CORONAL METALLICITIES OF ACTIVE BINARIES

Vinay Kashyap, Jeremy Drake, Deron Pease

Harvard-Smithsonian Center for Astrophysics

Jürgen Schmitt

Max Planck Institut für Extraterrestriche Physik

SUMMARY

We analyze EUV and X-ray data on a sample of X-ray active binary stars (**HR 1099**, λ **And**, **UX Ari**, **VY Ari**, ξ **UMa**, **44i Boo**, and **YY Gem**) to determine coronal abundances. EUVE spectrometer data are used to obtain line fluxes, which are then used to determine Differential Emission Measures (DEMs). The continuum emission predicted for these DEMs (constrained at high temperatures by measurements in the X-ray regime where available) are then compared with EUVE/DS counts to derive coronal metallicities. These measurements indicate whether the coronae on these stars are metal deficient (the "MAD Syndrome") or subject to the FIP-effect (low First Ionization Potential elements have enhanced abundances relative to the photospheres).

[0] Presented at the 192nd meeting of the AAS, San Diego, CA, Jun 7-11, 1998

EUV DATA

Table 1: *EUVE* Observations

Star	Instrument	Exposure [ks]	count rate [ct ks^{-1}]
HR 1099	DS	318	660 $\pm$ 1.49
	SW	306	80 $\pm$ 0.90
λ And	DS	81	187 $\pm$ 1.56
	SW	81	43 $\pm$ 1.52
UX Ari	DS	194	388 $\pm$ 1.44
	SW	189	47 $\pm$ 1.01
VY Ari	DS	140	155 $\pm$ 1.10
	SW	147	40 $\pm$ 1.11
ξ UMa	DS	249	293 $\pm$ 1.20
	SW	169	27 $\pm$ 1.00
44i Boo	DS	227	278 $\pm$ 1.22
	SW	178	31 $\pm$ 1.00
YY Gem	DS	256	228 $\pm$ 26
	SW	316	16 $\pm$ 0.6

METALLICITIES (METHOD)

We derive stellar coronal metallicities by comparing the flux predicted from a Differential Emission Measure (DEM) distribution at various metallicities with observed broad-band fluxes:-

1. Measure fluxes for lines detected in the *EUVE* spectrometers.

2. Identify these lines and compute emissivities using, e.g., the CHIANTI database (Dere et al. 1997, A&AS, 125, 173) of atomic data and the ion-balances of Arnaud & Raymond (1992, ApJ 398, 39).

3. Derive a DEM as a function of temperature using the measured line fluxes and computed line emissivities (e.g., Kashyap & Drake 1998, Aug 10). **The DEM thus derived is inversely dependent on the adopted metallicity.**

4. Use the DEM derived above to predict continuum as well as line emission in the EUVE/DS or the long wavelength part of the EUVE/SW.

5. The predicted fluxes will scale inversely as the adopted metallicity, and will thus enable us to measure coronal metallicities by matching the predicted and observed fluxes.

METALLICITIES (RESULTS)

Table 2: DERIVED METALLICITIES

Star	[Fe/H]
HR 1099	(-0.8, -0.4) [1]
λ And	$>$ -1.0
UX Ari	(-0.8, -0.4) [2]
VY Ari	$>$ -1.0
ξ UMa	-0.5 $\pm$ 0.2 -0.65 $\pm$ 0.05 [3]
44i Boo	(-1.0, -0.6)
YY Gem	$\sim$ -1 [4]

NOTES:-
1. Consistent with photospheric metallicity
2. ASCA estimate is [Fe/H] -0.7 – -0.3 (White 1996, Cool Stars 9, 193)
3. From VMEKAL fit to ASCA spectrum
4. "MAD" star

• Derived coronal [Fe/H] are similar to photospheric [Fe/H] for HR1099 (Randich et al. 1994, A&A, 283, 893).

• YY Gem appears to be strongly metal depleted; indeed, we are unable to place a proper lower bound on its metallicity.

• Contributions from lines that form at temperatures beyond those constrained during the derivation of the DEM will increase the predicted flux and consequently result in higher values of the metallicity. The derived [Fe/H] are therefore lower bounds.

FIGURE CAPTIONS

HR 1099 EUVE/SW Spectrum: The short-wavelength spectrum of HR 1099 obtained from concatenated EUVE observations of > 300 ksec. Flare events are excluded from this spectrum, which consequently represents the quiescent corona of HR 1099. Strong lines in the spectrum which were used to construct the Differential Emission Measure (DEM) distribution are labeled. The thin solid line denotes the location of the continuum computed using this DEM for a metallicity [Fe/H]$= -0.7$.

ξ UMa ASCA Spectrum: The best-fit three-temperature models to the ASCA flare and quiescent spectra of ξ UMa B (G0 V). In the fitting process, the abundances of elements with first ionization potentials above and below 10 eV were treated as two independent variables in order to test whether or not a solar-like "FIP Effect" — a relative enhancement of low FIP element abundances to high FIP element abundances — is present in the corona of ξ UMa B. Fitting using the Cash "C" statistic indicated aproximately equal high and low FIP abundances during both flare and quiescent states, with a value [Fe/H] $\approx$ -0.6 $\pm$ 0.05. We estimate the true uncertainty to be much larger at $\approx$ 50%. The photospheric metallicity of ξ UMa is [Fe/H]$= -0.34 \pm 0.1$.

Metallicity measurement: The metallicity of ξ UMa B measured by comparing the line and continuum fluxes. The curved line is the of the predicted flux as seen in the EUVE/DS (upper panel) and the long wavelength end of the EUVE/SW (lower panel) obtained by scaling the DEM (calculated using strong lines identified in the EUVE/SW, MW, and LW spectrometers) with the metallicity. A 10% error on line fluxes and atomic data are assumed, and are denoted by the flanking dotted lines. The thick horizontal line represents the observed integrated flux in the band. The horizontal dotted lines represent 1 σ errors on the observed flux.