SPECTRAL TRANSIENTS IN THE LINE PROFILES OF λ ERIDANI

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Recently we have monitored the absorption line profile variations of a number of rapidly rotating B stars. These variations are observed as alternating quasi-absorption and -emission bumps that travel blue-to-red across the profile with a local period defined by the time to move one bump spacing. This type of pattern can be modelled success--fully by assuming the presence of one or two active nonradial pulsation (NRP) modes in the photosphere of the star. Many observations show significant departures from the simple expectations of the models: successive bumps can have different amplitudes (which may vary on timescales of hours), and individual bumps can occasionally appear just ahead or behind the position predicted from a mean period. Nevertheless, we believe these anomalies can be treated as perturbations from a time-averaged pulsation model. In contrast, we describe here a number of transient spectral features that we have observed in the He I λ 6678 line profile of the Be star λ Eri, that are qualitatively different from the travelling bump pattern of a single mode or from beating between two well defined modes.

Over the 1985/6 observing season we obtained numerous high signal-to-noise spectra of the B2Ve star λ Eri from three observatories. The star's spectrum variations differed in two respects from observations in the previous two seasons. In 1983/4 and 1984/5, a single, moderate strength, Be outburst occurred producing sustained emission in the violet and red wings of the He I λ 6678 profile. Instead, during 1985/6 λ Eri exhibited a variety of short lived, small amplitude outbursts. The pulsational behavior also appeared to be different. The main 1=2 mode, which has a well defined period of 16.837 ± 0.002 hrs. continued to show variations in amplitude on timescales of months, but a second, normally well behaved 1=8 mode (which has a period, 6.6 ± 0.2 hrs.) produced an erratic bump pattern that was sometimes clearly visible and other times totally absent. In addition, we often observed bumps, apparently unrelated to the regular wave pattern, which appeared to grow on timescales of a few hours and did not participate in the normal blue-to-red motion across the profile. These unexpected transient events were also seen in 1984/5 but not with the frequency observed during 1985/6.

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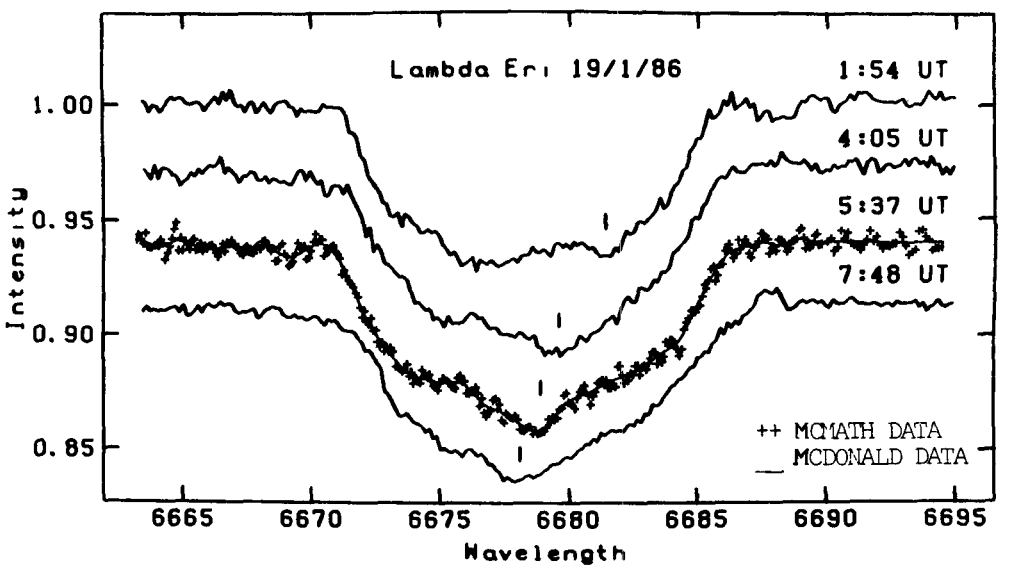
We have sorted these spectral transients into four categories: type a (global) -- These events represent a major disruption of the profile and typically appear as a slight and irregular filling of the profile over a substantial range in wavelength. They cause a marked change in the line's shape and symmetry and can lead to confusion in the phase of the l=2 mode. Type b (local, static) -- These are defined by the appearance of a wavelength-stationary, and often cusp-shaped, absorption "dimple", generally near the line center. The equivalent width of the entire line remains unchanged. Type c (local, moving) -- These events appear as shallow absorption features that move red-to-blue across a portion of the profile (see example in Figure 1 from two observatories). The growth of this feature can add $\geq$ 10% to the line strength. Type d (local, narrow) -- These, the least well documented in our group, are defined by the sudden growth of a very narrow and deep absorption feature which adds to the line strength.

The transients can occur when no emission is visible in any line, and consequently, at least during such times the transients are probably not caused by features in a circumstellar disk projected against the stellar surface. We suspect that there is a correlation between the disappearance of the l=8 bump pattern with the appearance of the narrow transients which suggests that the latter are associated in some way with the pulsations themselves. We caution that without an extensive time series of spectra, these events can play havoc with the interpretation of NR modes and can occasionally be confused with intermode beating or with small departures of the ephemeris of an individual wave in an otherwise well behaved NR pattern.

Figure 1 - Example of a type c transient.



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DISCUSSION FOLLOWING M.A. SMITH

Percy:

On what fraction of all your spectra of λ Eri did transients or other "oddities" appear?

Smith:

During the 1985/86 season, they appeared on 75 to 100% of the 30 or so nights we observed it. On the nights Penrod observed it, the star happened to be much better behaved - perhaps after years of intimacy with it he has it trained.

Bruhweiler:

You seemed to rule out a circumstellar origin for your D- type components. Can you account in any way for the narrow width of these features? What is the transition? And is the lower level of the transition metastable?

Smith:

The 6678 Å line is a 2^1S transition, and it is not metastable. According to models by Cluer and Mihalas (1972) the line is subject to departures from LTE, more so than several other optical-region HeI lines. This makes it less than an ideal probe of local velocity fields (though it is still good), but also an especially sensitive monitor of the emission measure of a circumstellar disk.

Underhill:

Your "type D" components may be discrete components. The level 2^1P° is well populated at the likely T_e, N_e of the mantle of λ Eri. It might be profitable to observe lines from 2^1S or 2^3S of HeI in the spectra of middle B stars.

Smith:

Thank you. We will consider intermittent observations of λ 5015.

Henrichs:

Your type D (i.e. sharp) features seem to be preferentially red shifted. Would you comment on this with regard to your suggestion of "ejection" as a cause?

Smith:

I don't have enough events to make a generalization. However, I would say it could be a *tangential* ejection, as was suggested by Peters' recent observation of a < 12 min. transient in μ Cen (B1e).

Peters:

What spectral behavior preceded the appearance of the sharp transient absorption components in λ Eri?

Smith:

On one occasion (12/20/85) the first exposure showed $l = 8$ bumps. An hour later the spectrum was featureless. Two hours later both a type A and D event occurred and remained through the night (4 hours). Four or five hours later Penrod found V/R emission in λ 6678 and in Hα. I have no other "before- observations" prior to a transient type D, but so far the impression I get is that all these events occur without warning.

Grady:

How long did Hα stay in emission during this observing season? *IUE* observations made on Dec. 31, 1985, in January and sporadically through March showed only weak CIV absorption.

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Smith:

We found λ 6678 and/or Hα emission on the following dates: 25-28 Dec., 1985; 26-27 Jan., 1986; 3-7 Feb.; 24 Feb.; 9 March; 15-16 March; and 6 April, 1986.

Harmanec:

I urge you and other spectroscopists observing the line- profile variations of B and Be stars using high signal-generating detectors to find some way to publish *all* your observations, not only few samples, to let other people undertake independent analyses.

Smith:

I certainly agree with this. In the past, I have presented a large sample of observations in discrete form so that any investigator could read them off the plots and use them quantitatively for himself. I will attempt to more in the future, and urge my colleagues to do the same. My immediate question back to you is whether it would be helpful to archive data on tapes (we do this now routinely with our McMath "solar- stellar connection" data) or publish them in a journal supplement?

Harmanec:

One must know better the amount of data it represents. I suspect that notably less important things have been published from time to time but I would be quite satisfied to see a note in your (and other) future papers that the data on the magnetic tape are available on request.

Torres:

What is the signal to noise ratio of your observations?

Smith:

Typically, 300-500 per pixel. Sometimes under cloudy conditions one has to make a trade-off between S/N and exposure time. Our absolute limits are S/N $<$ 150, and exposure time $<$ 90 min. I get uncomfortable at either extreme.