EUV PN 559

EUV-PN-559

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AN EUV DISSECTION OF A FLARE ON AU MICROSCOPII

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ABSTRACT The dMe flare star AU Mic was one of the first late-type stars observed by the Extreme Ultraviolet Explorer satellite (EUVE) spectrometers. During the observation a large flare was detected whose peak corresponded to an EUV photon count rate 15 times higher than that of quiescence. The resulting spectra have sufficient signal to permit some time-resolved analysis. When split into the different flare phases, the spectral data, together with light curves derived from individual spectral lines, indicate that the hot ($\sim 10^7$ K) Fe lines from high ionization stages (XX–XXIV) show larger enhancements over their quiescent fluxes at the flare peak, and a sharper initial decay, than do cooler ($\sim 10^6$ K) Fe lines. These hot lines persist throughout the flare decay phase, suggesting additional post-flare energy input, and/or that an expansion occurred over a sufficiently short timescale to avoid rapid radiative cooling. In general, the flare resembles large two-ribbon solar flares.

OBSERVATIONS

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AU Mic was observed as a wavelength calibration target for the three spectrometers on board EUVE. The pointing began at 12:28 UT 14 July 1992, and ended at 8:09 UT 18 July 1992, yielding a total exposure time of about 80,000s. The EUVE spectrometers provide coverage over the following wavelength ranges: 70–190 Å ("short wavelength," SW); 140–380 Å ("medium wavelength," MW); and 280–760 Å ("long wavelength," LW) (see Bowyer & Malina 1991, and references therein). AU Mic was detected in all three spectrometer channels, although the LW detection was predominantly the result of second order throughput.

Simultaneous photometry in the 65–190 Å bandpass is acquired during spectroscopic observations by the Deep Survey (DS) detector, whose Lexan/B filter intercepts on-boresight photons which do not fall upon any of the three spectrometer gratings. This photometric data has been analyzed by Cully et al. (1993). Figure 1 illustrates the light curve derived from the DS data: a large flare with a peak luminosity in the Lexan/B band of $\sim 10^{30}$ erg s^{-1} occurred at about 16:00 UT on 15 July 1992 (there is a small error in the time axis on the Cully et al. plot in Fig 1: to get the correct time add 3.8 hours). The decay phase, which lasted for more than one day, was broken by another, smaller flare.

Proc. 8th Cambridge Workshop on Cool Stars, Stellar Systems and the Sun.
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ANALYSIS

We have divided the flare episode into six different phases, using as a guide the Cully et al. (1993) DS light curve (Fig. 1). These phases correspond to: (1) pre-flare quiescence; (2) the flare rise and peak; (3) first flare decay; (4) second flare rise and peak; (5) first and second flare decay; and (6) final quiescence. For each of these different phases we have extracted SW and MW spectra. The MW spectrum sequence is illustrated in Fig. 2a; the SW sequence is illustrated in the companion review by Brown (this volume). We have also constructed light curves for some of the brighter spectral lines, providing some qualitative diagnostic information on the continuous evolution of the flare plasma. Curves corresponding to the lines Fe XXIV 192 Å, Fe XVIII 94 Å, and the cooler He II 304 Å line are illustrated in Fig. 2b.

DISCUSSION

The DS photometric light curve exhibits an exponential rise, followed by a decay with at least two exponential components. The secondary flare shows similar properties. We note here three characteristics of the spectroscopic behavior. (1) The hot $\sim 10^7$ K lines, represented in Fig. 2a and b by the Fe XXIV line at 192 Å, follow the photometric light curve, with a sharp rise to a factor of ~ 15 times their quiescent count rates. (2) The rise above the quiescent count rate of successively cooler lines decreases, as illustrated in Fig. 2b by Fe XVIII 94 Å ($10^{6.7}$ K). (3) The cool $\sim 10^5$ K He II 304 Å line also shows a sharp rise, but is almost absent during the decay and secondary flare. In general, these characteristics are much the same as those of large, two-ribbon solar flares.

The persistence of the hot $\sim 10^7$ K lines throughout the several hour duration of the decay phase suggests that a period of rapid expansion and adiabatic cooling could have decreased the pressure sufficiently quickly to prevent catastrophic radiative cooling. However, unless the density of the flaring plasma was exceptionally low, the length of the decay implies some additional post-flare heating. The exponential character of the decay suggests a dissipation of stored energy, where the dissipation rate is proportional to the energy stored. In such a case, the different exponential components would relate to different coronal loops. We will present a detailed analysis of these data in a future paper.

ACKNOWLEDGMENTS

This work has been supported by NASA Contract NAS5–30180.

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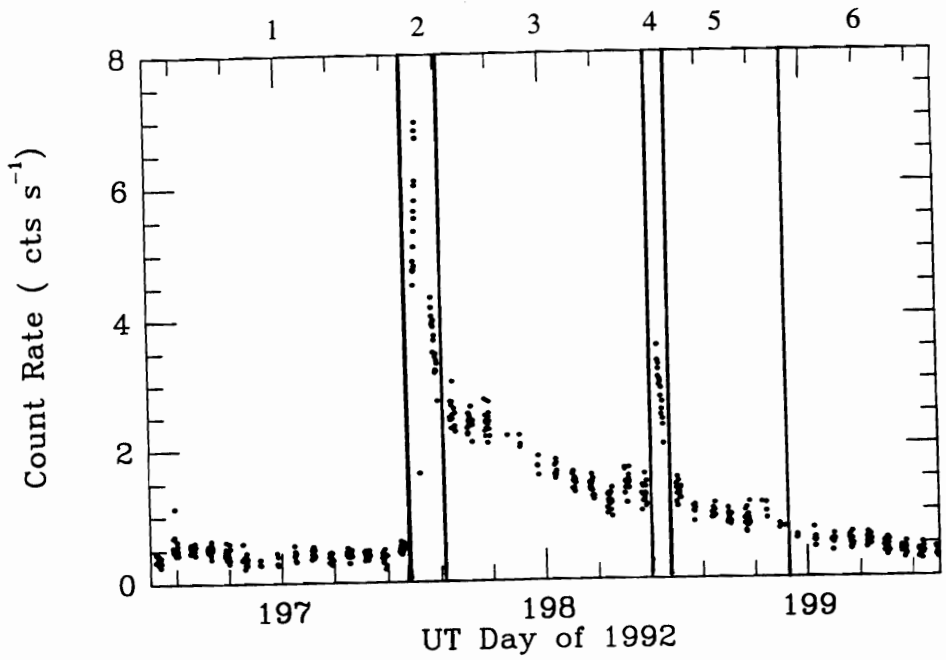

FIGURE I The Deep Survey photometry (65–190 Å) from Cully et al. (1993), shown split into six different phases (see text).

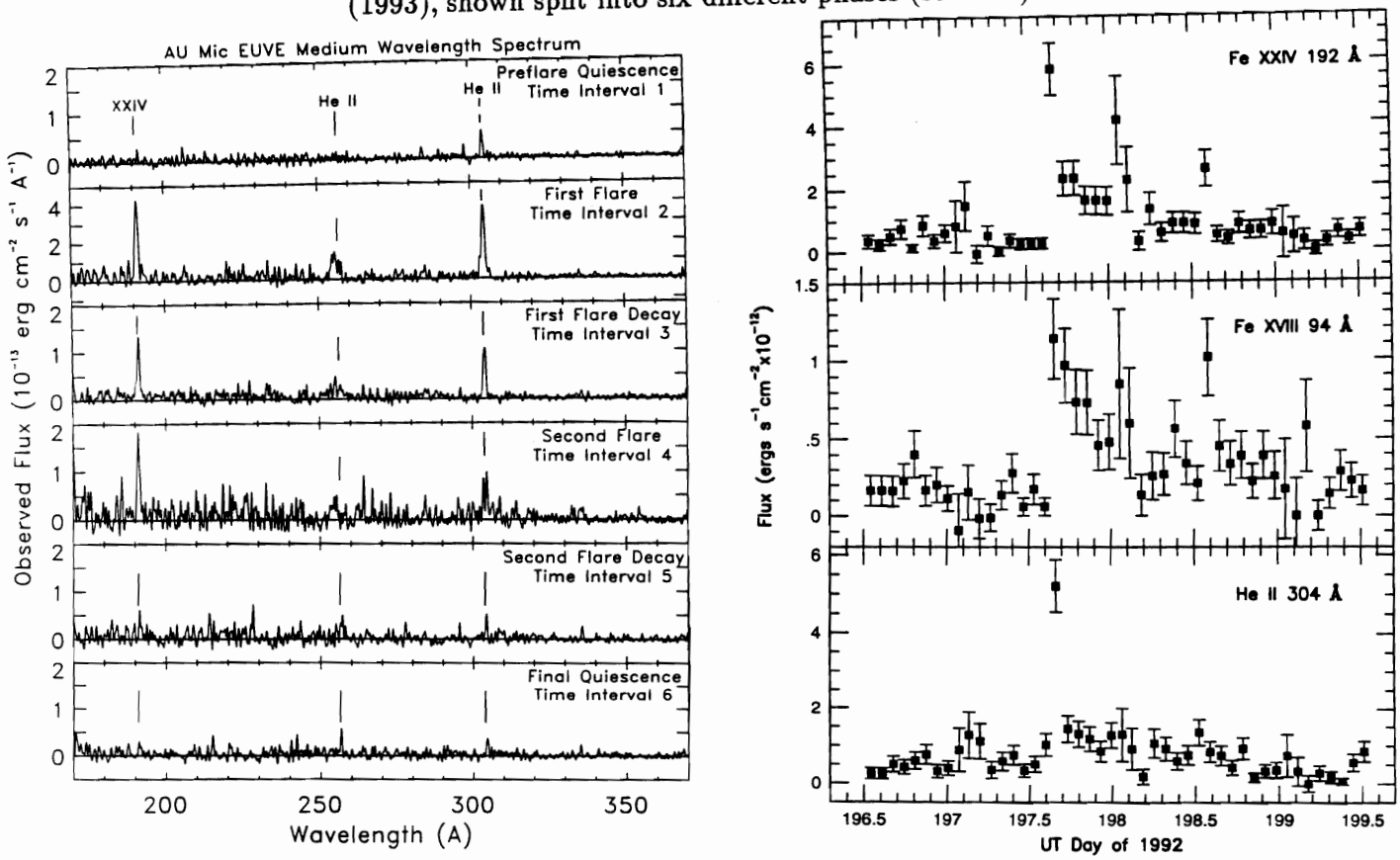

FIGURE II (a) The MW spectrometer data split into the individual phases illustrated in Fig. 1; Fe XXIV 192 Å and He II lines are labled; (b) light curves corresponding to lines of Fe XXIV, Fe XVIII and He II.