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EPSILON PERSEI AND MU CENTAURI AS SINGLE-PERIODIC RAPID VARIABLES

There has been a continuing discussion on the nature of rapid variability in early-type stars between the proponents of non-radial pulsations /Baade, Bolton, Penrod, Percy, Smith and others/ and the proponents of rotational /or possibly binary orbital/ modulation /Balona, Clarke, Engelbrecht, Harmanec, McGale and others/ - see, e.g., the recent reviews by Percy 1987, Baade 1987 a,b, Harmanec 1987 and references therein.

Baade 1987b pointed out that the formal difference between star "spots" and non-radial pulsations is that the spot patterns must always lead to variations with commensurate periods. He reported a discovery of two or possibly three non-commensurate periods for the B2e star Mu Cen, and also referred to a similar finding by Gies and Kullavanijaya 1987 for the B0.5III-V /non-emission/ star Epsilon Per.

As the issue of multiperiodicity is of primary importance, I decided to re-investigate the independency of the periods reported for both stars. My finding is quite exciting: for Epsilon Per the four different frequencies found are apparently overtones of a single /lower/ frequency, which may correspond to rotational or binary period, and the same is also true for Mu Cen !

Let us discuss both cases in more detail.

Epsilon Persei /45 Per, HR 1220, HD 24760/ is a well-known B0.5III-V rapid light and line-profile variable /Bolton 1983, Percy et al. 1984, Smith 1985/. It is also the brightest component of the visual triple system ADS 2888. Its line-profile

variations have an unusually large amplitude and are easily detectable even on normal photographic spectra. Percy and Fullerton 1985 analyzed their October/November 1984 UBV photometry of the star and concluded that the light of the object varied with a period of 3.84 ± 0.02 hours. The amplitude of the light curve changed from night to night.

Recently, Smith et al. 1987 proposed that Epsilon Per is non-radially pulsating with two periods, 3.85 and 2.25 hours, seen both in spectroscopy and photometry. So far the last word was said by Gies and Kullavanijaya 1987, who analyzed long series of high S/N Octicon spectrograms obtained on several nights. Using a sophisticated power spectrum analysis they were able to recover four different periods from their data. These periods - in a decreasing order of significance - are 3.84, 2.26, 4.47 and 3.04 hours.

After several trials I found that all four periods found by Gies and Kullavanijaya are in fact submultiples of a period of 26.9 hours i.e. 1.12 days !

The observed and predicted values /in hours/ are compared in Table 1.

TABLE 1	P	P/6	P/7	P/9	P/12
OBSERVED		4.466±.023	3.837±.005	3.036±.010	2.264±.012
PREDICTED	26.9	4.483	3.843	2.989	2.242

The mutual agreement is remarkably good considering that the observations used for the period determination consist of four nights of observations spanning an interval of five days only. This is certainly a tribute to the careful period analysis carried out by Gies and Kullavanijaya. Note that the most deviating value of 3.036 hours corresponds to the lowest peak in their final power spectrum.

Mu Cen /HR 5193, HD 120324/ is a similarly well-known B2IV-Ve star exhibiting both, rapid and long-term light and spectral variations. Baade 1984 reported the presence of two resonantly coupled periods of 0.505, and 0.101 days seen in Reticon Mg II 4481 and He I 4471 line profiles obtained in

June 1983. Later on, Baade 1987b applied the power spectrum analysis /also used for Epsilon Per/ to his new /April 1987/ spectroscopic observations of Mu Cen and found the following periods: 0.505, 0.391, and 0.440 /or 0.305/ days. He stressed that the ratio of the first two values differs significantly from 5:4 ratio and concluded that Mu Cen is in all probability a truly multiperiodic rapid variable.

I found that it may not be so. Table 2 shows that all the reported periods are in fact submultiples of a single period of 3.535 days .

TABLE 2	P	P/7	P/8	P/9	P/35
OBSERVED		0.505	0.440	0.391	0.101
PREDICTED	3.535	0.505	0.442	0.393	0.101

The most probable interpretation of my finding is that both stars vary with a single period /1.12 days for Epsilon Per and 3.535 days for Mu Cen/ in a highly non-sinusoidal manner. Although unusual, such complicated curves are not unique in the world of stars. I would like to remind in this connection that the X-ray light curves of some X-ray pulsars /which presumably reflect rotation of the objects in question/ also have a highly non-sinusoidal multipeaked shape /c.f., e.g., Joss and Rappaport 1984/.

Identifying the periods of 1.12 and 3.535 days with the rotational periods of the stars in question, and using the observed values of v sin i, 134 and 155 km/s for Epsilon Per and Mu Cen, respectively, one can estimate lower limits to the radii of both stars to be 3.0 and 10.8 solar radii. The radii expected for the observed spectral types would be 6.5 to 13 solar radii for Epsilon Per, and 5.0 to 8.5 solar radii for Mu Cen. Radius of 10.8 or more solar radii seems a bit too large for Mu Cen. It would thus be of interest to test whether this star is not a binary with a 3.535 /or even 7.07/ - day orbital period.

Nevertheless, I find reasonable to stop any further speculations here. Rather, I appeal to all those colleagues, who have access to the /largely unpublished/ observational data on both stars to re-analyze them in the light of the above findings, and publish the light, local line-intensity, and possibly RV curves folded with the best-fit periods near 1.12^d, and 3.535^d for Epsilon Per and Mu Cen, respectively. Searches for the possible presence of measurable magnetic fields and RV variations in both stars would also be of interest. All this could bring us closer to the understanding of these extremely interesting and unusual stars.

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References:

Baade D. 1984 Astron. Astrophys. 135, 101
Baade D. 1987a IAU Col. 92, 361
Baade D. 1987b IAU Symp. 132 /in press/
Bolton C.T. 1983 Hvar Obs. Bull. 7, 141
Gies D.R., Kullavanijaya A. 1987 Astrophys. J. /submitted/
Harmanec P. 1987 IAU Col. 92, 339
Percy J.R. 1987 IAU Col. 92, 49
Percy J.R., Fullerton A.W. 1985 Poster presented at the Canadian Astronomical Society Meeting, Toronto
Percy J.R., Bietenholz M., Fullerton A.W. 1984 Inf. Bull. Var. Stars 2588
Joss P.C., Rappaport S.A. 1984 Ann.Rev.Astron.Astrophys. 22, 537
Smith M.A. 1985 Astrophys. J. 288, 266
Smith M.A., Fullerton A.W., Percy J.R. 1987 Astrophys. J. /Sept.15/