X-RAY OBSERVATIONS OF A COMPACT BINARY SOURCE

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It is apparent that simultaneous X-ray and ultraviolet measurements of selected binary X-ray sources can provide a unique probe of the wind structure and mass loss phenomena in an extended stellar atmosphere.

When a compact object is orbiting essentially within the atmosphere of a primary star and producing X-rays by accretion of the stellar wind of the primary, we might expect the resultant X-rays to influence the atmospheric structure.

In fact, these effects in ultraviolet line profiles were first noticed to change in low dispersion spectra of Cygnus X-1 obtained with the IUE satellite (Dupree et al., Nature, 275, 400, 1978). Such behavior was considered theoretically by Hatchett and McCray (1977) who evaluated the effects of imbedded X-ray radiation upon a stellar atmosphere. Since the density of typical O and B star atmospheres is high, the response of a plasma will be immediate to a varying source of X-rays. The atmospheric response would first be expected to modify the line profiles of P Cygni features, by destroying the ion such as C IV or N V that produces the profile. This behavior should be phase dependent as the X-ray source moves around the primary star. Secondarily, one might expect the wind acceleration to be affected in a more subtle way since photo-ionization of ions that provide the necessary opacity to accelerate the wind might cause a restructuring of the flow

and resultant mass loss. In fact the first effect has been clearly identified in studies of Cygnus X-1, (Dupree et al., 1978, Nature, 275, 400; Treves et al., 1980, Astrophys. Journ., in press) and Vela X-1 (Dupree et al., Astrophys. Journ., in press).

To understand the atmospheric response it is necessary to know the X-ray flux simultaneously with the line profile measurement. Sources such as Vela X-1 (HD77581) and 4U 1700-37 (HD153919) that show highly variable X-ray emission are prime candidates for simultaneous measurement.

Activity during this Grant centered on acquiring and reducing the X-ray measurements of 4U1700-37 and Vela X-1 from the University College London experiment on the Copernicus satellite. Simultaneous ultraviolet spectra were obtained with the International Ultraviolet Explorer satellite and reduced at the Center for Astrophysics.

4U1700-37 (HD153919)

One of the first questions of interest is the presence of a short time scale periodicity - of 24 minutes (Branduardi, thesis 1977) or 97 minutes (Matilsky, , LaSala, and Jessen 1978, Astrophys. Journ. Lett., 224, L119) actually existed. Analysis of the OAO data obtained over a 5 day span in 1978 showed no evidence for periodic modulation of the X-ray flux either in the range 20-30 min. or 90-100 min. as well as over all the range down to $\sim$3 min. This work is reported by

Branduardi et al. (Nature, 279, 508, 1979).

The X-ray fluxes have also been averaged and binned to coincide with the time of the IUE observations. The P Cygni profiles of HD153919 were found to not vary substantially with binary phase -- in part because of the massive wind and optical depth of the absorption features over much of the line profile. Thus an X-ray source could be imbedded in the wind and ionize a cavity, but its ionizing effects are not observable in the line profile. It will be necessary to search profiles of ultraviolet lines that do not have the high opacity of the resonance transitions. This work is progressing in collaboration with scientists at the University of Amsterdam - but has been hampered somewhat by the necessary re-reduction of the IUE spectra due to an error in the intensity transfer function used to reduce the IUE data.

Vela X-1 (HD77581)

This Bo supergiant shows definite variability in its X-ray emissions and strong phase effects in the appearance of the resonance P Cygni profiles. The X-ray measurements made by Copernicus were contributed to an international campaign to monitor selected X-ray sources in the UV and X-ray region. A detailed model of the ionized volume was constructed and is in agreement both qualitatively and quantitatively with the

X-ray observations. These results are reported in Dupree et al. (1980 Astrophys. Journ., in press).

Publications and Presentations

During this Grant Period incorporating X-ray Observations from Copernicus:

"Search for Short Time-Scale Periodicity in the X-ray Flux o 4U 1700-37", G. Branduarci, A.K. Dupree, P.W. Sanford, G.S.C. Pollard, 1979, Nature, 279, 508.

"Ultraviolet Spectroscopic Measurements of Galactic X-ray Sources", A.K. Dupree, presented at NATO Advanced Study Institute on Galactic X-ray Sources, in press.

"X-ray Behavior of 4U 1700-37", G. Branduardi, presented at NATO Advanced Study Institute on Galactic X-ray Sources.

X-ray measurements from Copernicus are also used in: "Simultaneous Ultraviolet, Optical, and X-Ray Observations of the X-Ray Source Vela X-1 (HD 77581)", A. K. Dupree et al., Astrophys. Journ. in press.