A SEARCH FOR HIGH VELOCITY STARS

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1. INTRODUCTION

Fehrenbach's objective-prism technique for the measurement of radial velocities is well known and has already proved its efficiency. New measuring devices (MESUCOR, FENTOMIX at the O.H.P.) based on the correlation between records make the measurement more rapid and more accurate and will encourage others to use this method. An example is the Hipparcos radial-velocities program. But it is also true that this new process has its limits and does not permit one to get all the information which is on an objective-prism plate, for it is limited by the quality (principally the density) of the images. It will be necessary to continue with the classical visual measurements, especially if one wants to detect faint high-velocity stars quickly, which are often at the density limit of the photographic plate. We must keep in mind that the objective-prism technique is best for this purpose since a three or four hour exposure leads to a great number of spectra (about 60 near the pole, to 200 in the galactic plane in a field of 2X2 degrees).

1. QUALITY OF THE VELOCITIES

We have two ways to ensure the accuracy of the velocities: first, increase the number of the measurements on each plate, and second, increase the number of plates. We also use overlapping plates. Let n_i be the number of measurements on the plate i and p be the number of plates of the same field. The total number of measurements for one star is therefore:

$$N = \sum_1^p n_i$$

and the final velocity is:

$$v = (\sum_1^p n_i v_i)/N$$

where v_i is the velocity indicated by the plate i. The variance of v_i is:

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$$s^2 = \varepsilon^2/n_i + \mu^2.$$

ε depending on the measurer and μ being characteristic of the plate. The variance of the velocity is therefore given by:

$$\sigma^2 = (1/N^2)\sum_1^p (n_i \varepsilon^2 + n_i^2 \mu^2).$$

The value of ε depends on the quality of the seeing and the ability of the measurer; it varies for our plates taken with the 40cm astrograph with a dispersion of 100 Å/mm between 10 and 18 km/s. The value of μ lies around 11 km/s. For example, for three plates and five measurements on each, assuming ε = 14 km/s and μ = 11 km/s, we find σ = 7.3 km/s. For a single plate, one has to multiply the measurements but σ cannot fall below the limit μ. One of the handicaps of the objective-prism method is that one needs to know velocities on each plate in order to fix the level of all other velocities. Often such standards are missing in the field of 2°x2°. In that case it is possible to adjust the level by using a calculated mean value of the velocities in the galactic vicinity. But mostly the region one studies is larger than 2°x2° and contains several stars with known velocities. Then one has to use overlapping plates, taking into account a possible small slope of the velocities throughout the whole field, to build up a unit of plates with a single level constant. If we follow the above rules, we can get good velocities from objective-prism plates as compared with results of slit-prism spectrographs. But the best method is to compare objective-prism velocities with the others directly. Such a comparison between different catalogues can be made if we use three or more catalogues including the same objects. For this purpose we first used Abt's catalogue which provides objective-prism velocities. We compared the objective-prism velocities of P.O.H.P. with those given in the Ap.J. and D.A.O. publications, but we could only find forty common stars. A comparison was made by using the formula:

$$n^{-1}\sum (v_i - v_j)^2 - n^{-2}\left[\sum(v_i - v_j)\right]^2 = \sigma_i^2 + \sigma_j^2$$

which is correct when the random errors on v_i and v_j are independent and if n is large enough. We do not want to go into details of the following results. They only give the approximate size of the errors. We obtained:

Objective-prism (P.O.H.P.) σ = 8 km.s^{-1}
slit spectrograph (Ap.J.) σ = 2 km.s^{-1}
(D.A.O.) σ = 5 km.s^{-1}

More recently, Azzopardi published a list of Small Magellanic Cloud members indicating the velocities which were obtained by slit spectrograph, excluding the velocities obtained by Florsch 1972 with the objective-prism. We made the same comparison by using this catalogue and obtained the following results:

Slit spectrograph				Objective-prism
Author	ARM	DUB	FTW	FL quality ABC stars
σ km.s^{-1}	10	6	9	15

ARM : Ardeberg and Maurice
DUB : Dubois
FTW : Feast - Thackeray - Wesselink
Fl : Florsch

The quality A,B,C indicated by Florsch (1978) corresponds respectively to σ = 7 km/s, 10 km/s, 15 km/s. These values are approximate, for the number of common stars are low (10-15). But the value σ = 15 km/s is not surprising in the case of SMC, for the high velocity stars are faint and the background of the plates very high, so that the measurements are very difficult. We can also mention the values found by Thackeray (1978). He gives the difference between Florsch and Radcliffe:

$$\Delta V\ (F-R) = -1{,}6 \pm 4{,}7 \text{ (nine quality A,B stars)}$$
$$= -5{,}6 \pm 4{,}7 \text{ (13 quality A B C stars)}$$
$$= -18{,}4 \pm 17{,}1 \text{ (six quality D E stars).}$$

D E stars correspond to the lowest quality with $\sigma \gtrsim$ 22 km/s. These are the stars for which we could only distinguish if the velocity is high or low. In the same paper, Thackeray shows that for slit-spectrographs (Ardeberg and Maurice; (AM); Dubois : (D). :

$$\Delta V\ (R - AM) = -6 \pm 2{,}4 \text{ (26 stars)}$$
$$\Delta V\ (AM - D) = +16 \pm 3{,}3 \text{ (17 stars)}$$
$$\Delta V\ (D - R) = -6 \pm 3{,}8 \text{ (16stars)}$$

Except in the case of very faint stars, we can conclude that the results above show that the velocities obtained by objective-prisms can be compared with those obtained by slit-spectrographs with comparable dispersion. There is no reason to exclude these stars from the radial-velocity catalogues as is sometimes done.

2. THE SMALL MAGELLANIC CLOUD PROGRAM

The S.M.C.survey represents a good sample of what can be obtained by the objective-prism. This technique permitted us to cover a large area in a relatively short time, and if the quality of the velocities does not reach the level of other methods, the advantage lies in the statistical aspect. In Florsch (1972) we published nine hundred velocities of stars in a field of about 18 square degrees covering the cloud. The calculation of the velocities was made by using overlapping plates and with ten standard stars taken from the list of Radcliffe. We had to solve a system of equations of the type $M = A + Bx + K(1 + sx)\ V_r$ where M is the result of the measurement of one spectrum, A and B are constants depending on the plate, the measurer and the comparison spectra, x is the mean abscissa of the spectral lines, K and s are constants. The whole system included 4700 equations for 460 BAF stars and 2500 for 378 FGK stars, The magnitudes fall between 9 and 12.5. Few are outside this interval. Ninety of these stars show high velocities and belong to the cloud. We showed at that time that the velocities of these supergiants were divided into two groups. This was about seven years before this fact was again pointed out by other authors who possessed accurate but less numerous spectrographic velocities. As we had covered a larger area, we could calculate the slope of the velocities along the major axis of the cloud and bring out its accord with the velocities of H1 peaks of Hindmann. At the same time, we could obtain the magnitudes from the spectra with an accuracy of ± 0,17; the knowledge of one hundred supergiant cloud members permitted us to detect the great depth of the cloud (Florsch 1972). The plates concerning the outer regions of the cloud are unexplored and we started their measurement last summer. The results will be enhanced by the use of the FENTOMIX machine which we are building at Strasbourg Observatory along the lines of the one at Haute Provence Observatory and with its help.

3. HIGH VELOCITY STARS OF THE GALACTIC HALO

This second program has been underway for several years. It concerned first the galactic pole in an area of 10°x10° but is now extended to the circle l = 90°, in the northern and the southern hemispheres where we use the 40 cm astrograph of ESO. This is made possible by the participation of new observers. In the last year, about 30 good plates were taken in the south. Up to now, only 10 plates have been measured on which we found 36 probable high velocity stars. But as they were detected on single plates they have to be confirmed before their publication. This work will proceed more rapidly in the future. We undertook this work after analysing the content of Abt's catalogue which shows clearly that it is of interest to reach fainter stars, the relative number of high velocity stars increasing with the magnitude. We can hope for good results if we bring the limiting magnitude up to 12.5. We must remember that a gain of one magnitude multiplies the explored volume of the sky by four, and the number of high velocity stars by about the same number. Our program is restricted to the discovery of new high velocity stars, and they will have to be studied later with slit spectra or with CORAVEL.

A. Florsch, J. Marcout, A. Valbousquet and J. Florsch are taking part in this program.

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