THE SHOCKING TRUTH ABOUT BETA CASSIOPEIA

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ABSTRACT  Pulsation induced chromospheric heating is not evident in the archetype δ-Scuti variable β Cas. Previously-noted rapid flux variations in its H I Lyα emission very likely were due to changes in the diffuse sky background, not the star.

INTRODUCTION

The 2.4-hour δ-Scuti variable β Cassiopeia (HD 432: F2 III-IV) shows a strong deficiency of coronal X-ray emission compared with its chromospheric fluxes (Simon & Drake 1989 [SD]). SD suggested that β Cas is a prime candidate for an acoustically heated outer atmosphere: other pulsationally unstable objects like the Cepheids and Mira variables are known to exhibit cyclic chromospheric heating in response to the passage of pulsation induced shock waves. A number of years ago, I and J. Bennett noticed what appeared to be rapid flux variations in the H I Lyα emission of β Cas as recorded over a 3.5 hour interval by the International Ultraviolet Explorer (Ayres & Bennett 1987). Subsequently, Teays et al. (1989) found weak evidence for phase dependent emission in the Mg II doublet of β Cas, but peaking near minimum light, contrary to the behavior of the Cepheids (in Ca II: Kraft [1957], Hollars [1974]; in Mg II: Schmidt & Parsons [1984]). More recently, I observed the FUV emissions of β Cas with IUE over a several day period in an effort to detect rotational modulations, a clear signature of inhomogeneous surface magnetic activity (Ayres 1991). No significant rotational effects were seen, although again rapid flux variations appeared in Lyα. Unfortunately, the temporal sampling (geared towards the ≈ 2 day rotational period) was poor, and a possible link between the Lyα enhancements and pulsation associated shocks was inconclusive. That inspired a follow-up.

OBSERVATIONS

I observed β Cas on 1992 July 19 with the IUE using its low dispersion mode and SWP camera (1150–2000 Å). I obtained two sequences of five 2 × 6M large aperture double exposures over a 16-hour US1+US2 combined shift. The integration time yielded approximately 70 DN above background at H I λ1215 Lyα. In addition, I interspersed several single exposures of (8–)12M duration to permit a post-facto calibration of the diffuse Lyα sky emission (which can affect the flux of the stellar feature).
Diffuse Sky Emission

The diffuse Lyα sky background consists of a stable component due to interplanetary backscatter, plus a variable component (as a function of the satellite orbit) due to the Earth's geocorona. I measured the diffuse emission in the six single exposures of β Cas by a least-squares fit of a template derived from archival sky background images. The variations during the 13-hour period were unexpectedly large, and a challenge to model. I took two approaches: (1) the intensity of the diffuse emission was symmetric in time about the observed maximum (near perigee); and (2) a monotonic behavior as a function of the angular separation between the Earth and the target (which together with the altitude of the satellite determine the slant path through the geocorona).

Measurements

The ten double exposures of the sequence were corrected (spatially) for the sky background according to the alternative models, and further processed using a specialized extraction and measuring algorithm. For convenience, and to increase S/N, each double exposure was extracted as a single spectrum.

RESULTS & CONCLUSIONS

Figs. I and II illustrate phase-folded light curves for the λ1600 FUV continuum and the H I Lyα emission, respectively. In Fig. II, the dotted circles refer to H I flux measurements without compensation for the diffuse Lyα emission. The photometric uncertainties typically are smaller than the symbol sizes. The uncertainty in the modeling of the sky background affected essentially only three of the 16 spectra, with a maximum error of less than 10%. While the δ-Sct cycle appears clearly in the continuum fluxes (see Ayres 1991), there is no evidence for any strong (say, factor of two or more) phase-dependent changes in the chromospheric Lyα emission of β Cas. Consequently, pulsation induced chromospheric heating is unlikely in this key X-ray deficient giant.

ACKNOWLEDGMENTS

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REFERENCES

Ayres, T., & Bennett, J. O. 1987, in Stellar Pulsation, eds., A. Cox, W. Sparks, & S. Starrfield (New York: Springer-Verlag), 127
FIGURE I  FUV continuum fluxes phased according to 2.4-hour δ-Sct period.

FIGURE II  Phase-folded Lyα fluxes: dotted circles are fluxes not corrected for diffuse sky emission.