HELIUM EMISSION IN THE SPECTRUM OF KAPPA CANIS MAJORIS

by

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ABSTRACT

Coude spectra of κ CMa in the red region show Hα and He I λλ5876, 6678 in emission. Each of the lines has two emission components, but the helium lines have no detectable absorption feature in between. While the Hα emission peaks are separated by 160 km/sec, the helium lines are separated by 400 km/sec. A simple model is proposed to account for the behavior of these emission lines.

Key words: Be stars --- stellar spectra --- radial velocities.

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High dispersion coude spectra of κ CMa (HD 50013, B1.5 IV ne) were obtained with the 1.5-m reflector of Cerro Tololo Inter-American Observatory. The reciprocal dispersion is 18 A/mm in the first order red. The usable spectrum covers the range from about 5600 A to 6800 A on Kokak 098-02 emulsion. The star was observed on three nights: 3, 12, 13 February 1974. On each night two spectrograms were obtained, one short exposure and the other long. A long-exposure spectrum obtained on 13 February is shown in Plate 1.

The Hα is in emission having a typical shell-spectrum profile; two emission components are separated by a relatively sharp absorption core. The rest of the spectrum in the red is practically featureless, except for the very unusual He I emission lines. Both the triplet λ5876 (D3 line) and the singlet λ6678 are in emission at about the same strength. A further peculiarity is that both lines consist of two distinct, widely separated emission components with no discernable absorption features in between. It is rare to see both the singlet and triplet helium lines in emission at comparable strength in the same spectrum. In addition, the two emission components of the helium lines show much wider separation than the emission peaks of Hα, although the extreme wings of the latter are about as wide as in the helium lines. In all cases, the two emission components are of equal strengths; there are no appreciable asymmetry between the V and R components.

The radial velocities of the lines were measured on the Grant Spectrum Comparator at Kitt Peak National Observatory. Both plates of 3 February were under-exposed so that the continuum is barely registered. On these plates the helium lines could not be detected. On the other hand, on the long-exposure plates of 12 and 13 February the Hα is over-exposed. Each line was measured on four separated plates; the Hα on both plates of 3 February and on short-exposure plates of 12 and 13 February, while the helium lines were measured on four plates of 12 and 13 February.

The Hα absorption core gives a heliocentric radial velocity of +15±3 km/sec, in good agreement with the published value of +14 km/sec (Wilson 1953). Thw two emission peaks of Hα are separated by 160 ± 20 km/sec, while the two emission components of He I are separated by 400 ± 24 km/sec. The mid-point between the V and R components of Hα has a velocity of +11 ±5 km/sec, while the mid-points between the two components of He I lines have a velocity of +9 ±8 km/sec. In view of the uncertainties in the measurements of broad emissions features, it is concluded that the velocities of the midpoints of the V and R components of Hα and the He I lines are in good agreement with that of the only available photospheric absorption line in this spectral region, the Hα absorption core.

Based on these measurements, a following simple model is proposed. The star is surrounded by a rotating ring in which the excitation levels and rotational velocities decrease outwards. Helium emission arises in a small region of the ring very close to the star and hence, the portion projected onto the stars does not produce appreciable absorption. Now, the measured total width of the Hα feature is essentially the same as the separation of the He I emission components, namely about 400 km/sec. Hα emission takes place throughout the entire ring as is evidenced by the velocity spread. The double emission profile and velocity spread of Hα are easily explained by a consideration of the dynamics of a rotating ring with a gradient in line-of-sight velocity as well as conservation of angular momentum. The observed emission peaks of

Hα then effectively define the outer boundary and the separation of helium emission components fix the inner edge of the ring.

By assuming the conservation of angular momentum and knowing the projected rotational velocity of the star, V sin i, the distances of the inner and outer edges of the ring from the center of the star can be derived in terms of the star's radius. There is some uncertainty as to the correct value of V sin i for this star. Buscombe (1967) gives V sin i = 350 km/sec, which Bernacca and Perinotto (1971) have recomputed as 250 km/sec, while the more recent revised value according to Buscombe and Stoeckley (1974) is 191 km/sec. If the largest value is used, the distances from the center of the star to the inner and outer edges are 1.3 and 2.1 stellar radii, respectively. If the smallest value is used, these values become 1.0 and 1.6, respectively. From spectrograms of lower dispersion, Levato and Malaroda (1970) obtained V sin i = 110 km/sec for κ CMa; this is probably an underestimate.

Previous studies of this star (Jaschek, Jaschek, and Kucewicz 1964; Jaschek, Jaschek, and Malaroda 1969) indicate only a marginal appearance of helium emission in either blue or red spectrum. Dr. N.R. Walborn of CTIO obtained a blue spectrogram at a reciprocal dispersion of 9 A/mm on 6 April 1974. He has kindly sent us a tracing of λλ 4009, 4026, 4471, and Hγ. There is a clear double emission at Hγ. There is no obvious emission at any of the helium lines, but the profiles are quite asymmetrical and peculiar. There are two possibilities to explain peculiar behavior of the red lines. (1) It is a temporary phenomenon. It is important to make further observations to determine how stable these emission lines are; obviously the present material is not sufficient to say one way or the other. (2) Non-LTE effects are responsible for selective excitation of these lines. It has long been known that in many Be stars, the higher He I lines in the blue-violet region do not have noticeable emission even though the red lines show definite emission. Auer and Mihalas (1973) found that the helium lines in the blue-violet region are not affected, but that the ratio of λ6678 to λ5876 is very strongly influenced by non-LTE effects. These results are based on calculations for absorption lines. But it is expected that non-LTE effects are even more pronounced in the case of emission lines. Finally since the D3 line is in emission, one might expect to find the λ10830 line to be quite strong in emission.

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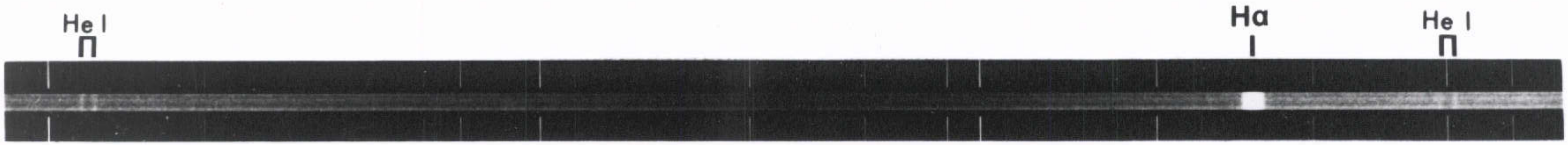
He I
Hα
He I