Short-term Photometric Variability in Be Stars in the Far-Ultraviolet - A Preliminary Report

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Abstract. In this paper we report preliminary results on the first search for short term photometric variations in the far-UV in Be stars. Results for mu Cen and 28 Cyg indicate no significant variations.

Introduction. Short term, ~ 1 day, photometric variability in Be stars at optical wavelengths is well established (cf. Percy, 1986). Amplitudes in the V band are typically less than 0.10 magnitude with some variations appearing periodic with $0.25 < P < 2.00$ days. Most models for this short term variability have used changes in effective temperature to explain the light variations.

In an effort to understand these photometric variations we have initiated a program with the Voyager ultraviolet spectrometers to monitor a few Be stars for multi-day intervals. The ultraviolet spectrometers (UVS) aboard the Voyager 1 and 2 spacecraft have been described by Broadfoot et al. (1977) and their inflight performance is summarized in Broadfoot et al. (1981). Briefly, both instruments are objective grating spectrometers which cover the 500-1700A range at a dispersion of 9.26A per detector channel with an effective spectral resolution of approximately 15A. The absolute calibration employed here is that of Holberg et al. (1982). A detailed description of the Voyager UVS reduction techniques can be found in Drilling, Holberg and Schonberner (1984) and Polidan, Stalio and Peters (1987). The UVS offers two distinct advantages over ground based observations. First, the ability to obtain almost continuous data over many days is a major advantage in studying both aperiodic, i.e. unpredictable, and ~1 day periodic variations. Second, if temperature variations are an important factor in the phenomenon then the UVS' high sensitivity in the FUV (500-1200 A) yields a much better measure of any change in total flux or the effective temperature than optical measurements for stars earlier than B7. For most Be stars this FUV region contains more than half the total emitted flux and, since we are observing shortward of the flux peak, has a non-linear response to changes in effective temperature.

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In this paper we present preliminary results on a search for short term photometric variability in Be stars in the FUV.

Observations. Voyager observations suitable to study short term variability have been obtained on mu Cen, 28 Cyg, 66 Oph, eps Cap, 48 Lib, alp Eri, 88 Her, and FW CMa. In this paper we will discuss only the mu Cen and 28 Cyg observations. Future papers will discuss the remaining stars.

mu Cen

Voyager 2 observations of mu Cen were obtained in late June 1985. The data covered 2.3 days but contained two major gaps. The longest continous observing interval was 0.55 days. Simultaneous IUE (Peters) and ground based spectroscopic (Baade) observations were also obtained. Analysis of the Voyager data is complete. No variations were found in the data. Limits on the variations are $< 2\%$ at 1050 A for timescales less than 8 hours and $< 0.6\%$ for timescales greater than 8 hours. This translates into a change in the integrated disk temperature of < 150 K and < 50 K respectively.

28 Cyg

Voyager 2 observations of 28 Cyg were obtained in Oct., 1985 along with simultaneous IUE (Peters) and ground based spectroscopic (Penrod) observations. Unfortunately, due to a spacecraft problem all Voyager data was lost after the first 0.5 day of observation. No statistically significant variations $> 4\%$ were observed. Optical light variations are well established in 28 Cyg. The variations are periodic with a period near 0.7 day and have an amplitude that varies between 0.02 and 0.10 in V. Unfortunately, no simutaneous optical photometric observations were obtained.

Preliminary Conclusions. No evidence has been found for short term FUV photometric variability in mu Cen and 28 Cyg. This result is particularly unexpected for 28 Cyg where periodic, optical variability is well established. Since the amplitude of these optical variations shows a significant long term modulation, without simultaneous optical photometry we cannot rule out the possibilty that at the time of our observation the amplitude was below our limit of detection. If the photometric variations in 28 Cyg are primarily due to an effective temperature difference this would require the optical light to be constant to better than 0.01 magnitude in order for us to observe a statistically constant FUV flux. Future observations of 28 Cyg and other stars combined with simultaneous optical photometery should resolve this problem.

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DISCUSSION FOLLOWING POLIDAN

Balona:

You have very few candidates in the southern hemisphere. Most of the photometry planned for the next few years will be of southern objects, so it would be a pity not to have far UV observations for these stars.

Polidan:

We have a number of southern hemisphere stars that we would like to observe. Most of our collaborators, however, observe at northern sites, so we have tended to concentrate on this hemisphere.

Percy:

Dr. Balona's comment notwithstanding, northern-hemisphere photometrists *will* continue to observe Be stars in the future! I agree, though, that more southern or equatorial stars should be studied. Also, since the proposed timescales for 28 Cyg range up to 0.8 day, *at least* 0.5 day of observations (preferably more) is necessary in order to comment on short-term variability. Are normal B stars reobserved with *Voyager* to see if they too show flux and temperature variations over time intervals greater than days?

Polidan:

I fully agree with your comment on 28 Cyg. Our observation was planned as a continuous three-day observation. Unfortunately, spacecraft problems intervened. Future observations are planned. As for normal OB stars FUV variability is much more common than was expected. These variations are typically smaller by a factor of 2 or 3 than those variations found in Be stars. We do, however, have a very few OB stars and a few subdwarfs and white dwarfs which are constant to better than a few percent over about 5 years of *Voyager* observations.