Rapid UV Spectroscopy of Flares on YZ CMi

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On 1994 Dec 21 the dMe flare star YZ CMi was observed using the Goddard High Resolution Spectrograph aboard the Hubble Space Telescope. The observations consisted of 11 spectroscopic time sequences, each having a duration of approximately 42 minutes, taken on successive spacecraft orbits. Each time sequence was obtained using the rapid readout observing mode, which allowed sequencing of spectra with 0.4s integration times and almost no dead-time between exposures. The spectra were obtained through the Large Science Aperture using the G140L grating and covered a wavelength range from 1150 Å to 1440 Å with a resolution (Δλ/λ) of approximately 1000.

The primary purpose of the observations was to investigate the UV properties of stellar flares. During the 7.5 hours of on-source observing a total of 29 clearly defined events were detected. These had peak integrated fluxes which ranged from 1.7 to more than 12 times the quiescent levels and had durations from 15s to 200s.

Co-addition of the quiescent observations taken during any given time sequence produces a strong emission line spectrum (see Fig 1), with pronounced lines of H I, C II, C III, Si III, Si IV, N V and O I. There is also a definite detection of the Fe XXI (λ1354) line. The continuum between these lines can be accounted for entirely by the background caused by Cerenkov radiation from cosmic rays hitting the window of the detector. During a moderate size flare (Fig 2) the emission lines all strengthen, with the C III (λ1175) and Si IV (λ1394,1403) features showing the most pronounced increase and the N V (λ1239,1243), O V (λ1371) and Ly α showing the least. This effect is shown quantitatively in Fig 3, which plots the flux increase as a function of the line formation temperature. Clearly, most of the effects of the flare occur at a temperature of ~70,000 K. Surprisingly, the Fe XXI line disappears during the flare. Several emission lines not previously seen in solar flares were also detected. The identity of these lines is still unclear.

All the line fluxes show approximately the same time history (Fig 4). The continuum intensity also varies significantly during this flare. The continuum generally follows the emission line fluxes, though it occasionally undergoes a large increase without a corresponding change in the emission line fluxes.
Fig 1: Quiescent spectrum of YZ CMi showing the region of observation.

Fig 2: Spectrum of a large flare event, integrated over its 3 minute lifetime.

Fig 3: Enhancements of various spectral lines during the flare shown in Figure 2. The enhancements are plotted against the temperature at which the lines are formed.

Fig 4: Time history of the large flare, whose integrated spectrum is shown in Figure 2.