most convenient to statistical workers. The enormous deficit of southern data is illustrated by the fact that stars with known velocities between declinations $+30^\circ$ and $+90^\circ$ outnumber those with corresponding southern declinations in the approximate ratio of five to one.

The following report is based mainly on reports submitted by members of the commission. Further information concerning some special aspects of radial velocity work may be found in the reports of Commissions 28, 29, 32, 33, 34, 40 and 42.

OBSERVATORY PROGRAMMES

Dominion Astrophysical Observatory, Victoria

B-type programme

Observations of 650 stars earlier than B8, $m=7.6$ to 8.6 or slightly fainter, north of $+20^\circ$, are 95% completed. A minimum of three plates per star (51 Å/mm. at H γ) are being secured. Photo-electric colours and magnitudes are also being determined. Measurement of about one-third of the material has been effected, and it is hoped that the radial velocities will be completed in about two years' time.

North Galactic Pole programme

This contains nearly 200 stars of types earlier than G0, brighter than 9^m.0, within 10° of the pole. Three plates per star (51 Å/mm. at H γ) are being secured. Spectroscopic absolute magnitudes will be estimated. Observations are 85% completed and rather more than one-third of the measures have been made.

Minor programmes

(a) *Stellar aggregates.* The Perseus group studied by Blaauw is being observed thoroughly for velocities, distances and colours. Observations of other B-type groups in the regions of Orion-Taurus and Cassiopeia have also begun.

(b) *Ursa Major region.* A number of stars selected according to type and apparent magnitude which may be members of the Ursa Major cluster are being observed.

(c) Certain selected clusters (Pleiades, Praesepe and clusters containing O stars) are being observed for various purposes.

Mt Wilson and Palomar Observatories

With the completion of the *General Catalogue* most of the major radial velocity programmes have been wound up, and, as at many other northern Observatories, shorter-term programmes designed to study special objects have been adopted.

Münch⁽¹⁾ has continued Adams' high-dispersion work on components of interstellar absorption lines; the velocities of the main components conform to a model in which the gas is strongly concentrated in spiral arms, just as in the radio observations. Minkowski has continued work on velocities of planetaries in the central bulge of the Galaxy and Joy plans to continue work on velocities of RR Lyr variables. O. C. Wilson⁽²⁾ has applied the power of the Palomar coude spectrograph to determine velocities of 15 members of the globular cluster M 92. Merrill⁽³⁾ has published velocities of 14 long-period variable stars and of 10 shell stars. Work has also been continued on northern W stars in which the emphasis is on motions within the atmosphere rather than the velocity of the star as a whole.

David Dunlap Observatory, Toronto

Yale zone dec. $+25^\circ$ to $+30^\circ$

Observations of 1042 stars type G to M, brighter than 9^m, selected from this zone have been completed, with a minimum of four plates per star. The stars have been classified on the MK system. A project to measure the photographic magnitudes in co-operation with the Hamburg and the Warner and Swasey Observatories has been initiated. Publication of velocities, spectral classifications and magnitudes is expected in 1955 or 1956.

High-velocity stars

Observations of forty-seven high-velocity stars have been completed.

6° × 6° Kapteyn zones

This programme on stars of class A0 and later with magnitudes 7.5 to 8.0 is now limited to zones centred on Kapteyn areas between 0^h and 6^h and dec. $+15^\circ$ northward (two plates per star). The curtailed programme involves 95 stars and is nearly complete.

$8^\circ \times 8^\circ$ Kapteyn zones

This programme on 104 stars brighter than $7^m.6$ in zones centred on Kapteyn areas between 9^h and 18^h will be limited to two plates per star and as such is nearly complete.

Clusters

Fifty-six stars to limiting magnitude 9.2 in the moving cluster around α Per are being observed. Twenty-one presumed members of NGC 752 ($m = 9.6$ to 10.7) are being observed for velocity and luminosity. Twelve selected stars in three other moving clusters are also being observed.

Kapteyn area fundamental stars

Fifty-five stars with unknown velocities, brighter than $10^m.1$, common to Hins' General Catalogue and the following Kapteyn areas are being observed: S.A. 13-15, 29-35, 53-60.

OB stars

One hundred and two distant OB stars (magnitude 10.6 and brighter) have been selected for observation from the lists in *Tonantzinila Bull.* nos. 5 and 9 (Iriate and Chavira) and from Morgan, Whitford and Code's aggregates north of the equator.

Lick Observatory and Berkeley Astronomical Department

Work here is now largely concerned with variable velocity stars and falls within the scope of Sub-commission 30c. Herbig and Moore⁽⁴⁾ have studied a secondary period of 676 days in the velocity curve of the 8-day cepheid S Sge. The system of Polaris is being exhaustively studied on the basis of velocity and astrometric data.

In addition to his studies of extragalactic nebulae, Mayall is engaged on velocities of planetaries towards the galactic centre.

Struve and his co-workers at the Berkeley Astronomical Department are utilizing Lick material for studies of β C Ma stars and visual binaries. McNamara⁽⁵⁾ has demonstrated that γ Peg, a B-type velocity standard, is subject to short-period variations in velocity.

Weaver reports that a programme on 53 OB stars in galactic longitudes 65° to 85° is nearing completion and that a further programme on such stars in longitudes 140° and 160° is planned.

Goethe Link Observatory, Indiana

Edmondson reports on the extensive programme on velocities of faint McCormick proper motion stars or stars in Selected Areas at -45° which he and others have observed with the McDonald 82-inch reflector under an agreement between the Indiana University and the Universities of Texas and Chicago.

K stars (G8-K3) dispersion 150 Å/mm.: observations and measurements are complete for 700 McCormick stars ($10.0-11.0 m_{pv}$). Of 130 stars at -45° ($11.0 m_{pg}$), 100 are observed, 52 measured.

A stars (B8-A2), dispersion 300 Å/mm.: observations are complete for 350 McCormick stars ($10.0-11.5 m_{pv}$); measurement is about 40% complete. Sixty stars at -45° are to be observed.

Haute Provence and Marseille Observatories

Fehrenbach reports that the technique of observing slitless radial velocities has been improved in various ways: a field lens increases the field to $3 \times 4^\circ$, flexure between the guiding telescope and objective prism has been compensated, and baked Kodak II aO emulsion is now used. The measuring technique has been improved and facilitated by the construction of a Hartman projection spectrocomparator.

With 2-hour exposures (double) on baked II aO emulsion stars of magnitude 9.5 are easily reached, and measurable spectra to 10.0 magnitude. From three spectra, internal probable errors range from ± 3 km./sec. for the best spectra to ± 10 km./sec. at the limit.

The emphasis of the observing programme is now on problems of galactic rotation, with studies of early-type stars in Cygnus and high-velocity stars as subsidiary subjects. The fields concerned in current programmes are as follows:

Programme I

Field	α 1950 h m s	δ 1950 ° ' "	Field	α 1950 h m s	δ 1950 ° ' "
3	18 45 0	- 6 3	12	4 48 0	+43 29
4	19 40 3	+ 8 16	13	5 36 2	+30 52
5	19 27 1	+20 10	14	6 10 6	+18 41
6	20 5 8	+34 16	15	6 35 2	+ 5 00
7	20 58 1	+47 19	16	7 01 6	-10 03
8	22 10 0	+56 35	Orion	5 23 2	+ 0 28
9	0 1 6	+62 00	P Cyg	20 15 9	+37 52
10	2 5 1	+58 11	28 Cyg	20 7 6	+36 41
11	3 51 8	+52 29			

Programme II

Field	HD	α 1950 h m s	δ 1950 ° ' "	Field	HD	α 1950 h m s	δ 1950 ° ' "
A	167720	18 14 3	-17 24	I	9878	1 34 8	+62 06
B	168815	18 19 4	-15 07	J	11857	1 55 0	+61 27
C	186745	19 43 3	+23 49	K	14817	2 21 9	+61 19
D	193370	20 16 7	+34 49	L	15449	2 27 8	+57 48
E	194193	20 21 0	+40 52	M	17086	2 43 3	+60 22
F	195050	20 25 7	+38 16	N	42995	6 11 9	+22 31
G	195986	20 31 1	+43 01	O	44974	6 22 7	+21 40
H	197018	20 37 7	+40 24				

In programme I practically all the exposures have been made. Spectral classification is well advanced, and some high-velocity stars have been detected. In programme II observations and spectral classifications have been begun.

Spectral classifications in the Morgan system are being undertaken in collaboration with the Lille Observatory, and photo-electric magnitudes and colours are being determined in collaboration with the Toulouse Observatory.

The 40 cm. objective prism is under construction and is expected to be installed in 1956. This will reach stars of magnitude 12 to 12.5.

Yerkes and McDonald Observatories

Miss Roman has measured velocities of 47 high-velocity stars, observed in co-operation with the David Dunlap Observatory. Blaauw has begun work on suspected spectroscopic binaries in the nearest stellar associations.

Leander McCormick Observatory

Dyer (6) has measured velocities of 166 red dwarfs using spectra, mostly at 110 Å/mm., which he obtained at the Mt Wilson Observatory. The stars were chosen as dwarfs, not previously observed for velocity, using spectrophotometric criteria obtained at Leander McCormick. Dyer finds that the velocity dispersion is markedly reduced compared with that derived from dwarfs selected solely from the more usual criterion of large proper motion.

Royal Observatory, Cape of Good Hope

The radial velocity programmes being undertaken with the Cassegrain spectrograph of the Radcliffe Observatory includes:

(1) All stars south of -26° for which the magnitude is brighter than 9.0 and *either* (i) the Cape parallax exceeds $0''.060$, *or* (ii) the annual proper motion exceeds $1''.0$, *or* (iii) the G.C. annual proper motion exceeds $0''.1$ and the star lies within an area $6^\circ \times 6^\circ$ surrounding the Kapteyn Selected Areas 140–206.

(2) Selected visual double stars and interferometric doubles from lists supplied by the Union Observatory, Johannesburg.

(3) About a dozen stars in NGC 2516.

(4) Twenty-five I.A.U. standard radial velocity stars.

Programmes (1) and (2) contain about 426 stars, each being observed at least four times. Results are intended for publication in batches of 100, accompanied by magnitudes and colours determined at the Cape. It is expected that two such lists of 100 stars each will be completed before the 1955 General Assembly.

Radcliffe Observatory, Pretoria

B-type stars

Velocities of 148 southern stars, type B5 and earlier, 7.5 mag. and brighter, were completed in 1954, with revised spectral classifications (7). (Photo-electric colours and magnitudes are being determined at the Cape.) In addition, 38 stars with previously determined velocities (chiefly Lick) were reobserved. Good progress has been made on a further programme on 100 stars with Oosterhoff modulus $m_0 - M \geq 11$. The two-prism Cassegrain spectrograph attached to the Radcliffe reflector is used for all this work, chiefly at 49 \AA/mm .

Twenty-four 8th mag. B stars, north of the equator, are being observed for overlap with the Dominion Astrophysical and Lick Observatories. This programme is practically complete.

A few selected high-latitude B stars are being observed.

Cepheid variables

Velocity curves covering all phases of 55 variables with minima brighter than 10.5 m_{pg} have been determined by D. W. N. Stibbs, Radcliffe Travelling Fellow. These stars lie in the quadrant of longitude not covered by Joy's observations and increase the total number of cepheids with known velocities to 189.

A few RR Lyrae variables, including V 703 Sco, V Ind and RU Scl have also been observed by Stibbs.

47 Tucanae

Spectra of twenty-eight stars in this globular cluster have been obtained. For all but six stars at least one spectrum with dispersion 49 \AA/mm is available, for the remainder the dispersion was 86 \AA/mm .

Long-period variables

Spectra of thirty-two southern long-period variables have been taken in a programme designed to study velocities and physical properties of these stars.

Magellanic Cloud objects

Spectra of selected objects are being obtained for velocities and other purposes.

Leyden Observatory, Southern Station

In a co-operative scheme with the Radcliffe Observatory, a programme on velocities of the Tonantzintla southern OB stars has been begun.

Commonwealth Observatory, Canberra

The initiation of radial velocity work at this Observatory is most welcome in view of the urgent need for southern data. Dr Gollnow reports that work has begun with the Cassegrain spectrograph attached to the 30-inch reflector. Velocity work with the 74-inch reflector may be confined to the coudé and Newtonian foci.

The current programmes are:

- (1) Scorpio-Centaurus cluster.
- (2) Stars of the N 30 catalogue with unknown or uncertain velocities between declinations $+25^\circ$ and -90° .
- (3) Orbits of binaries included in (1) and (2).

It is a matter of great regret that the Crimean Astrophysical Observatory, Simeis, which has been such an active contributor of radial velocities in the past, has not resumed this work in view of wartime destruction of equipment.

At the Pulkovo Observatory experimental determinations of radial velocities have been made with a 10 cm. F/7 astrograph and objective prism; a small reversed prism gives simultaneous images of stars (8). With exposures of $1\frac{1}{2}$ hours the limiting magnitude is 7.5 and the mean square error from four plates is 7.8 km./sec. Observations of radial velocities in selected areas of the Milky Way have begun. Further developments of this important technique are awaited with great interest.

From the La Plata and Cordoba Observatories no long-term radial velocity programmes are reported. Studies of individual stars are, however, being made (9) and those with variable velocity are reported to Sub-commission 30c.

The Asiago Astrophysical Observatory reports the commencement of work on standard stars and members of the solar system, on spectroscopic binaries and on bright Be and normal B stars.

MISCELLANEOUS PROBLEMS

Relativity shift

Popper (10) has measured a relativity shift of 21 ± 2 km./sec. in the white dwarf 40 Eri B in satisfactory agreement with the computed value of 17 ± 3 km./sec.

Petrie (11) finds that his fundamental work on wave-length standards for B-type stars based on 16 stars, fails to support the idea that B stars in general will yield a positive K term of 1 to 2 km./sec. due to relativity shift.

Struve and Kraft (12) confirm Trumpler's red shift of $+9$ km./sec. for the massive star τ C Ma in NGC 2362.

Radial velocity parallax

In confirmation of the general principle of radial velocity determinations, Wesselink (13) has measured the difference in velocity of the two components of α Centauri, which in combination with the visual orbit yields a parallax of $0''.776 \pm 0''.008$, agreeing within the observational error with the trigonometrical parallax. Wesselink's determination has the smaller error.

High-velocity stars

Stars with space velocities greater than 60 km./sec. are becoming of special interest in problems of stellar evolution. Morgan and Blaauw (14) have discovered the remarkable fact that the early type B stars μ Col and AE Aur are moving away from the Orion association in almost exactly opposite directions with the same speed, 127 km./sec. Mayall (15) has measured the velocity of the nebulosity apparently associated with AE Aur.

Two other early-type stars with exceptionally high velocities have been discovered at the Radcliffe Observatory: HD 214539 (A0) $+333$ km./sec., and HD 168476 (Bp)

—165 km./sec. The latter star is a hydrogen deficient star like HD 124448 and 160641 which also have high velocities.

In a different category, mention may be made of Minkowski's⁽¹⁶⁾ remarkable achievement in detecting large internal motions (over 2000 km./sec.) in very faint filaments which coincide with radio sources.

ANALYSES

Edmondson, in a preliminary analysis of the Goethe Link-McDonald velocities of faint A and K stars which was reported at the Berkeley Conference 1954, finds normal constants of galactic rotation for K III and A stars at low latitudes; but for latitude +10 to +50, and longitudes 0 to 120, the velocities of the K stars are systematically negative. He further finds that the previously reported absolute magnitude for K dwarfs (5.4) can be made to agree with Morgan's value (6.0) and others by adopting a solar motion of 14.7 km./sec. and a velocity dispersion of 17.2 km./sec.

Radial velocities of southern cepheids observed by him at the Radcliffe Observatory have been analysed by Stibbs as Radcliffe Fellow at Oxford and the results are nearing publication.

Petrie and Moysls⁽¹⁷⁾ have discussed the convergent point and space motion of the Ursa Major cluster.

Ewart⁽¹⁸⁾ has analysed the radial velocities of 820 stars of types F to M and with m_{pg} 8.5 to 9.6. The constants of the velocity ellipsoid agree well with previous results, but no deviation of the vertex is found—in agreement with proper-motion results for faint stars.

Wilson and Coffeen⁽¹⁹⁾ derive a mass of $3.3 \times 10^5 \odot$ for the globular cluster M 92 from their observations of fifteen cluster members, with an upper limit of $7.7 \times 10^5 \odot$. Sandage⁽²⁰⁾ has discussed this result in comparison with his derivation of $1.4 \times 10^5 \odot$ for M 3.

Weaver⁽²¹⁾ has studied motions and distributions of B stars in the light of a hydrogen spiral model of the galaxy based on the radio observations of neutral hydrogen.

For further reports on analyses of stellar motions the report of Commission 33 should be consulted.

SUGGESTIONS FOR FUTURE WORK

Observers planning future programmes should note the formation of a sub-commission to Commission 33, formed since the 1953 Groningen conference, for the purpose of co-ordinating galactic research.

In response to an inquiry addressed to the President of this sub-commission, Prof. Oort urges the construction of stellar spectrographs capable of determining velocities of stars fainter than the 11th magnitude and secondly the importance of luminosity classifications as well as radial velocities. In the southern hemisphere, Prof. Oort also stresses the need for velocities of faint objects—e.g. Cepheid, RR and long-period variables, globular clusters and faint planetaries.

The expansion effect detected in stellar associations by Blaauw provides a further strong incentive for the accurate study of velocities of members of such groups.

It is to be hoped that such suggestions will be fully discussed at the meeting of the commission in 1955.

A. D. THACKERAY
President of the Commission

REFERENCES

- (1) G. Münch, *Publ. Astr. Soc. Pacif.* **65**, 179, 1953.
- (2) O. C. Wilson, *Ap. J.* **119**, 197, 1954.
- (3) P. W. Merrill, *Ap. J.* **116**, 344, 501, 523, 1952.
- (4) G. H. Herbig and J. H. Moore, *Ap. J.* **116**, 348, 1952.
- (5) D. H. McNamara, *Publ. Astr. Soc. Pacif.* **65**, 144, 1953.
- (6) E. R. Dyer, *Astr. J.* **59**, 218, 221, 1954.
- (7) *Mem. R. Astr. Soc.* (in the Press).
- (8) L. A. Panaiotov, *Pulkovo Bull.* no. **152**, 87, 1954.
- (9) *Ap. J.* **116**, 654, 1952; **117**, 234, 1953; *Publ. Astr. Soc. Pacif.* **65**, 88, 1953.
- (10) D. M. Popper, *Ap. J.* **120**, 316, 1954.
- (11) R. Petrie, *Publ. Dom. Astrophys. Obs.* **9**, 297, 1953.
- (12) O. Struve and R. P. Kraft, *Ap. J.* **119**, 299, 1954.
- (13) A. J. Wesselink, *Mon. Not. R. Astr. Soc.* **113**, 505, 1953.
- (14) W. W. Morgan and A. Blaauw, *Ap. J.* **119**, 625, 1954.
- (15) N. U. Mayall, *Publ. Astr. Soc. Pacif.* **66**, 132, 1954.
- (16) R. Minkowski, *Ap. J.* **119**, 208, 1954.
- (17) R. M. Petrie and B. N. Moysls, *Mon. Not. R. Astr. Soc.* **113**, 239, 1953.
- (18) D. G. Ewart, *Mon. Not. R. Astr. Soc.* **113**, 553, 1953.
- (19) O. C. Wilson and M. Coffeen, *Ap. J.* **119**, 197, 1954.
- (20) A. Sandage, *Astr. J.* **59**, 162, 1954.
- (21) H. F. Weaver, *Astr. J.* **58**, 177, 1953.

30b. SUB-COMMISSION ON WAVE-LENGTHS

Review of the fundamental system

The present phase of the sub-commission's work has been completed with the determination of wave-length standards for single-prism spectra of B stars. It is perhaps appropriate now to review briefly the construction of the homogeneous system which extends from types B0 to K8, inclusive. The first step was to set up a system which embraced spectral types F5 to K8 and gave velocities in agreement with those calculated from the accurately known motions of members of the solar system^(1, 2). This was followed by investigations linking the A-type spectra with the later types through the use of moving clusters and visual binaries^(3, 4). Finally, the B-type spectra were brought into the system by connecting them with the A stars, again making use of galactic clusters and visual binaries⁽⁵⁾. At each step care was taken to see that the adopted wave-lengths did, in fact, reproduce velocities in agreement with previously verified results. It is considered that the system is now sufficiently homogeneous to allow of a discussion together of radial velocities of stars in the range B0 to K8.

The desirability of testing the system by calculating radial velocities of moving clusters from parallaxes and proper motions has been suggested in a previous report. This does not appear to be possible at the present time because of the limits encountered in measuring parallaxes except in the case of the Ursa Major cluster, the nearest of such groups. Here a recent calculation of the space motion, using only the data of positional astronomy, confirms the radial velocities of member stars measured with the revised wave-lengths⁽⁶⁾.

A large body of observations and measurements has been required to set up the fundamental system, and it appears to be unnecessary for this to be repeated. It may be assumed that the wave-lengths determined at Victoria will apply generally to spectrograms of comparable purity and dispersion. Each observer should, however, verify this by measuring an adequate number of spectrograms and inspecting the agreement of each line with the adopted velocity. Lines which show significant departures from the standard