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IDENTIFICATION AND PROPERTIES OF THE M GIANT/X-RAY SYSTEM HD 154791 = 2A 1704+241

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ABSTRACT

We identify the *Ariel V* X-ray source 2A 1704+241 (= 4U 1700+24 = 3A 1703+241) with the M3 II star HD 154791. The identification is based on a precise X-ray position determined by the *HEAO 1* scanning modulation collimator and the *Einstein Observatory* imaging proportional counter, together with a spectrum measured by the *International Ultraviolet Explorer*. The ultraviolet spectrum shows strong emission of C IV λ1550 Å, N V λ1238 Å, and Mg II λ2800 Å, which is very unusual among M giants. This is the first X-ray detection of an M giant which has a completely normal optical spectrum. The X-ray luminosity reaches three orders of magnitude above the mean upper limit for the coronal X-ray flux from M giants. Although we have no direct evidence for a binary system, since we have not observed radial velocity variations, we show that a plausible neutron star binary model can be constructed.

Subject headings: stars: individual — stars: late-type — ultraviolet: spectra — X-rays: binaries

I. INTRODUCTION

The high positional accuracy given by the *HEAO 1* scanning modulation collimator (MC) and *Einstein Observatory* imaging proportional counter (IPC) revealed a surprising candidate for the *Ariel V* X-ray source 2A 1704+241: the optically normal M giant star HD 154791. Because of the relatively high surface density of M stars and the normal optical spectrum of this particular one, the identification could not be considered absolutely certain on the basis of the X-ray position alone. Subsequently, spectra taken with the *International Ultraviolet Explorer* (*IUE*) showed strong emission of C IV, N V, and Mg II, thus confirming the identification.

We report on the X-ray position, spectrum, and variability in § II, the optical spectra in § III, and the ultraviolet observations in § IV. We discuss a compact binary model for this star in § V. The only previously known M giant associated with an X-ray source is GX 1+4 (Davidsen, Malina, and Bowyer 1977), which is a symbiotic star showing a rich, high-excitation emission-line spectrum. Recently, the symbiotic star AG Dra has been observed to have an X-ray luminosity similar to HD 154791 but a much softer spectrum (Anderson, Cassinelli, and Sanders 1981). The cataclysmic variable T CrB has a M giant primary (Kraft 1958). We suggest that a higher wind velocity and/or lower mass loss rate explain both the lower X-ray luminosity and the absence of the emission-line spectrum in the case of HD 154791 as compared to GX 1+4.

II. X-RAY OBSERVATIONS

a) *Position*

We have binned the *HEAO 1* MC data about the center of the *Ariel V* position on three seprate scans (for a description of the instrument and the data analysis technique, see Schwartz *et al.* 1978 and Gursky *et al.* 1978), centered at 1977 September 5, 1978 March 3, and 1978 September 4. The only individual scan in which the MC data clearly reveal a source is the third, when we detect a 4.5 ± 1.8 μJy[7] source at 3.9 σ in both the 30″ and 2″ collimators. The greater sensitivity of the *HEAO 1* A-2 experiment (Rothschild *et al.* 1978) also yielded a detection in the first scan at about 1.4 μJy. One of four possible MC intersections, of total area 7.5 arcmin^2 within the 2A catalog (Cooke *et al.* 1978) uncertainty region, contained a 7th magnitude star. As part of a survey of 2A error boxes, 2A 1704+241 (= 3A 1703+241; McHardy *et al.* 1981) was observed with the *Einstein Observatory* on 1980 March 7, for 2000 s using the IPC (see Giacconi *et al.* 1979 for a description of the instrument and analysis). A source was detected at a position consistent with the star and gave a flux density of 1.1 ± 0.1 μJy in the monitor proportional counter (MPC).

Intersecting the MC and IPC positions yields a joint error region of 1.1 arcmin^2 which contains HD 154791 (Fig. 1), listed as $m_v = 7.3$, spectral type = Ma in the

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[7] For an assumed Crab-like spectrum averaged over 2–11 keV. Flux densities at 5.2 keV convert as follows: 1.0 *Ariel V* SSI counts s^{-1} = 2.5 μJy, 1.0 UFU = 1.1 μJy, 1.0 MPC counts s^{-1} = 0.8 μJy; 1.0 μJy = 0.242×10^{-11} ergs cm^{-2} s^{-1} keV^{-1}.

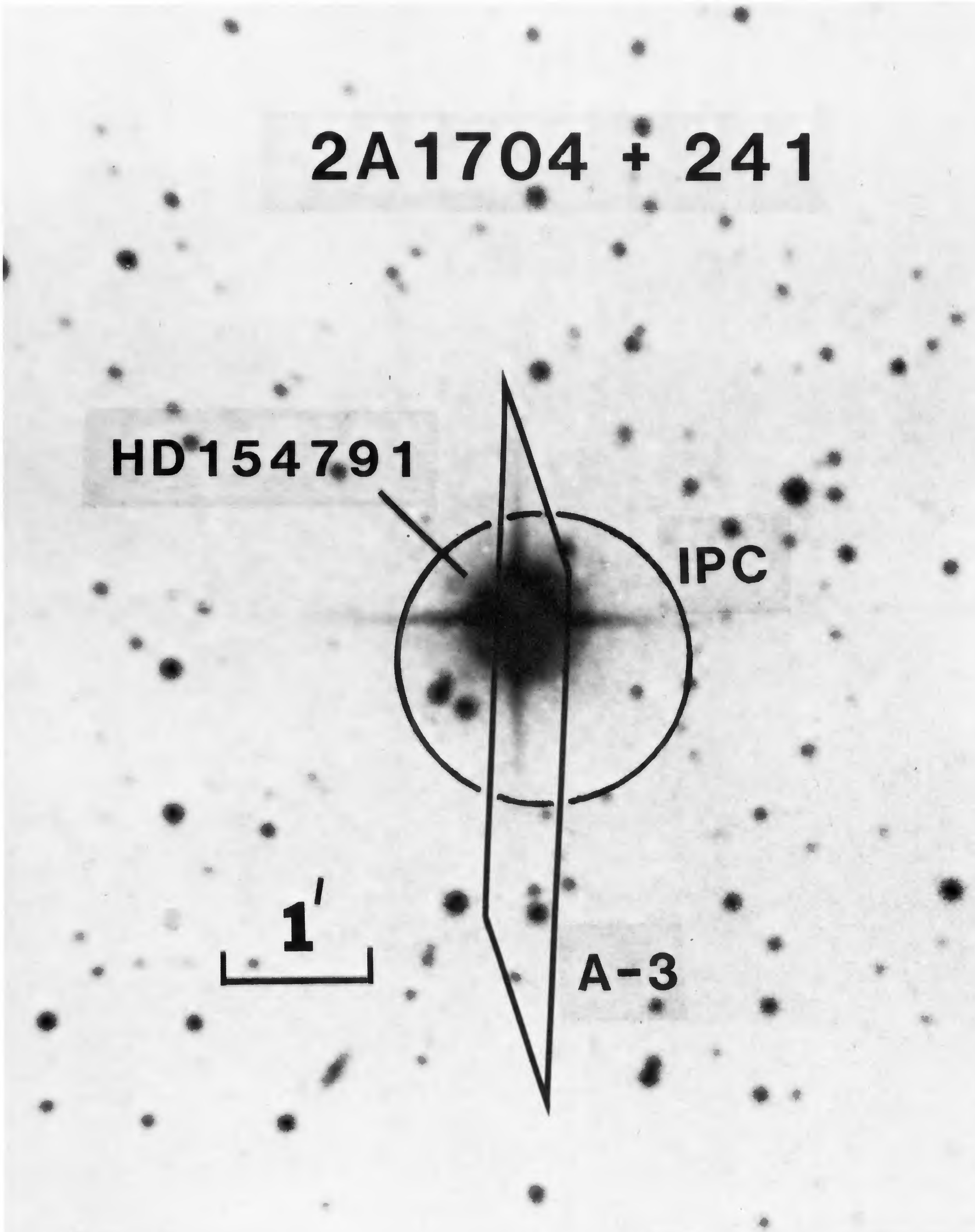

FIG. 1.—Overlay of the X-ray positions for 2A 1704+241. The *HEAO 1* MC error diamonds and *Einstein* IPC error circle are superposed on the POSS red plate. Spectra have been taken of the five stars visible inside the IPC circle.

Henry Draper catalog. It does not appear in the *General Catalog of Variable Stars* (Kukarkin *et al.* 1970). The SAO catalog lists this star as number 84844 at R.A.(1950) = $17^h04^m29^s.718$, decl.(1950) = $+24°02'13''.96$. The probability of a star brighter than 8th magnitude falling in this error region is 2×10^{-4} at the galactic latitude of 45°. With about 100 strong X-ray sources at high galactic latitude, the probability of a star brighter than 8th magnitude falling within any error region becomes 2%, making the identification likely, *but not certain*, solely on positional grounds. However, single late-type stars are not expected to be bright, hard X-ray sources. We thus turned to optical and ultraviolet data for supporting evidence and for clues to the emission mechanism.

b) Variability

The X-ray source 2A 1704+241 was first reported in the 2A catalog (Cooke *et al.* 1978) at a peak flux of 4.2 μJy with variability of a factor of three. It also appears in the fourth *Uhuru* catalog (Forman *et al.* 1978) at a peak flux of 4.6 μJy with variability greater than a factor of 2. We have combined the fluxes and upper limits measured by four different X-ray satellites into a single long-period light curve (Fig. 2). The source is clearly variable by at least a factor of 8 on the time scale of years. Figure 2 (*insert*) also shows variability by at least a factor of 2 in a few hours.

Looking at 100 s averages of the IPC counting rate during the 1980 March observations (Fig. 3, *left*), we can see three nearly equally spaced distinct peaks. The possibility of periodic emission prompted the second, longer observation on 1980 September 26 (Fig. 3, *right*). In this observation the source again showed 15 minute quasi-periodic variations with an amplitude of nearly 50%, but *without* phase coherence. A Fourier transform of the 1980 September 26 data revealed no excess for periods between 2.3 and 2700 s to a limit of roughly 40% amplitude.

The GSFC Cosmic X-ray Spectroscopy Experiment on *OSO 8* (CXSE) observed 2A 1704+241 in 1975 August–September and 1977 September with the A detector, a xenon detector having a 5° FWHM field of view and an energy range of 2–60 keV (Serlemitsos *et al.* 1976). Each observation spans a little over a 2 week period. During each observation 2A 1704+241 had a flux level in the range 0.5–9.2 μJy and was variable on a time scale of days. Although short-term variability is also evident, a power spectrum analysis failed to disclose any significant periodicity, and we can set an upper limit of 30% to the pulsed fraction for periods on the order of 15 minutes.

c) Spectrum

In order to determine the X-ray spectrum of the source, a thermal spectrum was folded through the detector response function and then compared to the observed counts using a χ^2 test. The temperature and hydrogen column density are free parameters in the fitting process. The *OSO 8* spectrum for the 1977 observation is best fit by a thermal bremsstrahlung model with $kT \simeq 15$ keV and an equivalent hydrogen column density of $\sim 10^{22}$ cm^{-2}. This model fit is shown in Figure 4 along with the 90% confidence contour (which we calculate in accordance with Avni 1976) for n_H and kT. A power law (number spectrum $\propto E^{-1.9}$)

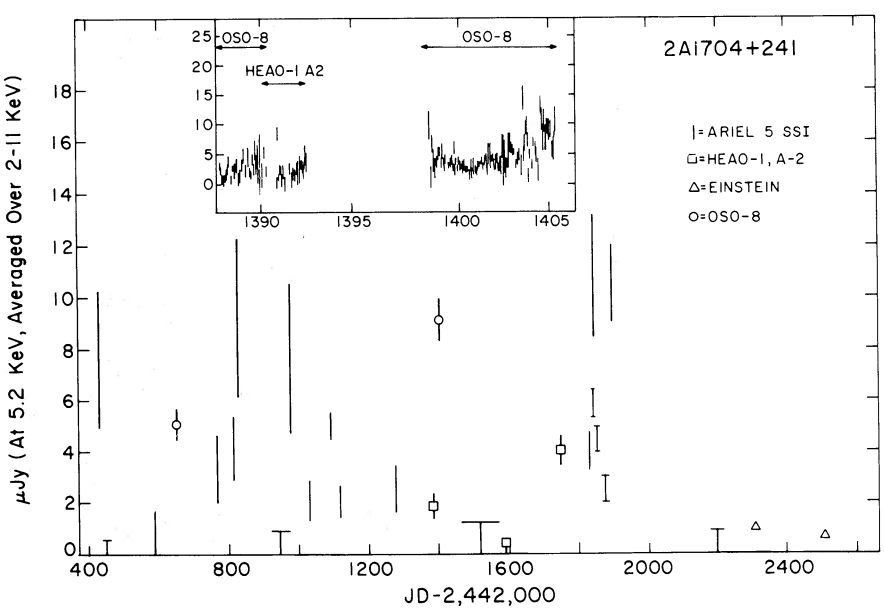

FIG. 2.—The long term composite X-ray light curve for 2A 1704+241. The insert shows short-time scale variability in the *OSO 8* and *HEAO* A-2 data near relative day 1400. The *Ariel V* SSI data points are 1–5 day averages. We have further averaged some points over longer periods; the length of the horizontal bar indicates the time over which the averages have been made. Only a few data points enter the long period averages.

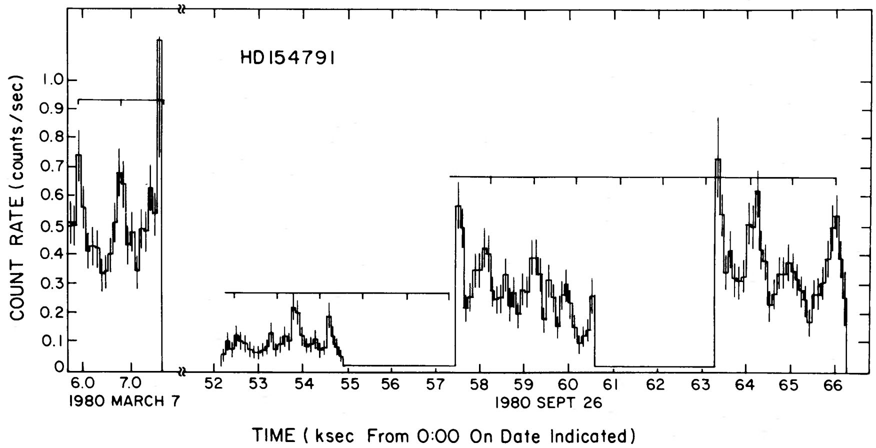

FIG. 3.—The *Einstein* IPC light curve for 2A 1704+241. The data in PHA channels 1–31 (nominally 0.1–5.0 keV) have been binned in 100 s time intervals. Based on normalization to the MPC during the 1980 March observation, 1 IPC count $s^{-1} = 2.7 \times 10^{-11}$ ergs cm^{-2} s^{-1} (from 2–6 keV). The variations are quasi-periodic, but phase coherence is not maintained. The tick marks above the data are equally spaced 15 minutes apart.

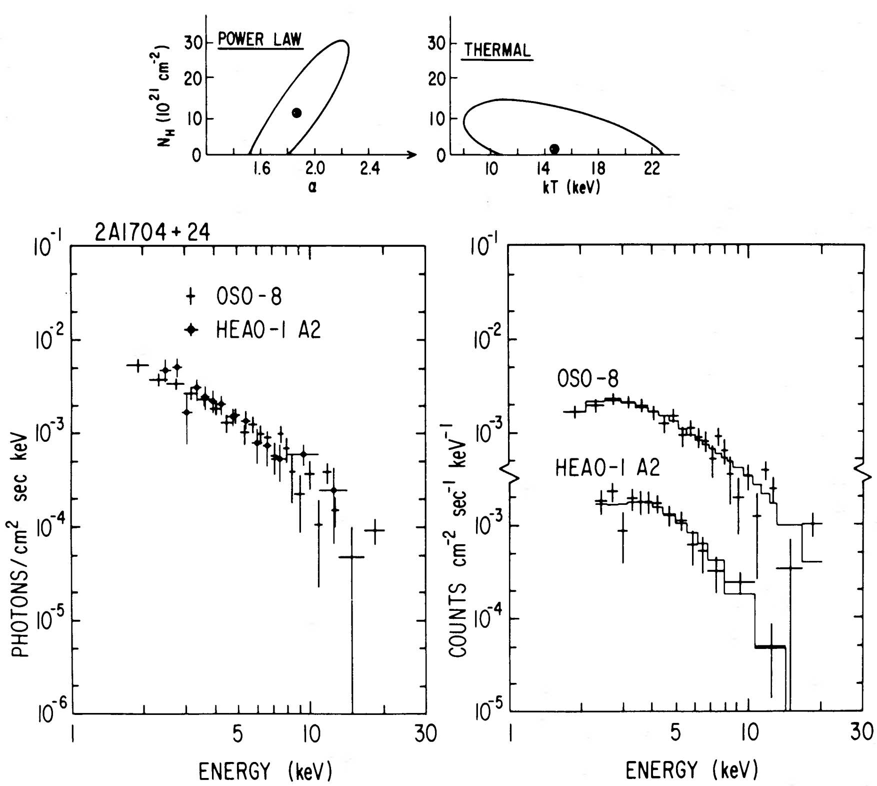

FIG. 4.—The top two graphs show the spectral parameters for power-law and thermal bremsstrahlung that best fit the *OSO 8* 1977 spectrum, along with their 90% confidence contours. The bottom right figure shows the measured fluxes from *HEAO 1* A-2 and *OSO 8* compared to those predicted from the best fit spectra (*solid line*). The bottom left figure shows the inferred incident photon flux, which is consistent between the two satellites.

also provides an acceptable fit. The 2–11 keV flux derived from the thermal model is $8.5^{+0.7}_{-0.2} \times 10^{-11}$ ergs cm^{-2} s^{-1}. We can place an upper limit on the equivalent width of iron line emission of 800 eV, which does not exclude its presence since an optically thin thermal model predicts an equivalent width of 600 eV for $kT = 15$ keV and approximately solar abundance of Fe.

The 1977 spectral data from the *HEAO 1* A-2 argon detector was best fitted with an 11.8 keV thermal bremsstrahlung model, consistent with that derived from the *OSO 8* data. The spectrum measured during the *Einstein* observations is also consistent with these parameters.

In addition to measuring the time integrated spectrum, we searched for spectral variability on the observed 15 minute time scale of the IPC intensity variations. In order to do this, we computed the hardness ratio of the source using the method of Fabbiano *et al.* (1981). The data of the March 7 observation was divided into four equal time bins of 7.5 minutes length, giving two bins when the source was in the high state, and two when it was in the low state. The results are consistent with a constant hardness ratio of 0.68 ± 0.5, in contrast to the correlation of harder emission with greater intensity found in U Gem by Fabbiano *et al.* (1981).

III. OPTICAL OBSERVATIONS

In order to search for a binary companion and the emission lines that typically characterize an accretion driven X-ray source (McClintock, Canizares, and Tarter 1975), we have obtained high- and low-dispersion optical spectra of the bright star HD 154791 and four others that are in the IPC circle (Fig. 1). We have also obtained a series of high dispersion (echelle) spectra of HD 154791.

a) *Low Dispersion*

Spectra of all five stars were taken with the 1.3 m telescope at McGraw-Hill Observatory on 1980 July 4. They all showed normal late-type stellar spectra. HD 154791 again showed a normal late-type spectrum on 1981 February 17 (F. Walter, 1981, private communication). A spectrum of this star with very high signal-to-noise ratio was taken by J. Huchra on 1981 March 9 (Fig. 5) with the 1.5 m telescope at Mount Hopkins Observatory using the *z*-machine spectrograph and intensified Reticon array (Davis and Latham 1979). In order to eliminate a coincidence counting effect when looking at this bright star, a number 1 neutral density filter was used in the spectrograph. We have compared this spectrum to a template M giant spectrum on an expanded wavelength scale. There are no significant differences between the two. None of the emission lines (Hα, Hβ, He II λ4686) characteristic of accretion driven X-ray sources were detectable.

b) *High Dispersion*

In order to evaluate the level of chromospheric activity and to search for duplicity, 10 echelle spectra of HD 154791 were taken from 1980 June to 1981 February (Table 1). These cover a 30 Å region around the Ca II K (3933 Å) line with 0.04 Å resolution and

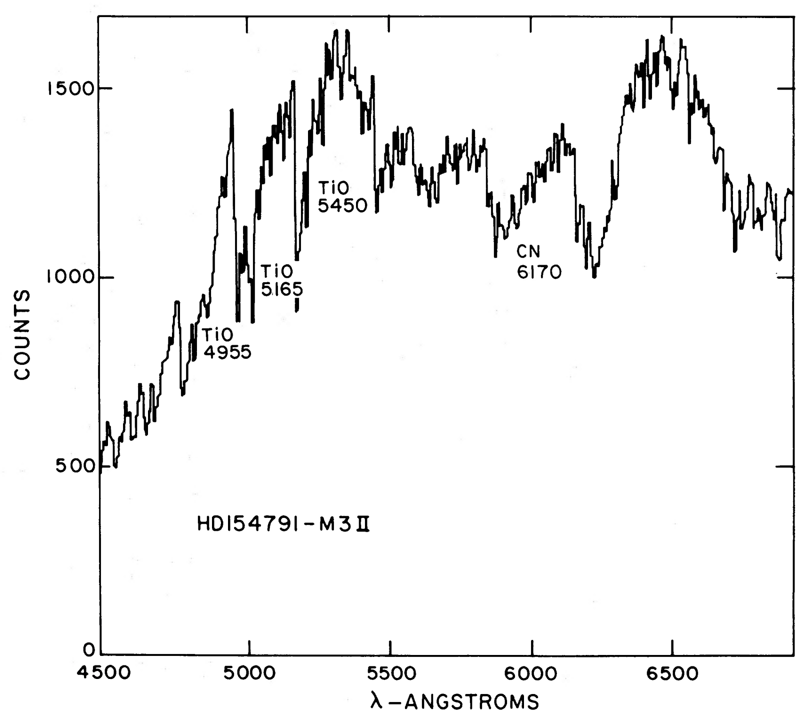

FIG. 5.—Spectrum of HD 154791 on 1981 March 9, taken with the *z*-machine spectrograph and intensified Reticon array on the 1.5 m telescope at Mount Hopkins. The spectrum is that of an M3 giant. There is no emission evident at Hα, Hβ, or He II λ4686.

TABLE 1

ECHELLE OBSERVATIONS

Date	Time (UT)	ΔV_{rad}[a] (km s^{-1})
1980 Jun 30	7:37	−2
1980 Aug 28	2:00	+2
1980 Aug 29	3:20	+3
1980 Sep 2	3:51	0
1981 Feb 14	12:15	0
1981 Feb 14	12:41	−3
1981 Feb 14	13:05	0
1981 Feb 16	12:20	−1
1981 Feb 16	12:43	−3
1981 Feb 16	12:55	−1

[a] Based on calibration to β Dra on 1980 Jun 30, $V_{rad} = -48$ km s^{-1}.

were obtained with the echelle spectrograph and intensified reticon detector on the 1.5 m reflector at Mount Hopkins Observatory. Figure 6 is the sum of three 20 minute exposures taken on the night of 1981 February 13/14, and it is typical of all the other echelle spectra. The level of Ca II K emission seen here is high, but not unusual for an M giant (Wilson 1976).

To search for a secondary star, we calculated the cross-correlation function (cf. Tonry and Davis 1979; Garcia *et al.* 1980) of the photospheric spectra of HD 154791 with that of Arcturus, a single, sharp-lined template of high signal-to-noise ratio. In order that only the absorption lines contribute to the correlation, the emission core was excised from each of the spectra. The cross-correlation functions show only one peak, indicating that any companion must have photospheric lines in the region much weaker than those of HD 154791.

To search for radial velocity variations, we used one of the photospheric spectra of HD 154791 as a template and calculated the cross-correlation function with each of the other nine photospheric spectra. After correcting to a heliocentric wavelength scale, the position of the cross-correlation peak can be used to search for radial velocity variations. As can be seen from Table 1, the peaks of all nine of the cross-correlations match to within our systematic uncertainty of approximately 3 km s^{-1}. This indicates that the radial velocity variations imparted to this M giant by any companion must be less than 3 km s^{-1} over the 8 months of our observations. The observations are sufficiently well spaced that we can exclude periodicities with amplitudes in excess of ~ 5 km s^{-1} on time scales from 40 minutes to ~ 1 year.

We measure the width of the Ca II emission line to be 1.98 ± 0.1 Å at the base. By using the Wilson-Bappu relationship (Engvold and Rygh 1978) we calculate a M_v of -2.3 ± 0.25 from this width, indicating a luminosity class of II (Morgan, Keenan, and Kellman 1943). The measured hydrogen columb density in the direction of HD 154791 ($= 7.2 \times 10^{20}$ n_H cm^{-2}; Heiles 1975) indicates that there are 0.28 mag of interstellar absorbtion. The observed m_v of 7.3 then indicates a distance of 730 ± 90 pc to this star.

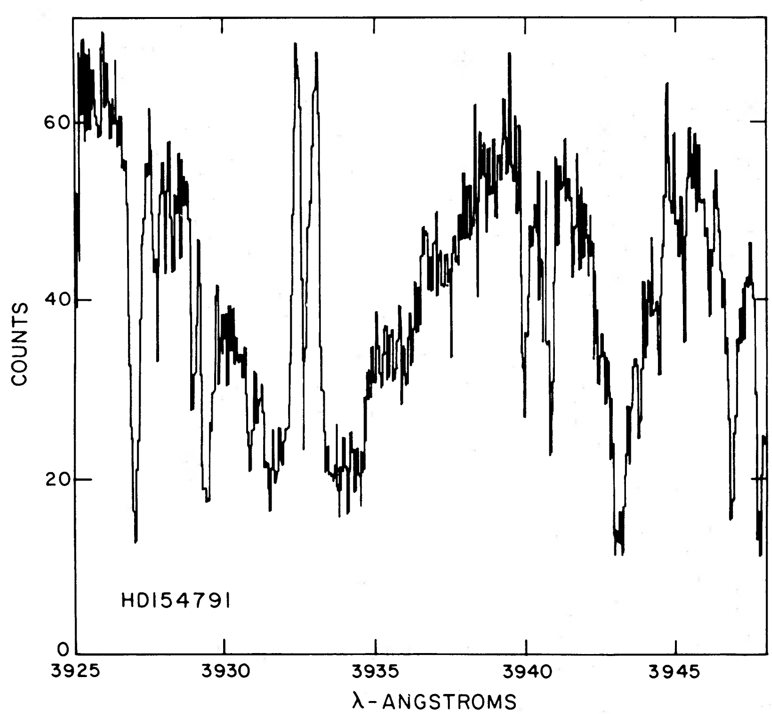

FIG. 6.—Spectrum of the Ca II Ka λ3933 line taken with the echelle and intensified Reticon on the 1.5 m reflector at Mount Hopkins. The resolution is 0.4 Å. The level of K line emission is typical for an M giant. The width of the K line indicates a luminosity class II star.

TABLE 2

Broad-Band Optical Fluxes

Color	Mag
U	11.26 ± 0.02
B	9.132 ± 0.028
V	7.791 ± 0.022
J	4.317 ± 0.026
H	3.427 ± 0.013
K	3.277 ± 0.023
L	2.91 ± 0.2
Observers	M. R. Sherrington and R. F. Jameson, Astronomy Department, University of Leicester
Telescope	IR flux collector, Cabezon Observatory, Tenerife
Detector	Leicester InSb Photometer system

c) *Colors*

In addition to measuring the spectrum of this star, we have also the optical and infrared broad-band colors measured by M. R. Sherrington and R. F. Jameson at the 1.5 m telescope in Tenerife. Their results taken on 1981 May 15 are shown in Table 2. They find that the colors do not vary in additional observations on 1981 May 17 and 18. The interstellar absorbtion of 0.28 mag leads us to expect approximately 0.1 mag of reddening. However, the colors are consistent with those from a normal M giant, except that the star is 0.3 mag brighter than normal in the blue.

IV. ULTRAVIOLET OBSERVATIONS

Observations with the *IUE* satellite first demonstrated clearly the anomalous nature of HD 154791. Figure 7 shows the long and short wavelength spectra of this star obtained on 1980 December 14. The emission lines C IV λ1550 Å, Mg II λ2800 Å, and N V λ1238 Å are evident; their fluxes are listed in Table 3. These lines are similar to those found in the UV spectra of cataclysmic variables. The high temperature lines of C IV and N V have never been found in a solitary M giant (Linsky and Haisch 1979; Hartman, Dupree, and Raymond 1981).

A short wavelength ultraviolet continuum was not found. We can place an upper limit on the continuum ultraviolet flux of 1.5×10^{-14} ergs cm^{-2} s^{-1} Å^{-1} at the Earth, corresponding to an ultraviolet luminosity of less than 2×10^{33} ergs s^{-1} (from 1200–2800 Å). There is some ultraviolet continuum visible at long wavelengths. From 2950 Å to 3150 Å one can see a rising continuum

TABLE 3

UV Line Fluxes

Line	λ (Å)	FWZI (Å)	Flux (10^{-13} ergs cm^{-2} s^{-1})
N V	1238	10.0	2.6
C IV	1550	17.8	11
Mg II	2800	15.6	5.6

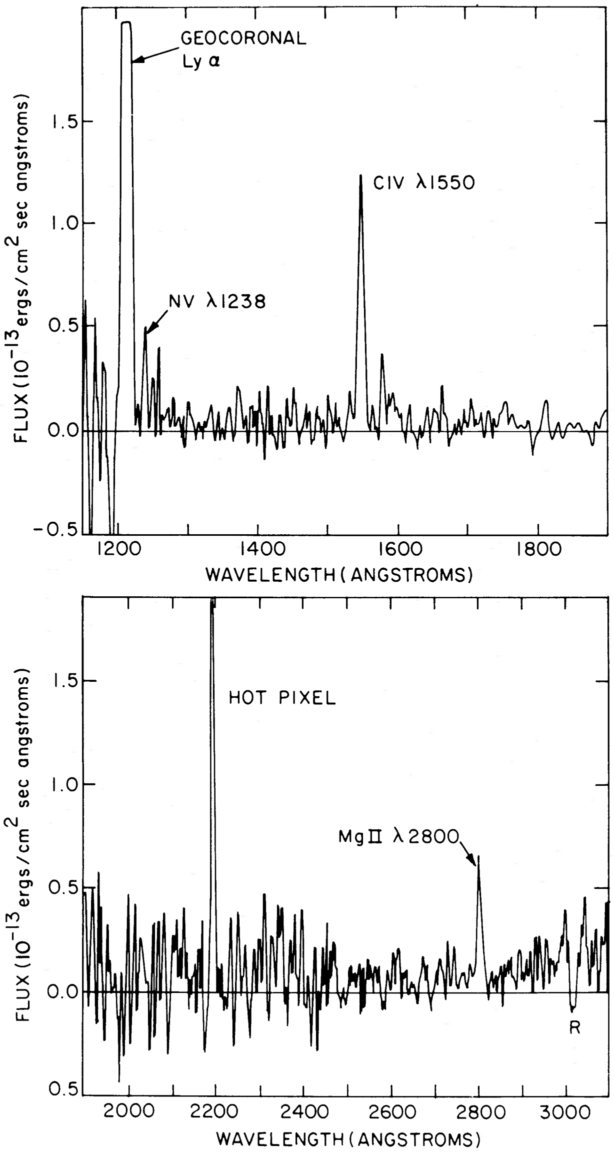

Fig. 7.—The long and short wavelength *IUE* spectrum. The exposure time was 30 minutes. R denotes reseau, a fiducial mark. Longward of 2900 Å, the continuum due to the M giant is apparent.

with a flux of approximately 3×10^{-14} ergs cm^{-2} s^{-1} Å^{-1} Scaling *OAO 2* observations of β Peg appropriately (Koornneef *et al.* 1980) indicates that a normal M giant spectrum would have a flux of 3.5×10^{14} ergs cm^{-2} s^{-1} Å^{-1} at 3000 Å, which is consistent with that observed in this star.

V. DISCUSSION

The combination of a precise X-ray position and an unusual ultraviolet spectrum make the identification of HD 154791 with the X-ray source 2A 1704+241 virtually certain. At the indicated distance of 730 pc the 2–11 keV X-ray luminosity of this star ranges from

$\lesssim 10^{33}$ to 1.1×10^{34} ergs s^{-1} and is 5.4×10^{33} ergs s^{-1} during the 1978 September *HEAO 1* observation.

The absence of radial velocity variations over 8 months would naively indicate that HD 154791 is not a binary star. The fact that its X-ray flux is three orders of magnitude above the *Einstein Observatory* stellar survey limit for coronal emission from M giants (Topka *et al.* 1982) indicates that it is not a coronal X-ray emitter. Thus it is not obvious that either of the two standard explanations for X-ray flux are plausible scenarios for 2A 1704+241. If this is an M giant star with an X-ray emitting corona, there should be some evidence of an active chromosphere in its optical spectrum. If it is a binary, we ask whether reasonable models can be constructed in which optical emission lines and radial velocity variations are not expected to be observable, without invoking a projection factor $\sin i = 0$.

a) *Coronal Models*

Three other arguments against a coronal interpretation are the lack of strong Ca II emission, the high X-ray temperature, and the low stellar rotation rate. Strong Ca II emission has been found to be a good predictor for X-ray emission from hot coronae in cool stars (Mewe and Zwaan 1980), and the level of emission seen in this star is typical of that seen in other M giants (Wilson 1976). The measured X-ray temperature of 15 keV is much higher than that typically found in coronae ($\lesssim 1$ keV; Vaiana *et al.* 1981), except for flares in RS CVn systems (Garcia *et al.* 1980; Swank and White 1980). This last argument is extremely qualitative, of course, and might be obviated if the star is in a continual flaring state (cf. Fig. 2). Swank *et al.* (1981) also detect the presence of additional components with $kT = 2$–8 keV in RS CVn systems. Finally, the association of X-ray luminosity with stellar rotation rate (Walter 1981; Pallavicini *et al.* 1981, Fig. 5) would require equatorial velocities two or more orders of magnitude greater than the escape velocity from the M giant.

b) *Binary Models*

Temperatures of 15 keV or more are typical of those found in X-ray binaries (Bradt, Doxsey, and Jernigan 1978 and references therein). Also, fast quasi-periodic variability like that seen in this star has been seen in other binaries, most notably in the cataclysmic variables such as SS Cyg and U Gem (Córdova 1979; Cordova *et al.* 1980).

In constructing binary models of this source we are restricted to those that would show radial velocity changes of the primary of less than 3 km s^{-1} over 8 months. For the moment we will take the observed orbital velocity of the M giant to be equal to our upper limit of 3 km s^{-1}. We will assume the compact object is a neutron star and use standard models of stellar wind accretion (Davidson and Ostriker 1973; Lamers, van den Heuvel, and Pettersen 1976; Conti 1978) in order to determine if reasonable parameters can produce the observed X-ray flux.

In these models, the compact star accretes a fraction of the mass lost by the primary through its stellar wind (Lamers *et al.*, eq. [5]). The fraction is determined by the accretion radius (Lamers *et al.*, eqs. [6] and [7a])

$$Ra = \frac{2Gm}{V_{\rm orb}^2 + V_w^2 + V_t^2}, \quad (1)$$

where m is the mass of the secondary, $V_{\rm orb}$ is the orbital velocity of the two stars with respect to one another, and V_t is the thermal velocity of the wind. Because V_t is small ($= 10$ km s^{-1}: Bernat 1977; Deutsch 1960 and references therein) as compared with the stellar wind velocity V_w($= 30$ km s^{-1}; Reimers 1977), we will neglect it. The X-ray luminosity can now be written as the product of the mass infall rate and the released gravitational potential energy, times a conversion efficiency factor ξ which is typically of order 0.1 for neutron stars (Conti 1978, eq. [7])

$$L_x = \xi\left(\frac{\dot{M}}{4a^2}\right)\left(\frac{2Gm}{V_{\rm orb}^2 + V_w^2}\right)^2\left(\frac{Gm}{d}\right), \quad (2)$$

where d is the radius of the secondary, a is the separation of the two stars, and $\dot{M}$ is the mass loss rate of the primary. While there is a large range of mass loss rates found in M giants, a typical value is 10^{-9} $M_\odot$ yr^{-1} (Boesgaard and Hagen 1979). For a neutron star, m can be taken to be 1.4 $M_\odot$ (Rappaport and Joss 1977) and d to be 10^6 cm (Lamb 1977). By expressing $V_{\rm orb}$ in terms of the observed radial velocity of the primary ($V_{\rm obs}$) we introduce M (mass of the primary) and $\sin i$ into the equation. Unfortunately, the mass of M giants is rather poorly known. We are left with $\sin i$, a, and M as free parameters in the equation. This leads us to rewrite equation (2) as (assuming nearly circular orbits)

$$M = \left\{\left[\left(\frac{\xi\dot{M}}{L_x}\right)^{1/2}\left(\frac{Gm}{a}\right)\left(\frac{Gm}{d}\right)^{1/2} - V_w^2\right]^{1/2} \times \left[\frac{\sin(i)}{V_{\rm obs}}\right] - 1\right\} m \,. \quad (3)$$

With this form of the equation it is clear that we can draw lines of constant $\sin i$ on a graph of M versus a. Figure 8 shows the lines of constant $\sin i$ for the above parameters for a neutron star. There is a large range of parameter space allowed. The shaded area on the left of the graph is excluded because in this area Roche lobe overflow will occur. There is evidence that if Roche lobe overflow occurs the X-ray luminosity of the source would approach the Eddington limit of $\sim 10^{38}$ ergs s^{-1} (Arons 1973), and this clearly is not happening. We have used the formula of Paczyński (1971) to compute the Roche lobe limit. Based on the measurements of the radii of other cool giants (Wesselink, Paranya, and DeVorkin 1972) we have taken the radius of this M giant star to be 300 $R_\odot$.

The larger radius of a white dwarf (Allen 1973, p. 225) and correspondingly lower gravitational potential energy release upon infall require it to accrete 1000 times more mass flux than a neutron star in order to produce the

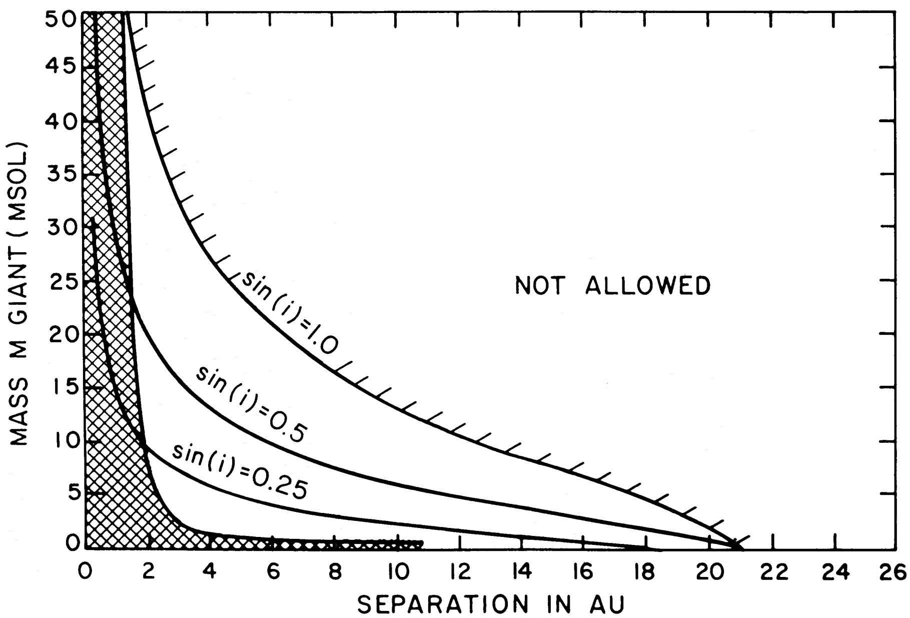

FIG. 8.—Contours of sin i in a plot of M giant mass vs. orbital separation. We have fixed the parameters $L_x = 5 \times 10^{33}$ ergs s^{-1}, $V_w = 30$ km s^{-1}, $\dot{M} = 10^{-9}$ $M_\odot$ yr^{-1}, and set the radial velocity at its upper limit of 3 km s^{-1}. The crosshatched area on the left is excluded since in this region we would have a contact binary and expect much higher L_x. This figure shows that a reasonable binary system can be constructed without requiring sin $i \sim 0$.

same X-ray flux. Calculations show that, in this case, a white dwarf cannot accrete enough of the stellar wind to produce the observed X-ray luminosity unless it is in a contact binary system. The system should then be a cataclysmic variable (CV), similar to T CrB, which is believed to be at the Roche lobe limit (Kraft 1958). In T CrB, which has an M giant secondary, optical emission lines are seen but are sometimes weak (Kraft 1958). The optical luminosity from HD 154971 is about 10 times that from T CrB (M II vs. M III), which might be enough to overpower any emission lines due to a CV-like component. The X-ray luminosity of HD 154791 is comparable to the maximum X-ray luminosity of CVs (Córdova, Mason, and Nelson 1981 and references therein). However, the analogy to T CrB implies the presence of a strong UV continuum (Krautter *et al.* 1982) which is clearly not present.

The lack of a blue continuum in the optical can be understood in the context of the binary model. The value of L_x/L_V for the accreting component in binary systems is bimodal and centered at ~ 1 and ~ 1000 (Patterson 1981). Using either of these values and scaling with the observed X-ray flux we find that the maximum possible optical luminosity from the compact component is $\sim 5 \times 10^{33}$ ergs s^{-1}, which is three orders of magnitude less than that from the M giant star ($\sim 10^{37}$ ergs s^{-1}; Allen 1973, p. 209).

The separation indicated in Figure 8 corresponds to orbital periods of 0.3–40 years for masses of the M gaint from 30 to 3 $M_\odot$. It is therefore likely that we have not searched for radial velocity variations over a long enough time span to detect them. We note that the X-ray luminosity is dependent upon V_{obs} to the fourth power (eq. [2]), and therefore predict that the time V_{obs} will be found to be near 3 km s^{-1} if it is measured over a long enough time span. Such a velocity is detectable if radial velocity standards are measured in order to calibrate the spectrograph each time HD 154791 is observed.

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