HST OBSERVATIONS OF THE FLARE STAR AU MIC

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ABSTRACT    We report the results of two observations of the flare star AU Mic taken with the Goddard High Resolution Spectrograph as part of a multi-wavelength observing program. The first observation shows unambiguous evidence of FeXXI (1354.1 Å), formed at 10 million degrees, in the quiescent spectrum. The second showed a transient event in which Si III (1206.5 Å) increased by a factor of 6.6 in integrated flux.

Keywords: Stellar atmospheres; stellar activity; flare stars; HST.

INTRODUCTION

In early Sept, 1991 the flare star AU Mic (Gl 803) was the subject of an intense observing campaign involving optical, UV and radio wavelengths. This campaign was in support of two observing programs carried out by the Goddard High Resolution spectrograph aboard the Hubble Space Telescope (HST). The first of these (GTO #1158) examined the UV spectrum between 1345 Å and 1375 Å. This region contains emission lines formed over a wide range of temperatures, going from FeXXI 1354, formed at 10^7 K, to CI and OI lines formed near 10^4 K. By observing flux variations and Doppler shifts in these lines during the impulsive and decay phases of a stellar flare it was hoped to gain information concerning the initial site of energy release as well as energy balance and transport mechanisms.

The second program (GO #2321) examined the Ly-α region in an attempt to detect evidence for the acceleration of high energy protons during the
impulsive phase of a flare. According to a theory first proposed by Orrall and Zirker (1976) protons in the 10-300 keV energy range are accelerated downward during the flare and change exchange with ambient hydrogen atoms, becoming energetic, highly excited neutral hydrogen. These atoms then emit redshifted Ly-α radiation up to 20 Å from line center.

In this paper we describe some of the major results of these observations.

OBSERVATIONS

Both HST programs were performed using the Goddard High Resolution Spectrograph (GhRS) in rapid readout mode. The star was observed through the 2 arcsec aperture with a medium resolution grating (G160M), giving a wavelength coverage of 32 Å and a spectral resolution (λ/Δλ) of 10,000. Observations were grouped into a series of orbits with one 30 minute time sequence for each 90 minute orbit. Individual spectra had an integration time of 0.4 s.

RESULTS

There was no evidence for flaring during the 3.5 hours of on-source observations taken in program GTO #1158. The integrated spectrum, shown in Figure 1, should therefore be an accurate representation of the “quiescent” phase of this star. Of most interest is the clear detection of the Fe XXI line. Preliminary analysis suggests a differential velocity of 12 ± 5 km s⁻¹ between the Fe XXI and the C I / O I lines, with the neutral atoms red-shifted with respect to Fe XXI. There is also weak evidence for an enhancement in the red wing of the Fe XXI line, possibly indicating a downflow of as much as 200 km s⁻¹.

A comparison of the spectrum in Figure 1 with Skylab spectra (see Cohen, 1981) shows a closer agreement with a solar flare than a solar active region.

Fig 1: Flux calibrated spectrum after summing the entire 3.5 hour time sequence of program GO #1158. The background, before subtraction, had 135 counts. The C II line has 230 counts above background.
Of the four successful orbits in program GO #2321 only the last, starting at 13:09 UT on 1991 Sept 3, showed any transient activity. The integrated counts in the Si III (1206.5 Å) line showed an enhanced level at the onset of observations and peaked 20 s later at approximately 6.6 times the quiescent level. The flux then decayed exponentially with an e-folding time of 160 s. Figure 2a shows the Si III profile during various phases of the event. Aside from a slight asymmetry near the peak of the event, the profile shape remained remarkably constant throughout, with no indications of the large Doppler shifts often associated with flares.

Fig 2: (a) Profiles of the Si III (1206.5 Å) line during the transient event on 1991 Sept 03. The solid line is an integration over the first 50 seconds, the short dashed line integrations from 100 to 200 s, the long-dashed line is the quiescent star. (b) Profiles of the Ly-α line integrated over the same time periods as the Si III in (a).

Integrating over the shortward (1216-1217 Å) and longward (1217-1227 Å) part of the red wing of Ly-α shows no indications of changes correlated with the Si III transient. Thus, there is no evidence for energetic protons associated with the event. There is however a detectable enhancement in the blue wing of Ly-α (see Figure 2b) which may be a signature of chromospheric evaporation. The large changes in the core of Ly-α between 1215.2 and 1215.9 Å can be accounted for by orbit-modulated variations in the geocoronal emission.

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