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ULTRARAPID ACTIVITY AT Hα IN THE SPECTRA OF Be STARS

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ABSTRACT

High-resolution spectra of some Be stars, taken with an Isocon television camera, show changes in the Hα line profile in times of the order of a minute or less.

I. INTRODUCTION

Rapid variation of features in the spectra of Be stars has been reported in several instances (e.g., Hutchings 1970; Bahng 1971). The changes take place in the strength of emission of lines formed in the extended envelopes surrounding these objects. Some of these changes occur in times of the order of hours and may be attributed to the rotation of the stars together with inhomogeneities in their envelopes. Changes of the order of minutes have been observed on top of these, at "active" times, and little is known about the rapidity and extent of these phenomena.

In order to investigate this further, observations have been made of a few Be stars, with very high time resolution. The greatest activity was found at Hα, where emission is stronger and comes from a larger region of space than emission from the other Balmer lines. We report here on the detailed observations at Hα of HD 142926 (B9e, $m_v = 5.6$), and κ Dra (B7e, $m_v = 3.8$), which show typical activity and are among the best made to date.

II. OBSERVATIONS

An Image Isocon television camera (English Electric P850) was used as the detector in the coudé spectrograph of the 48-inch telescope of the Dominion Astrophysical Observatory. The system has been described in detail by Walker *et al.* (1971). The camera integrates a spectrum and dark signal for a specified period, up to several minutes. The accumulated signal is read by a 650-line raster, with ~200 μ resolution, digitized, and recorded magnetically. The Hα profiles shown in Figures 1 and 2 occupy 125 of the 700 channels, observed at an original dispersion of 5 Å mm^{-1}. The data in the diagrams are from 74 scans with a time resolution of ~30 s of HD 142926, and 50 scans with a time resolution of ~20 s of κ Dra, on 1971 August 5. The projected slit width in the spectrum was 0.9 Å for HD 142926 and 0.6 Å for κ Dra. The dark current has been removed, and profiles are normalized to the continuum adjacent to Hα and smoothed by taking three-point running means. The lower profile in each figure is the weighted mean of the whole run. In the case of HD 142926 the double-peaked profile has a mean separation of ~2.9 Å and peaks at 1.78 (*R*) and 1.80 (*V*) of the continuum. (Mean profiles from May 11 and June 4 showed separations of 2.8 and 2.6 Å, respectively, and *R* and *V* peak heights of 1.73, 1.70 on May 11 and 1.51, 1.44 on June 4. The weakening in the overall emission strength on June 4 revealed broad absorption wings not seen on the other nights. These are typical of the "slow" changes in these features.)

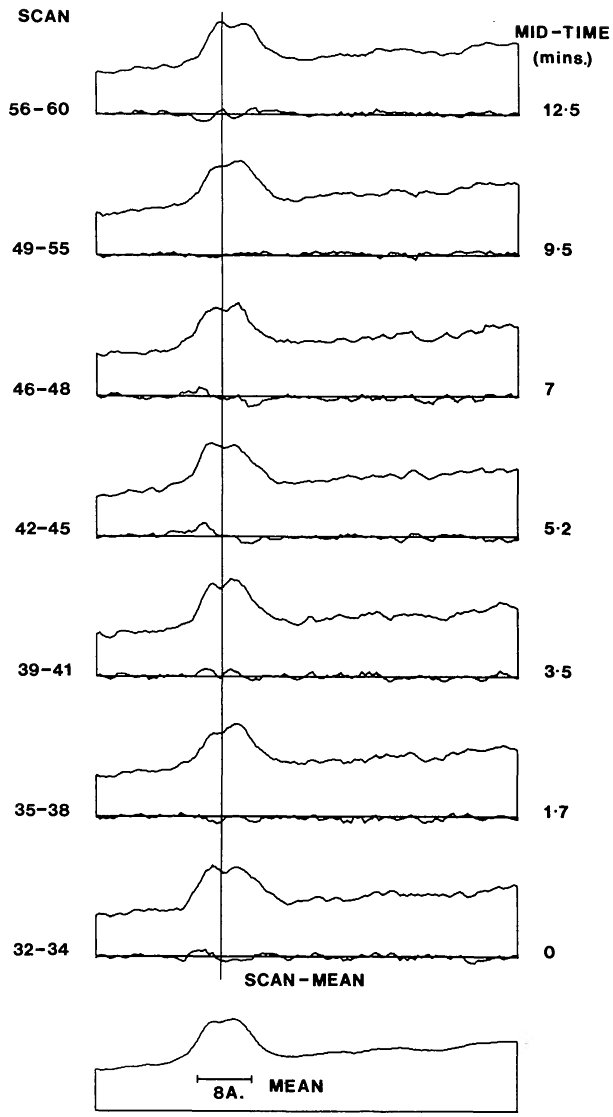

FIG. 1.—HD 142926 Hα profiles. Lower profile mean of 74 scans of ~30 s each. Means of scans as numbered and their differences from the lower profile are shown. Longer wavelengths to the left.

Figure 1 also shows mean profiles of scans as numbered, and their differences from the "grand mean." They are selected as those showing consecutive systematic variations in the spectrum. Figure 2 shows the mean profile of κ Dra and a sequence of differences from this mean, above it.

It can be seen that

(1) There are large systematic differences within the line which are not seen in the continuum.

(2) Systematic effects are present in the differences, within the profile, often in the form of S shapes. These indicate a shift in the whole profile, of up to 2 Å. Check scans on the emission-line comparison spectrum indicated that such shifts are not instrumental. They are also too large to have been caused by guiding errors.

(3) Systematic changes from profile to profile can be seen, and these are illustrated clearly in Figure 2.

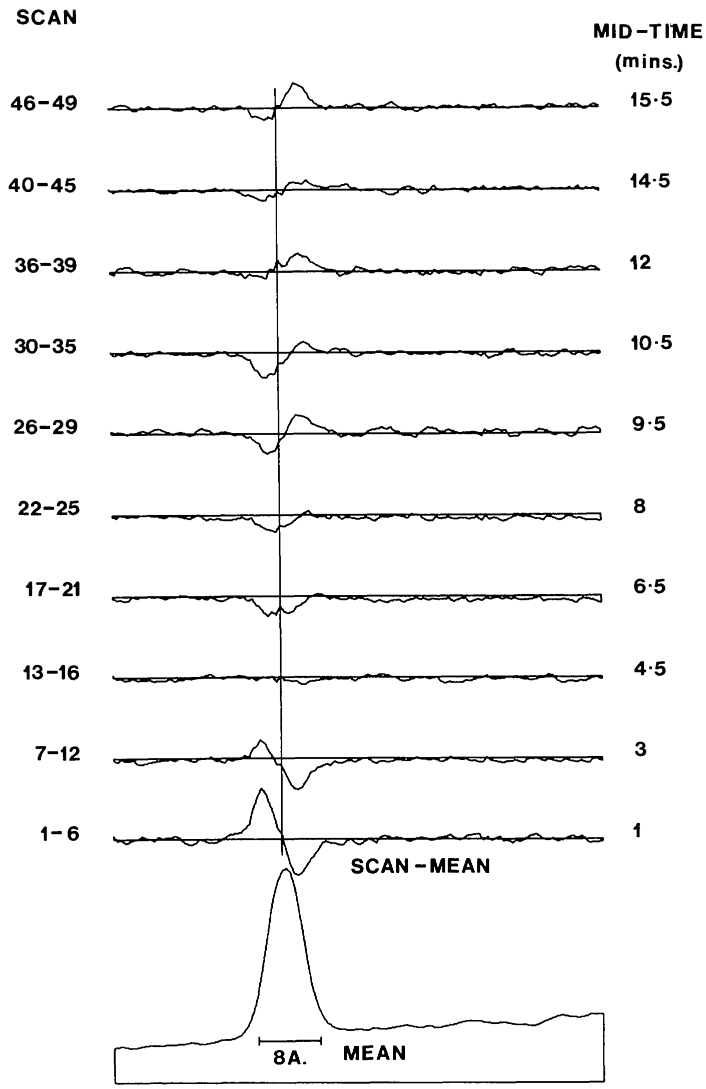

FIG. 2.—Hα profiles of κ Dra. Lower profile mean of 50 scans of ~20 s each. Differences of means of scans as numbered, from the lower profile, are shown. Longer wavelengths to the left.

III. DISCUSSION

The mean double-peaked profile in the spectrum of HD 142926 and the single peak in that of κ Dra can be understood in terms of the models developed by Hutchings (1971) for these stars, and the deduced angles of inclination. The rapid changes in the spectrum of HD 142926 are predominantly in the form of (1) growth of a third component of emission (as, e.g., on the right side in scans 32–34 and 42–45); and (2) a weakening of one of the permanent peaks (as, e.g., in scans 35–38). Changes in emission intensity during these times are typically up to 20 percent of the peak emission intensity above the continuum. During the last ~25 scans very few changes were seen. The activity therefore is not continuous.

In the case of κ Dra, the changes in line structure are not so obvious. However, there are smooth systematic changes in both height and position of the profile maximum (as yet not obviously correlated). The observations were not continued for long enough to see whether the changes were cyclic.

Two possible causes may be suggested for the phenomena: (1) The extended equatorial envelope is though to contain "knots" of higher-density material released at the photosphere (Hutchings 1970; Bohlin 1970). If there are rapid fluctuations of light from points along the equator, associated with this activity, then the flashes of radiation will take a minute or two to traverse the extended envelope. As they do so, they may excite Hα emission in the knots, whose different radial velocities and intensities may cause the rapid profile changes observed. (2) The flashes may be localized events in the knots themselves, excited by local conditions, or radiative events on the stellar surface, and the duration of the flashes will then be determined by the excitation mechanism.

Both of these hypotheses are consistent with the fact that this activity is most easily observed at Hα, since its emission region is larger than that of other Balmer lines. The slower changes, thought to be associated with the rotation of the envelope with steadily emitting knots, are best observed in smaller emission regions in which the size of the knots is larger relative to the whole.

IV. OTHER OBSERVATIONS

Similar observations have been made on several other main-sequence Be stars, and indications are that this rapid activity may be a common feature in their emission spectra. Longer periods of observation are being undertaken, to look for periodicities; and simultaneous scans of several Balmer lines will be made to see whether the changes are correlated. The star HD 142926 has been followed extensively with a four-channel photometer to search for changes in continuum intensity which may be associated with the line changes. A preliminary analysis shows no definite persistent effects, although occasional rapid changes occur.

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