First Observations with CORAVEL at La Silla

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CORAVEL is a spectrometer specialized for the determination of stellar radial velocities with very high time resolution and high accuracy. The first instrument has been operational since 1977 on the 1 m Swiss telescope at the Haute-Provence Observatory where nearly 20,000 radial velocity measurements have been made by astronomers from the Geneva and Marseille Observatories. Although a preliminary report on the prototype has been given by M. Mayor (THE MESSENGER No. 8, March 1977) it seems interesting to give further information about the instrument's performance: they are exceptional both for accuracy (0.5 km s^{-1} or better) as well as for high-speed acquisition (measurements in less than 5 min.) and for sensitivity (limiting magnitude $B > 13$). The efficiency of this technique was so impressive that observing programmes in the southern hemisphere far beyond the limit of classical radial velocity spectrographs could be considered. Therefore a second CORAVEL has been installed at the Cassegrain focus of the 1.54 m Danish telescope at La Silla, and observations took place in January-February 1981. The results obtained during this period are quite remarkable.

The Instrument

The spectrometer, already described by A. Baranne, M. Mayor and J. L. Poncet (*Vistas in Astronomy*, vol. 23, p. 279, 1979), contains an echelle grating (79 grooves mm^{-1}) used between orders 43 and 62; it gives a dispersion of 2 Å mm^{-1} and a useful spectral range from 3700 Å to 5200 Å. The spectrum of the star or of the comparison lamp is focused onto a mask containing about 3000 apertures. A scanning plate moves the spectrum with respect to the mask. This produces a variation of the flux which is at a minimum when the absorption lines of the star to be measured are in coincidence with the apertures of the mask. The scanning rate is fixed at 5 Hz in order to minimize the effects of atmospheric scintillation. The flux, corresponding to the correlation function between the relative positions of the spectrum and the mask, is measured by means of a photomultiplier. The correlation function is calculated on-line by incrementation in the memory of an HP 21-MX computer. Integrating a number of scans allows determination of the peak of the correlation function which is permanently displayed on a screen; this allows the radial velocity determination with a typical accuracy of 0.5 km s^{-1}. The velocity zero-point is determined twice for each exposure, using the spectrum given by an iron hollow-cathode lamp. The heliocentric velocity is computed immediately after the exposure, and all the data are stored on magnetic tape.

The present mask has been made photographically from the spectrum of Arcturus. It allows a range of spectral compatibility from early F to late M types.

Programmes and First Observations

Undertaking new programmes of major interest implied that CORAVEL should be mounted on a rather large telescope (1.5 m or more) allowing fast automatic pointing. The 1.54 m Danish telescope at La Silla was in fact the only instrument well adapted to receive CORAVEL (Fig. 1). Moreover, the bulk of the programmes considered and some technical imperatives required rather long observing periods which could be obtained owing to the use of reserved Danish periods jointly to those allotted by ESO. This has naturally led to a collaboration between several astronomers from several institutes or observatories including, among others, J. Andersen and B. Nordström (Copenhagen), A. Ardeberg and E. Maurice (ESO), M. Mayor (Geneva), M. Imbert and L. Prévot (Marseille). Within the framework of this collaboration, several prime-interest programmes have been defined and should be carried out in a short time. They can be summarized as follows.

(1) Programmes allowing fast data acquisition and requiring a large number of measurements.

– Stars in the Yale Catalogue of Bright Stars: it is necessary to complete the fundamental data of this catalogue, as 850 late-type stars do not yet have radial velocities.

– Population II F-G stars already observed photometrically: more than 200 bright stars need radial velocity measurements to allow the determination of their dynamical trend.

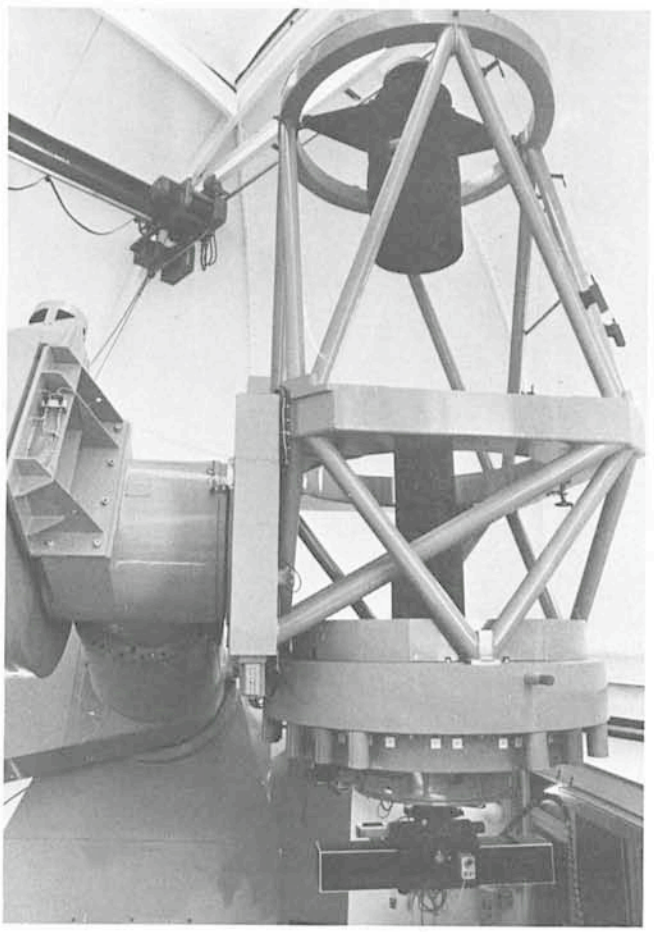

Fig. 1: *CORAVEL mounted at the Cassegrain focus of the 1.54 m Danish telescope at La Silla.*

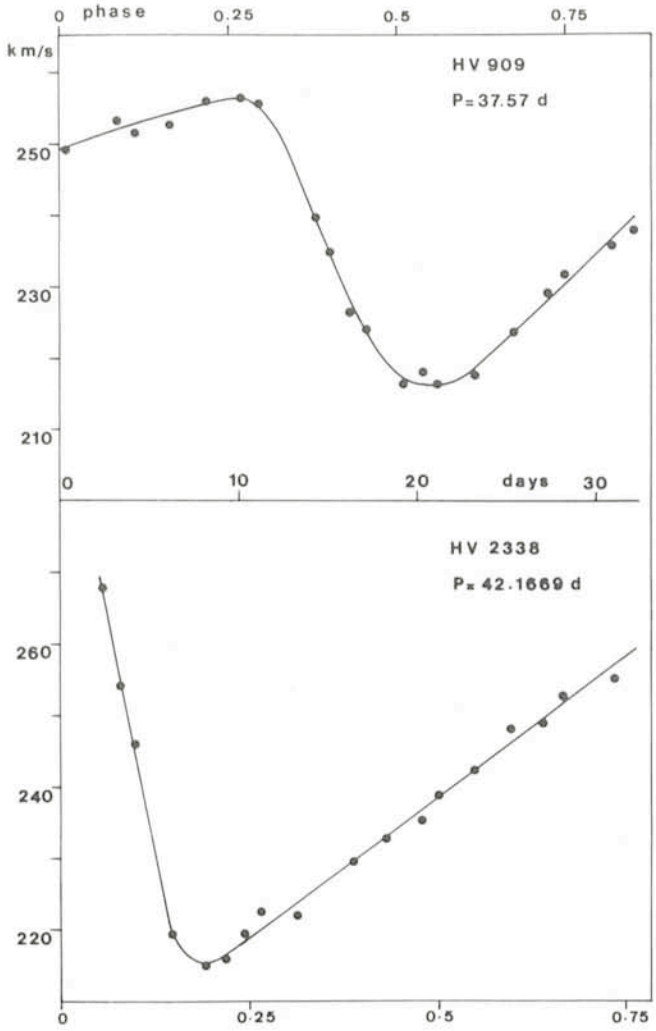

Fig. 2: *Radial velocity curves of two cepheids in the Large Magellanic Cloud. The observations cover nearly one cycle; they show the high quality of measurements made on very faint objects (B = 14.1 to 15.1 for HV 909 and B = 13.8 to 14.4 for HV 2338).*

(2) Programmes beyond the limit of classical spectrographic methods:

– Individual radial velocities of 350 stars in the globular clusters ω Cen and 47 Tuc, for which a few poor quality velocities exist. The main aim concerns the kinematic study of globular clusters and the fit of their velocity fields to theoretical models.

– Pulsations of extragalactic cepheids: this programme concerns 15 LMC and 5 SMC long period cepheids for studying their pulsation modes and determining their radii.

– Radial velocities in the Magellanic Clouds: 400 LMC and 150 SMC red supergiants must be observed in order to go further into the knowledge of the Population I velocity fields in these galaxies.

A first period of observations (January-February 1981) allowed us to obtain 1,500 radial velocities for stars up to B = 15.3, with an accuracy of around 1 km s^{-1} for the faintest objects. We were able to undertake all programmes and none of them has proved unfeasible. Most of the bright stars have been measured once; this represents several hundreds of new radial velocities. High velocities have been found for some, among the Population II F-G stars. One hundred and fifty radial velocities have been determined for luminous cepheids in the LMC. The observations cover nearly one cycle for the objects

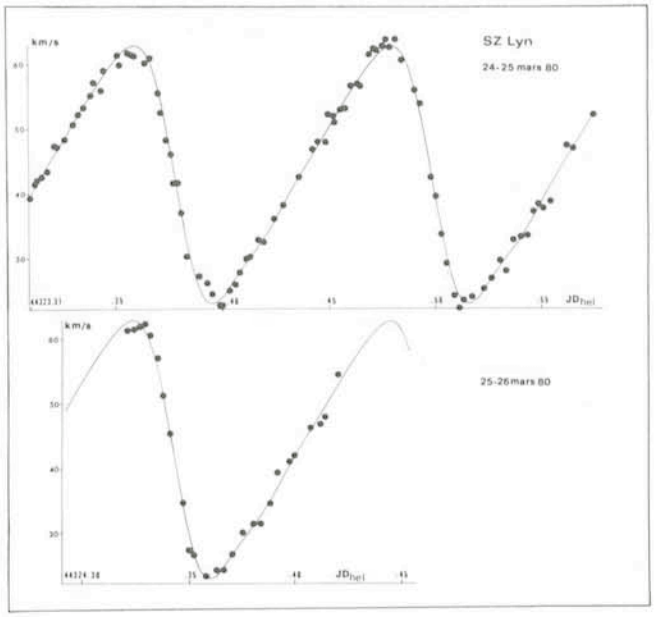

Fig. 3: *Another aspect of the performances of CORAVEL, the high time resolution, is illustrated by this figure which reproduces the radial velocity variations of the dwarf cepheid SZ Lyn (Period 2^h49^m, V = 9.2 to 9.6) observed at the Haute-Provence Observatory with integration times around 1 min.*

of shorter period (P = 30 to 40 days). The results show clearly that there exist variations in the amplitudes and in the shapes of the velocity curves for stars of similar periods (Fig. 2). One hundred and fifty red giants were measured in ω Cen, some in the centre of the cluster. A rough analysis of the velocities shows a relative complexity of the stellar motions. Around 120 LMC red supergiants were also measured; among them 100 stars were confirmed as members on the basis of radial velocities. Despite their unfavourable position at the time of the observations, some stars in the globular cluster 47 Tuc and in the SMC could be measured in order to prove that these objects are accessible with CORAVEL.

In short, the first observing period (30 nights) has allowed us to obtain an exceptional number of highly accurate radial velocities. Such large and difficult programmes were totally outside the range of the performance of classical instruments. In the near future, two additional periods, already allotted by ESO, will be used to collect additional data for the programmes undertaken, particularly the pulsation of cepheids in the Magellanic Clouds and the kinematics of 47 Tuc.

Thus, the mounting of CORAVEL on a highly automated instrument like the 1.54 m Danish telescope has been a full success. It is hoped that future runs may be as positive and take place with a similar collaboration.

New Head of the Scientific Division

Professor P. O. Lindblad has resigned as of 31 August from his position as Head of the Scientific Division, following his election to be Director of the Stockholm Observatory.

The Director-General has appointed in his place Professor Giancarlo Setti who will take up his duties on 1 January 1982.