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ROTATIONAL VELOCITIES OF G AND K GIANTS

Rotational velocities, $v\sin i$, are often helpful in determining the properties of ellipsoidal variables and other rapidly rotating stars by providing a measurement of the absolute radius (e.g., Hall 1990). With this in mind, I have obtained high-dispersion spectra for a large number of late-type stars during 6-11 February 1990 (UT) with the stellar spectrograph of the National Solar Observatory's McMath Solar Telescope on Kitt Peak in Arizona. While most of these stars were slowly rotating giants observed for another purpose, a number of known or suspected rapid rotators and binaries containing a cool giant were included in the program as ancillary targets. The spectra covered the range 6520-6600 Å, at 0.09 Å/pixel, and were taken with an 800×800 pixel TI CCD. All the data were reduced with the standard computer programs available at the telescope.

Rotational velocities were determined by artificially broadening spectra of slowly rotating comparison stars of appropriate spectral type by various amounts and comparing such spectra calculated for a range of $v\sin i$ with a spectrum of the star in question. This technique can be quite accurate because rotational broadening has pronounced, characteristic effects on the many line blends in the Hα region. Results are given in Table 1. The numbers in parentheses refer to the references listed below the table. References to existing rotational velocities are generally to Uesugi and Fukuda, who gave much more extensive information than I can justify including here. Most of the spectral types have been taken from the Bright Star Catalogue. Unfortunately, it was impossible to classify the stars with these Hα spectra, since the metallic lines seem to be only mildly dependent on T_{eff} but are more sensitive to differences in abundance and turbulence.

There are caveats to be applied to the results of this technique. First, we must not apply spectra for giants to supergiants, which have such intrinsically broad line profiles that they would all be thought rapidly rotating. Several of the stars in Table 1 (notably 5 Cet, ζ And, and UU Cnc, which are ellipsoidal binaries) have sizes rather large for K giants and might be expected to have greater turbulence than in normal giants. This effect is generally not a problem, however: for the *strengths* of the broad shallow lines of these

Table 1. Rotational Velocities and Spectral Types

Star		No. of Spectra	Spectral Type	Comparison Star	*vsini* (km/s)	Other Values (km/s)
5 Cet	HD 352	2	K3 III (1)	α Tau	23±1	22±3 (1)
α Cas	HD 3712	1	K0 III	δ CrB	≤5	20 (2)
β Cet	HD 4128	1	K0 III	δ CrB,56 And	≤5	3.0 (3)
ζ And	HD 4502	1	K1 IIe	56 And	41±1	40,36 (2,4)
HR 439	HD 9352	1	K0 Ib+B9 V	α Tau	≤5	≤50 (2)
56 And	HD 11749	2	K0 III	Jupiter	<5	<25 (2)
μ Cet	HD 17094	1	F0 IV	χ Leo	<25	55 (2)
HR 958	HD 19926	2	K1 IIIep+A6	α Tau	17±2	≤50 (2)
58 Per	HD 29094	1	K4 III+A3 V	α Tau	8±2	<25 (2)
HR 2137	HD 41162	1	K0 III+A2	Jupiter,56 And	<5	
μ CMa	HD 51250	1	G5 III+A5	Jupiter	≤5	
σ Gem	HD 62044	1	K1 III	56 And	27±1	25 (2)
30 LMi	HD 90277	1	F0 IV	Jupiter,δ CrB	30-40	35 (2)
72 Leo	HD 97907	1	K3 III	α Tau	<5	<20 (2)
HR 4430	HD 99967	2	K2 III	56 And	17±1	16 (5)
93 Leo	HD 102509	1	G5 III+A7 V	Jupiter+δ CrB	5±2	
12 Com	HD 107700	1	G0 III+A	Jupiter+δ CrB	<5	
24 Com	HD 109511	1	K2 III	α Tau	<5	≤25 (3)
γ Vir	HD 110380	1	F0 V	Jupiter	30±5	30 (2)
31 Com	HD 111812	1	G0 IIIp	Jupiter,δ CrB	63±5	57 (5)
35 Com	HD 112033	1	G8 III+F6 V	δ CrB	<5	<15 (2)
FK Com	HD 117555	4	G5 III	Jupiter,δ CrB	160±10	165±5 (6)
κ Her	HD 145000	1	K1 III	56 And	11±2	10 (2)
HR 6136	HD 148513	1	K4 III	α Tau	<5	≤20 (2)
β Oph	HD 161096	1	K2 III	α Tau	<5	1.6 (3)
UU Cnc	...	8	K4 III (7)	α Tau	25±1	23±3 (7)

References: 1. Eaton and Barden, 1987; 2. Uesugi and Fukuda 1982; 3. Gray 1989; 4. Huisong and Xuefu 1987; 5. Strassmeier et al. 1990; 6. Buzasi 1987; 7. Eaton, 1990.

objects agree very well with the broadened profiles of K giants. Likewise, HR 439 which is classified K0 Ib has only an upper limit on *vsini* presumably incorporating any elevated turbulence. Second, *very* rapidly rotating stars such as FK Com will be flattened and gravity darkened, and this may result in systematic errors from an analysis with a rotating spherical model star. Again, this does not seem to be a problem. To explore this question, I used a computer program that calculates profiles of contact binaries to form the profile of a distorted star with V_{rot} = 130 km/s. The calculated profile (for the backside of the larger component) was indistinguishable from one calculated for a spherical star.

A second purpose of this program was to explore the possibility of using Doppler

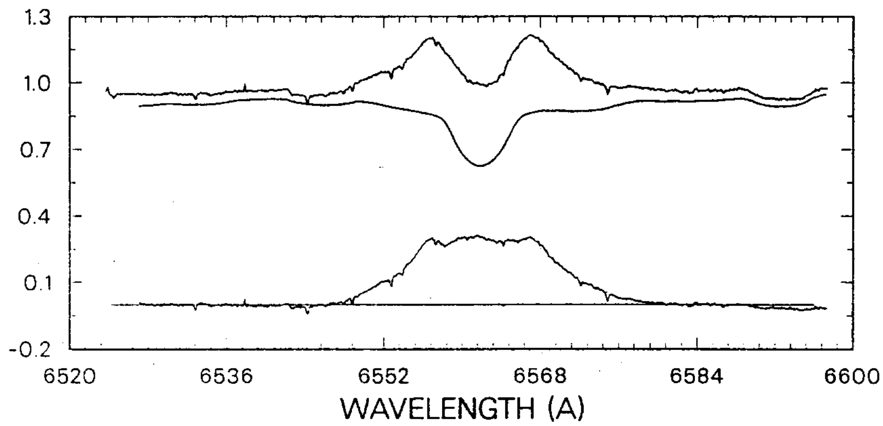

Figure 1. Composite of spectra of FK Com on three nights. A spectrum of δ CrB (G3.5 III-IV), artificially broadened to *vsini* = 160 km/s and displaced to lower intensity, is shown for comparison. Below is shown the difference between these two spectra.

images to map the surface brightness of stars rotating moderately or very rapidly. Cool, spotted stars studied to date with this technique (HR 1099, Vogt and Penrod 1983; HD 199178, Vogt 1988; and HD 26337, Strassmeier 1990) have all been found to have large *polar* spots from the abnormally shallow centers of their line profiles. The observation of σ Gem (*vsini* = 27 km/s) did not reveal a perceptible distortion of the sort revealing a large polar spot. Spectra of FK Com (~ 160 km/s) in the blend at 6595 Å appear slightly flatter than expected from a rapidly rotating star without a polar spot. The difference (see Figure 1) is very slight, making any conclusions suspect, but they do suggest FK Com has a polar spot, as might be suspected, and that it should be possible to form conclusive Doppler images of more appropriate lines, such as Ca I λ6439 or the blend at 6463 Å.

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