X-RAY DETECTION OF THE SYMBIOTIC STAR AG DRACONIS

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ABSTRACT

The symbiotic star AG Draconis was observed by the HEAO-2 Imaging Proportional Counter (IPC) and found to be an unusually intense source of very soft X-rays.

I. INTRODUCTION

AG Draconis was observed with the IPC on 1980 April 11, for an effective exposure time of 8800s. During the exposure, 2345 net IPC source counts were detected. The pulse-height distribution is shown in Figure 1. The spectrum is very soft, consistent with all of the counts being caused by photons of energy less than 0.28 keV.

II. DISCUSSION

X-ray spectrum analysis is performed by folding a source model spectrum through the detector response function and comparing the result with the data via a χ^2 test. The source of the X-rays is assumed to be a volume of gas at a single temperature having an emission spectrum (continuum plus lines) as calculated by Raymond and Smith (1979). The source spectrum may be attenuated by a foreground column of material having the opacity per hydrogen nucleus of the interstellar medium given by Brown and Gould (1970). The source temperture, T, emission measure, EM = N_e^2 x Volume, and the foreground column density, N_H, are free parameters in the fitting process. In addition, the value of the IPC gain used by the detector response function has been allowed to vary ± 10% to accomodate uncertainties in the IPC calibration.

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The results of the spectral fitting are shown in Figure 2. Below the solid line is the 90 % confidence region in the T versus N_H plane, determined using the procedure described by Lampton, Margon and Bowyer (1976). Also shown are contours of the best-fit emission measures. If we adopt the M_V of an ordinary K3 III star then the object's V = 9.4 indicates a distance of 700 pc. From the data of Heiles (1974) we then estimate a foreground interstellar hydrogen column density of 3 x 10^{20} cm^{-2} for this distance in this direction. A further limit on the likely values of the emission measure can be made following the technique described by Nordsieck, Cassinelli and Anderson (1981). The absence of various coronal lines in the visable spectrum at the 1 A equivalent width level limits allowable models to the region of the EM versus T plane below the various lines in Figure 3. The combination of these loci transforms to the long-dashed line in Figure 2. Together these numbers and reasonable estimates of the uncertainties therein lead to the following characteristics for the X-ray source in AG Dra :

$T = 1.1 \times 10^{6}$ K
$EM = 2.6 \times 10^{55}$ cm^{-3}
$N_H = 3 \times 10^{20}$ cm^{-2}
L_x (.2-1.0 keV) = 5×10^{32} ergs s^{-1}

Because of the uncertainty in the IPC gain and its relatively broad smearing function and because of the multiplicity of and uncertainty in the free parameters in the fitting procedure, all of these characteristics are uncertain by factors of the order of 2.

The implications of these observations are discussed in more detail by Anderson, Cassinelli and Sanders (1981) who find that if the source of the luminosity is to be associated with mass transfer from a red-giant to a white dwarf, an extraordinarily large mass loss rate is required. On the other hand, this luminosity would be produced if about 10% of the acoustic flux expected in a K3 III star were converted to X-rays in a chromosphere-corona region. Efficiencies of this order are not unusually high.

Recently we have investigated as an alternate input model spectrum a simple Planck function. With the same foreground column density adopted above we find that the best fit temperature is 2.5 x 10^{5} K and the emitting area corresponds to a sphere of a thousasnd kilometers radius. Just at the lower limit of acceptability in the model fits is a temperature of 1.5 x 10^{5} K and a radius of 1.4 x 10^{4} km .

The X-ray observation was made during the rise to the most recent, unusually bright maximum. The object was to be reobserved, but the untimely demise of the HEAO-2 spececraft made this impossible.

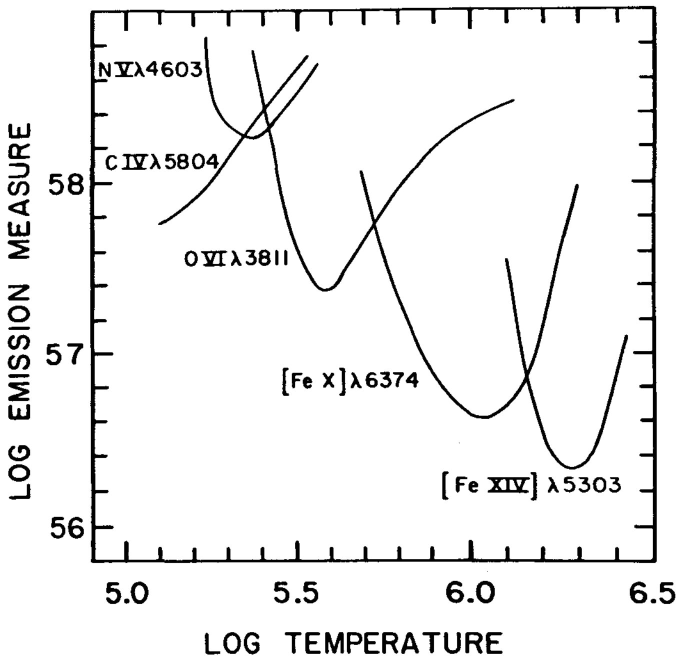

Figure 3. The EM, T plane for AG Dra. The absence, at the 1 A equivalent width level, of each of the indicated coronal lines restricts the object to the region below the various lines.

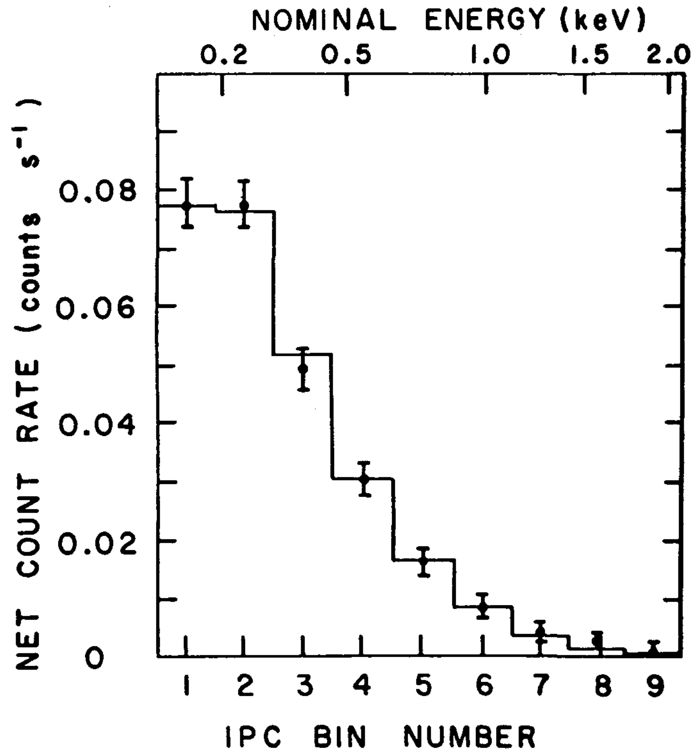

Figure 1. Pulse height distribution in IPC counts per second per energy bin versus IPC bin number. Error bars indicate 1 σ statistical uncertainty. The solid line is the best fit model with N_H fixed at 3 x 10^{20} cm^{-2}, and T = 1.3 x 10^6 K, and EM = 7 x 10^{54} cm^{-3}.

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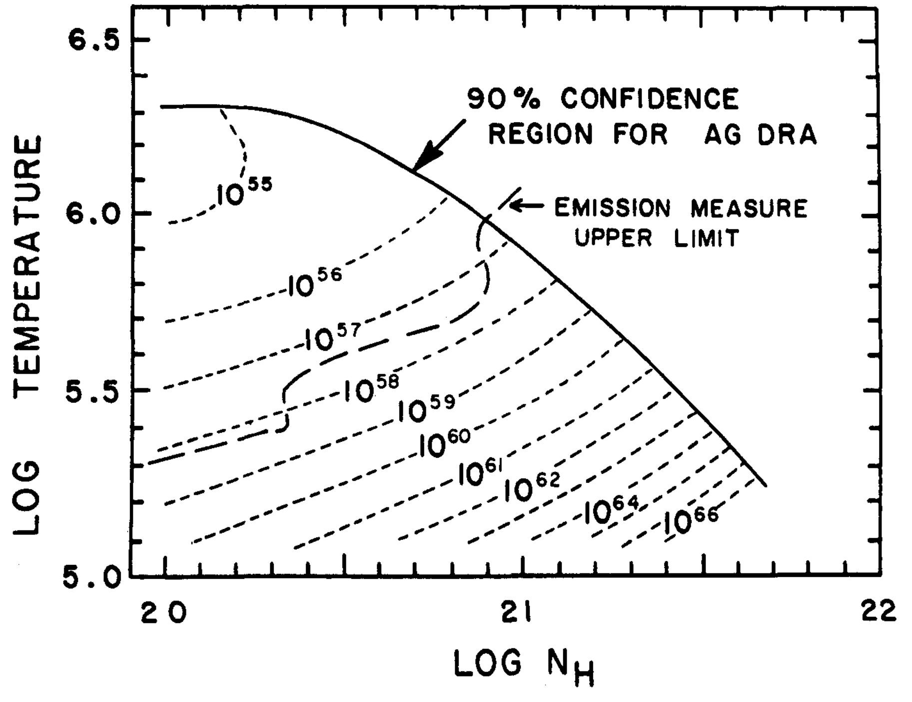

Figure 2. The region below and to the left of the solid line is the 90% confidence region for the AG Dra temperature and absorption column density. Inside the 90% confidence region are contours of the best fit emission measures. Allowance has been made for a ± 10% untertainty in the IPC gain.

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REFERENCES

Anderson, C. M., Cassinelli, J. P. and Sanders, W. T. 1981, Ap.J. 247, L127.

Brown, R. L. and Gould, J. R. 1970, Phys. Rev. D, 3d Ser., 1, 2252 .

Heiles, C. 1974 Astr. Ap. Supl., 20, 37.

Lampton, M, Margon, B., and Boyer, S 1976, Ap.J., 208, 177 .

Nordsieck, K. H., Cassinelli, J. P. and Anderson, C. M. 1981, Ap.J. 248, 678.

Raymond, J. C. and Smith B. W. 1979 , private communication.

DISCUSSION ON X-RAY OBSERVATIONS

Keyes: The HeII 1640 A Zanstra temperature of AG Dra before outburst interpreted with Hummer and Mihalas (1970) log g = 5.0 models, is about 120000K, and the stellar radius, implied by integration of the observed ultraviolet flux is very roughly 2.5×10^4 km.

Viotti: We have estimated the hydrogen column density from the Ly interstellar line in the high resolution IUE spectra of AG Dra obtained after the outburst, and showing a detectable continuum down to $\sim$1200 A. We found log N(HI)$\sim$20.2 in agreement with the X-ray determination and with the weakness of the 2200 A band.
As regards the other three X-ray sources, I note that they also are radio sources, and I would like to know what are the physical implications of this.

Kwok: In response to Dr. Viotti question, the X-ray emission from HM Sge, V1016 Cyg, and RR Tel may be the result of wind interactions in these systems. If part of the kinetic energy from a hot star wind is dissipated in the collision process, enough X-rays can be produced to be observable.