THE ACTIVE UV PHASE OF 59 Cyg

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Abstract : Coordinated UV and visual observations of 59 Cyg in 1978-81 show strong mass ejection activity and strong variability in displacements and profiles of superionized lines during the new Be phase, starting from a "quasi normal B" phase in 1977, and increasing irregularly through 1981 to a low and then moderate Hα emission. These data show that visual data alone cannot describe the activity of the star.

I. Introduction

Mc Laughlin (1948) characterized 59 Cygni's behavior by "long periods of quiescence and short periods of activity" which, if understood as "Balmer emission line" activity has been largely confirmed by subsequent visual observations. However, UV observations have shown that "mass ejection" activity of the star cannot be infered from only the strengths of the Balmer emission line. A calm,inactive mass ejection phase can be assigned to the star on the basis of visual observations, at an epoch where indeed UV observations show a highly active one. These conclusions come from a comparison of UV and visual observations of 59 Cyg, in the interval 1972-present. It was shown that : (i) at "almost normal B phase", near minimum Hα emission, line displacements exceeding escape velocities are observed in superionized species (Doazan et al 1980a). By contrast, much smaller displacements in these lines were observed during the last episode of spectacular variations in the visual (Snow and Marlborough 1980). (ii) Near that minimum Hα emission phase, and during the subsequent new Be phase of low level Hα emission, a strong variability in displacements and profiles of the superionized lines is observed (Doazan et al 1980 b). So, the period of highest activity thus far observed in the UV corresponds to one which is considered uninteresting in the visual spectrum, and which was thought to characterize "a calm and quiescent" period in that star. This demontrates that any description of the mass-flux activity in Be stars, from visual data alone, can be misleading, and that an interpretation of the Be phenomena must necessarily combine visual and UV observations. To illustrate the activity of 59 Cyg in 1980, where Hα emission has reached a moderate level, we present an abstract of UV data from a coordinated program

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of UV and visual observations, which began in 1978 and which continues through 1981 in an enlarged collaboration.

II. The observations.

From 1978 to 1981, 59 Cyg has been regularly observed in the UV, almost monthly, at high dispersion with IUE, and with Copernicus (in 1979). The IUE data were reduced using software written in the Interactive Data Language (IDL), at the Laboratory for Astrophysics and Space Sciences (Univ. of Colorado). Fig. 1. shows selected profiles of CIV resonance lines observed in 1980. One sees clearly the presence of

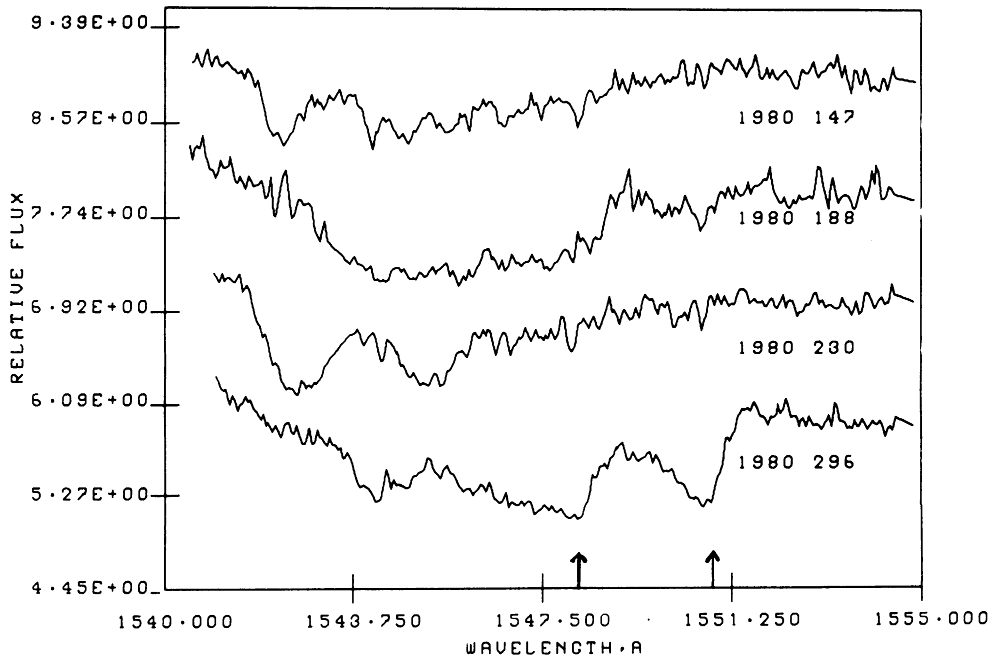

Fig. 1. Representative profiles of CIV resonance lines of 59 Cyg in 1980 ; the arrows show laboratory wavelengths.

multiple components, whose positions and strengths vary strongly. The majority of the spectra obtained so far show 2 such components : one of low expansion velocity (< 100 km/s), one of high (in the range 600 to 1000 km/s) if one measures the displacement of the deepest part of the absorption profiles. The position of the blue edge varies from -900 to -1200 km/s. The most frequent configuration is the one where the high velocity component is the stronger, but the reverse is also sometimes seen. At other times, a broad profile is observed, where one can identify the different components from similar features corresponding to the difference in velocity of the doublet. Large variations are observed on time scales of a month, but some observations taken 24 or 48 hours apart, show smaller variations which suggest a progressive change in the profile. Regular observations made at interval of days, over a period of one or two months, will help to understand the pattern of variability.

By contrast to the superionized resonance lines, the Si IV resonance lines showed almost no variations. In 1978-79, their profiles are quasi-symmetric, quasi-undisplaced and quasi-nonvariable. In 1980, some asymmetry begins to appear with a larger extension of the violet wings. A detailed discussion of all the combined UV and visual observations from 1978 to 1981 will be given in a more extensive paper.

III. Discussion

Our data lead to the 2 important conclusions :

(i) The activity of a Be star consists of a whole cycle : from the beginning of the recharging of the extended atmosphere to its complete dispersal, wherein the Hα minimum emission phases are very important. Thus, one cannot infer from visual observations only, the details of the mass ejection activity of the star. The prespatial description of the activity of the star, related to strong Hα emission only, where phases of minimum Hα emission, or quasi-normal B phases, were neglected and considered "uninteresting", can give a wholly erroneous picture of the Be phenomena. This implies that the history of the star over the whole cycle be considered and not only some selected spectacular phases observed in the visual (Doazan 1981).

(ii) From the above, to base a model on only the visual spectrum and only on observations at one or a few epochs, will be wholly misleading. From the visual spectrum alone, one will model for the Be star an outer "cool" atmosphere producing Hα emission. From UV data alone, one will model an outer superionized atmosphere. An empirical model of the real Be star must necessarily combine both UV and visual data. The above underlined importance of the history of the star throughout a whole cycle, from "shell build up" phase to "shell dispersal" phase, requires the mass flux, thus the model to be time-dependant.

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DISCUSSION

Dachs: Do your UV observations of 59 Cyg permit the following conclusion: During phases of weak or no H_α emission, the velocity and strength of the stellar wind in this star are maximum, and the stellar wind blows away the H_α emitting envelope. When the strength of the wind declines, the envelope will recover. Is this a possible model of the activity cycle of a Be star?

Doazan: The observations seem to suggest the following:
1. For some reason the H_α emission shell disappears and the star becomes a "quasi-normal B star".
2. Then, about this "minimum Be phase", the mass flux "activity" is large and continues so, for at least two years, up to the present. It is during this 2-3 years that the "extended atmosphere" where H_α emission is formed builds up, i.e. the F_M "fills the balloon".
3. The important question is what fixes the outer boundary of the atmosphere; the observations seem to suggest that it is the "enhanced" F_M running into a previous low F_M, not the ISM, which will build the extended atmosphere.
4. Once the extended atmosphere is built up, this situation seem to constitute the quasi-state Be star phase.

Viotti: I agree with you that one has to go down to UV to make a good modelling. My question is the following: Did you look for excited lines (photospheric) that would tell you more about the temperature deep in the atmosphere, and what about the continuum energy distribution in UV, is it variable?

Doazan: From a rough examination of the spectra one would conclude that the photospheric lines do not show conspicious variations. These results and those for the continuum will be published in a seperate paper.