

30. RADIAL VELOCITIES (VITESSES RADIALES)

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General

The Commission suffered severe losses by death during the last three years. In 1976 October, a few weeks after he had been re-elected to the Organizing Committee, J.F. Heard died as a result of a heart attack. He had already served several terms on our Organizing Committee and was President of the Sub-Commission on Radial-Velocity Standards from 1955 until 1961, when all sub-commissions were eliminated in a reorganization of commission structures. In 1978, another distinguished member of our Commission, A.D. Thackeray, was killed in an accident caused by a freak whirlwind. He had been Commission President from 1952-58, and was actively corresponding with me about our affairs shortly before his death. We also note with regret the death of R.K. Young in 1977 December. He was a member of the Commission from 1935 to 1952.

Two Working Groups were set up by the Commission during the Grenoble Assembly. The first, under the chairmanship of M. Barbier-Brossat, dealt with the problem of defining a mean radial velocity from heterogeneous sources of material. All members of the Commission have had a chance to contribute to the deliberations of this Group, and its report and recommendations will be a major item of discussion at Montreal. The Organizing Committee has formed the other Working Group which has been concerned with various problems of standard-velocity stars. No firm recommendations have yet been agreed upon, except that standards should be observed more thoroughly. Many observers, however, clearly feel that present lists of standards are inadequate. Hube emphasizes that the velocities of some stars adopted as standards may be variable or different from the accepted value. Andersen remarks that there are not enough standards in the southern sky, and he points out that if early-type standards are to be adopted they should include stars of widely differing rotational velocities. Beardsley has drawn attention to the possible existence of rapid velocity-variations in B-type stars that should not be overlooked if standards of that spectral type are chosen. Some of these problems have been discussed in more detail in a recent article (*Vistas Astron.* 22, p. 265.) and further discussion of them will be an important part of our meetings in Montreal.

The remainder of this report consists of edited versions of the various reports sent to me by observatories active in the field of radial velocities. I am grateful to Ch. Fehrenbach, A. Baranne, M. Duflot, M. Imbert, E. Maurice, M. Mayor, J. Andersen, G.A. Harding, I.D. Kharachentsev, and L. Prévot, who have each provided sections or sub-sections of the report, as well as to other members of the Commission whose short reports I have summarized in the concluding section. Much of the work done by members of this Commission has applications to other topics and interested readers will sometimes find more detailed discussion of radial-velocity work in the reports of other commissions, especially 26, 27, 28, 29, 33, 34, 37 and 42.

Observatoire de Haute Provence

L'activité de l'Observatoire de Haute Provence pour la mesure des Vitesses

Radiales a continué dans trois domaines:

1. Mesure de V.R. avec le spectrographe à fente.
 - a) d'étoiles standard IAU - résultats communiqués avant publication à Batten (publication en cours).
 - b) d'étoiles de tous types pour des magnitudes 9-10 pour étalonnage des champs de P.O. (publication en préparation).
2. Le groupe de Genève-Marseille a installé au télescope de 1 m helvétique de l'Observatoire de Haute Provence un spectrographe a corrélation. Ce groupe fait son propre rapport.
3. Les prismes objectifs de 40 cm de diamètre de l'Observatoire de Haute Provence et de l'E.S.O. continuent à fonctionner normalement. Les résultats sur le Grand Nuage de Magellan sont publiés dans le rapport de l'Observatoire de Marseille.

Mme G. Amieux et R. Burnage ont étudié l'amas galactique NGC 3114. Sur une centaine d'étoiles, 80 étoiles font partie de cet amas.

G.P.O. DE 62 CM DE DIAMETRE

Un prisme objectif de 62 cm de diamètre, monté devant le télescope de Schmidt Liège-CNRS à l'Observatoire de Haute Provence est utilisé à mi-temps pour la mesure des Vitesses Radiales.

Cet instrument donne une dispersion de 200 \AA mm^{-1} vers 4220 \AA , le domaine spectral va de $3900\text{-}5900 \text{ \AA}$, les spectres sont d'excellente qualité. Avec les plaques IIAJ hypersensibilisées, la magnitude limite est de 12, avec une hauteur de spectre de 250μ en 1 heure de pose (Fehrenbach-Burnage-Compt. Rendus Ac. Sci. Paris, B 281 p. 481).

Un effort a été fait pour la mesure des clichés par corrélation. Cette méthode est absolument impersonnelle; le pointage, l'enregistrement, la mesure et le calcul nécessitent 2 minutes.

Nous avons comparé nos résultats à ceux obtenus par le spectrographe à fente classique ou à corrélation. Pour tous les types spectraux aucune différence systématique n'apparaît dans cette comparaison. (Compte Rendu Acad. Sci. Paris B 286 p. 289).

L'erreur standard sur l'ensemble des mesures de plusieurs clichés est de $\pm 8,5 \text{ km s}^{-1}$.

PROGRAMMES ACTUELLEMENT EN COURS OU ARCHIVES (P.O. 62)

Etude systématique de champs situés à $+30^\circ$ et -30° de latitude galactique pour l'étude des répartitions des V.R. et recherches d'étoiles du halo, analogues à celles détectées dans la direction du Grand Nuage de Magellan.

champ de 2 x 4 degrés	Centre 1950	Etat
champ Ia	$\alpha = 1^{\text{h}}00^{\text{m}}04^{\text{s}}.3$	$\delta = 31^\circ 32' 11''.0$
II	$\alpha = 2^{\text{h}}09^{\text{m}}27^{\text{s}}.9$	$\delta = 30^\circ 04' 13''$
IIa	$\alpha = 3^{\text{h}}17^{\text{m}}25^{\text{s}}.1$	$\delta = 23^\circ 30' 37''$
III	$\alpha + 4^{\text{h}}11^{\text{m}}52^{\text{s}}.1$	$\delta = 9^\circ 53' 12''$

Chaque champ comprend environ 250 étoiles de magnitude 9 à 12.

Observatoire de Marseille

PRISME-OBJECTIF

L'équipe du prisme-objectif a terminé la mesure des clichés pris en direction du Grand Nuage de Magellan (GNM). Complétant le catalogue publié en 1974, un deuxième catalogue sera prêt à la publication dans le premier semestre de 1979. Il comprendra environ 1500 nouveaux résultats de vitesses radiales répartis approximativement

en 300 vitesses radiales d'étoiles du GNM
et 1200 vitesses radiales d'étoiles de la Galaxie

Une étude de la qualité de ces vitesses radiales, très variable avec l'étoile mesurée, est préparée par Ch. Fehrenbach et M. Duflot.

CORAVEL

Le projet CORAVEL a été mené à terme par le Laboratoire d'optique de l'Observatoire de Marseille (équipe Baranne et al.). Il s'agit d'un spectromètre photoélectrique destiné à la mesure des vitesses radiales. Le spectre stellaire obtenu (appareil dispersif: réseau échelle + prisme à champ normal) est déplacé devant la grille correspondante par l'oscillation d'une lame à faces parallèles.

Les parties électronique et informatique ont été réalisées à l'Observatoire de Genève, les parties optique et mécanique à Marseille.

Un premier appareillage CORAVEL fonctionne depuis un an sur un télescope genevois de 1 m à l'Observatoire de Haute Provence. Un deuxième appareillage sera installé sur le télescope danois de 1,5 m à l'ESO-Chili.

Les résultats obtenus depuis un an à l'OHP montrent que depuis que le "CORAVEL" est en fonction, les conditions et les résultats d'observation sont complètement changés en ce qui concerne les vitesses radiales d'étoiles froides (F5 → M).

L'ordre de grandeur des deux paramètres, quantité et qualité, est différent:

La 11e magnitude s'atteint en 3 minutes avec souvent moins de 0,5 km s⁻¹ d'erreur. (A. Baranne).

Détermination d'éléments orbitaux d'étoiles doubles spectroscopiques et à éclipses dans les hémisphères nord et sud.

Les vitesses radiales sont obtenues à partir de spectres à 20 Å mm⁻¹ à l'Observatoire de Haute Provence et de l'ESO et récemment avec le spectromètre à corrélation CORAVEL.

Les premiers résultats obtenus avec CORAVEL montrent une amélioration considérable de la rapidité d'accès à la vitesse radiale et de la précision sur les éléments orbitaux. Pour quelques étoiles observées avec CORAVEL et dont la couverture de l'orbite est presque complète on peut déterminer la vitesse radiale du centre de gravité à 0,1 km s⁻¹ et les masses ou fonctions de masses avec une erreur relative de 0,02, l'écart type des résidus étant inférieur à 0,5 km/s et ceci quelle que soit la magnitude de l'étoile.

Actuellement plusieurs dizaines d'étoiles doubles spectroscopiques et à éclipses sont à notre programme d'observation au CORAVEL. Plusieurs d'entre elles ont été découvertes avec un spectre double. (M. Imbert).

Les vitesses radiales d'une dizaine de supergéantes M de la région de h et

X Persée ont été mesurées avec le spectromètre photoélectrique CORAVEL.

La comparaison de nos mesures avec celles obtenues par G.F. Gahm et J.G. Arkling (Astron. Astrophys. 10, p. 414) avec une dispersion de 16 \AA mm^{-1} montre une différence systématique de $0,1 \text{ km s}^{-1}$. La grande précision des mesures obtenues avec le spectromètre CORAVEL nous a incités à entreprendre une étude systématique et détaillée de toutes les supergéantes rouges de la région de h et X Persée. (L. Prévot et E. Rebeiro).

SLIT-SPECTROGRAPH VELOCITIES

Maurice in collaboration with Ardeberg (Lund Observatory, Sweden) has published (Ardeberg and Maurice, Astron. Astrophys. 54, p. 223, Astron. Astrophys. Supp. 28, p. 153 and 30, p. 261) stellar and interstellar radial velocities in the Small Magellanic Cloud and in the galactic cluster IC 2944 in the direction of the inner side of the Carina Spiral feature. All these velocities are measured on intermediate dispersion spectrograms at 74 \AA mm^{-1} . In the SMC, radial velocities are given for 51 supergiants; the Cloud and Galactic interstellar Ca II K line velocity is given for 6 and 3 stars respectively. Velocities of forbidden lines of ionized oxygen have been measured in the spectra of 3 stars. In IC 2944, 58 stellar velocities are given together with 28 velocities for interstellar calcium and 17 forbidden lines of ionized oxygen. In these papers measurements of radial-velocity standard and reference stars are given and discussed; the accuracy and zero-point of radial velocities obtained with Cassegrain spectrographs are discussed. (E. Maurice).

MINOR PLANETS

A program of spectrographic observation of minor planets as radial-velocity standards has been undertaken by M. Duflot and E. Maurice. Ceres and Vesta were observed, at intermediate dispersion, during five nights from La Silla (June 1978) and the plates are being measured. M. Imbert has measured radial velocities of Ceres, Eunomia and Vesta with the (French-Swiss) correlation spectrometer "CORAVEL" installed in Haute Provence (OHP) with an accuracy (standard error) of 0.5 km s^{-1} ; these test observations were made respectively in August 1977, January 1978 (1 measurement for each) and June 1978 (2 measurements).

AUTRES OBSERVATIONS

D'autre part l'Observatoire de Marseille est engagé dans l'étude de nombreuses galaxies extérieures et régions H II galactiques. Ces études s'appuient sur des mesures de vitesse radiale, obtenues par des techniques très différentes (spectrographe nébulaire, interférométrie sur le gaz ionisé).

Observatoire de Genève

Depuis le printemps 1977 un spectrophotomètre CORAVEL pour la détermination des vitesses radiales par corrélation est en activité sur le télescope de 1 m de l'Observatoire de Haute-Provence. Le principe optique de ce spectrophotomètre a réseau échelle a été brièvement décrit (A. Baranne, M. Mayor, J.L. Poncet, 1977). Une description de l'ensemble de l'appareil va être publiée ainsi que l'analyse des mesures de divers échantillons de comparaison, en particulier les étoiles standard IAU (A. Baranne, M. Mayor, J.L. Poncet, 1978). Durant la première année de mesure, environ 6000 mesures ont été effectuées.

Un programme important de mesures d'étoiles d'amas ouverts a été commencé. (Voir le rapport de la Commission 37.)

Des programmes d'observations ont été entrepris dans le champ des étoiles binaires visuelles, des étoiles ($m_B < 13$) des zones de McCormick et de la micro-variabilité des supergéantes froides.

Dominion Astrophysical Observatory

Selection and testing of suitable wavelengths for radial-velocity measurements at various dispersions has continued. Two sets of wavelengths for spectral classes AO-F2 and B0-B9 at dispersion 15 \AA mm^{-1} have been published (Batten Pub. Dom. Astrophys. Obs. 14, p. 367), together with radial velocities for 12FK4 stars of these spectral types. The IAU standard-velocity stars are being observed with dispersions of 6.5, 10, and 15 \AA mm^{-1} in order to check their constancy and their suitability as standards. As a further check, both on the standards and the adopted wavelength system, a programme of observations of the brighter minor planets has been begun. Preliminary results are encouraging, although there is some evidence that small systematic differences between our spectrographs can develop if care is not taken to keep everything in correct adjustment.

Crampton has continued his studies of the radial velocities of O-type and B-type stars in H II regions. He and Georgelin have compared stellar velocities with those of the gas in the corresponding regions (derived from H α Fabry-Perot measures) they have shown that velocities of early-type stars are being obtained on nearly the same system as those of other objects. They found $V_{\text{gas}} - V_{\text{star}}$ to be $-1.9 \pm 1.5 \text{ km s}^{-1}$ for the B-type stars and $-0.2 \pm 2.1 \text{ km s}^{-1}$ for the O-type stars (see Astron. Astrophys. 40, p. 317).

Preliminary measures by Crampton and Morrison of spectrograms at 30 \AA mm^{-1} obtained with an ITT 4089 image tube indicate that there is no significant systematic difference between these results and those obtained from ordinary spectrograms made with the same spectrograph, but that random errors with the image tube are about twice as large as for the photographic spectra.

Hill, in collaboration with Aikman, Barnes (Kitt Peak) and Hilditch (St. Andrews) is continuing his studies of the dynamics of A-type and F-type stars in the galactic pole regions in order to determine the local mass density. So far at least three spectrograms (80 \AA mm^{-1}) each of some 550 stars brighter than 10^m within 15° of the NGP and some 350 stars brighter than 9^m within 15° of the SGP have been obtained. Photometric results (ubvy, β) are available for all of the stars.

Morbey has developed a method of digitally averaging the line profiles in a stellar spectrogram and in the accompanying comparison spectrum simultaneously. Averaging the results for a selected list of wavelengths gives a measure of the radial velocity of the star. The method is analogous to that employed directly at the telescope in a radial-velocity scanner. The technique is particularly useful in sorting out multiple spectra where low contrast or close blending of different sets of lines makes it difficult to measure the components of individual lines. It was developed for the triple system HD 165590 (Morbey et al. Pub. Astr. Soc. Pacific 89, p. 851), and has since been successfully applied to the detection of marginally visible secondary spectra. Comparisons of the technique with more conventional methods are being made, and the results indicate that at a dispersion of 6.5 \AA mm^{-1} the plate-to-plate scatter is less than 0.5 km s^{-1} .

Copenhagen University Observatory

The observations for the programme by J. Andersen, B. Nordström, and P. Grosbol, comprising some 740 bright southern B - F4 stars, have been completed. About 2800 plates (ESO 1.5 m coudé, 20 \AA mm^{-1}) have been taken, including some 350 plates of standard stars, and the measurements have been started. The programme will complete the radial velocities for the entire FK4 catalogue and the Bright Star Catalogue to spectral type F4, and is designed to

enable a full discussion of available uvby β photometry and proper motions of these stars.

A programme by E.H. Olsen and B. Strömgren to define the group of intermediate Population II F stars on purely photometric grounds has resulted in a candidate list of some 400 stars. J. Andersen and B. Nordström, in collaboration with B. Mayor, Geneva, have started an observing programme to determine radial velocities of these stars, combining one coudé plate and several photoelectric measures in order to check for spectral peculiarities at the same time. Observations are starting October 1978.

Royal Greenwich Observatory, Herstmonceux

1. Pike, Stickland and Lloyd have investigated techniques for obtaining radial velocities using the PDS microdensitometer. Two methods have been evolved:

- a) scanning individual lines and fitting profiles to determine the centroids.
- b) cross-correlating segments of spectrum to find velocity changes.

The results for α Equ and HR 6684 are contained in Mon. Not. Roy. Astron. Soc. 184, p. 265 and Acta Astronomica (in press).

2. Stickland has used the Isaac Newton telescope to obtain about 40 spectra of Hg-Mn stars at 8.5 \AA mm^{-1} . The programme is continuing and being extended to the Southern Hemisphere.

3. Walker has observed the Ap Si star HR 3413 photometrically and for radial velocity in order to monitor variations. Radial velocity changes appear to be small except for the λ 3954, 4200 and 4261 lines of silicon which show a total amplitude of $\sim 10 \text{ km s}^{-1}$.

Observatories in the U.S.S.R.

Radial velocities have been measured for 340 Markarian and Arakelian galaxies. The observations were made in the Crimea (125 cm aperture, 220 \AA mm^{-1}) and at Alma-Ata (70 cm aperture, 90 \AA mm^{-1}). Results have been published in several papers in volumes 11 and 12 of Astrofizika by Arakelian, Denisjuk, Doroshenko, Kopylov and others, and also by Denisjuk et al. (Pysma v Astr. Zh. 3 p. 7) and Arakelian et al. (Astr. Circ. No. 914, p. 7).

Radial velocities for 190 galaxies in groups and interacting systems have been obtained at the Crimean Astrophysical Observatory (260 cm aperture, 360 \AA mm^{-1} and as given above), Alma-Ata (as above), Tautenberg (200 cm, 180 \AA mm^{-1}) and ESO (100 cm, 280 \AA mm^{-1}). The results have been published by several authors in a variety of journals (Astronomicheskii Zhurnal, Astronomy and Astrophysics, Astronomical Circular, Astronomische Nachrichten, and Astrofizika) during the past three years.

At Zelenchuk (Special Astrophysical Observatory of the U.S.S.R. Academy of Sciences), Karachentsev has measured 500 radial velocities of double galaxies in his Catalogue of Isolated Pairs. The work was done with 6m telescope at a dispersion of 90 \AA mm^{-1} and the results are in press. A Catalogue of Galaxy Red-shifts, containing over 5,000 entries, has been compiled on magnetic tape.

Miscellaneous Short Reports

Sahade reports from the Institute de Astronomia y Fisica del Espacio (Buenos Aires) that V.S. Niemela is continuing her studies of Of stars and Wolf-Rayet stars. She finds velocity gradients both in the regions of the atmospheres where the absorption lines are formed and in those where the emission lines are formed.

She has studied three objects of these classes in the Carina association (HD 93129A, HD 93131, and HD 93162) and can find no periodicity in their velocity variations. R.H. Mendez has studied the central star of VV 1-7 and found no clear evidence of radial-velocity variations, although his value for the mean velocity from 12 plates disagrees with a single earlier observation.

W. Buscombe reports from the Lindheimer Astronomical Research Center (Northwestern University) on a study of high-velocity stars in the southern hemisphere by H.J. Augensen. Careful comparison of measurements on direct photographic and image-tube spectrograms shows the latter to give reliable results consistent with those obtained from the former. Some stars have been found to possess interesting kinematical properties. E.M. Hendry, also at Lindheimer, continues her radial-velocity work on spectroscopic binaries.

Griffin reports that his programmes discussed in earlier Commission reports are continuing, with observations being made both from Cambridge and Palomar.

Hube (Calgary) continues work on standard-velocity stars, Ap stars, and binaries, mainly at the Dominion Astrophysical Observatory in Victoria. Gleesking (Bonn) has developed a new method of determining radial velocities with the objective prism and is applying it to spectroscopic binaries. Oetken reports only limited activity in the field of radial velocities at Potsdam. The chief results are new orbital elements for some spectroscopic binaries containing magnetic stars.

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