

These Aren't the Stars You're Looking For: On the Detection of X-ray Emission from HD 143352

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ABSTRACT

As part of a search for X-ray emission from RV Tau variable stars, we discovered a serendipitous X-ray detection of the closest RV Tau variable star, HD 143352. X-rays were detected in the 0.2-2.0 keV energy band, with most counts detected in the 0.5-1.0 keV band. The emission is consistent with a 10^6 K plasma and $L_X \sim 2 \times 10^{28}$ erg s⁻¹. This would be the second RV Tau star detected in X-ray emission. However, after estimating the temperature ($T_{\text{eff}} \sim 6000$ K) and bolometric luminosity ($L_{\text{bol}} \sim 4L_{\odot}$) from the spectral energy distribution, we place HD 143352 on the main sequence. These stellar parameters suggest HD 143352 is neither an RV Tau variable nor a post-asymptotic giant branch star nor a super giant, but rather an early F-type main sequence star. The X-ray emission detected from HD 143352 is consistent with coronal-like emission with $L_X/L_{\text{bol}} \sim 10^{-6}$.

Keywords: RV Tauri variable stars (1418), X-ray surveys (1824), F stars (519), Stellar activity (1580), Stellar classification (1589), Henry Draper catalog (719)

INTRODUCTION

RV Tau variable stars are luminous post-AGB objects, and only one, U Mon, has been detected in X-ray (Vega et al. 2021). Vega et al. (2021) suggest the X-ray emission could be due to interactions between the binary companion to U Mon and the system's circumbinary disk. Since many RV Tau stars are suspected binaries, X-ray emission may be prevalent among these stars. Hence, we initiated a survey of *Chandra* and XMM-Newton (XMM) archives to search for serendipitous X-ray observations of RV Tau variable stars¹. We report on the detection of HD 143352 in archival observations from XMM. This is the only confident detection from our larger search for serendipitous X-ray observations of RV Tau stars, which resulted in many objects that were either too distant, impacted by large extinction, or confused by crowded fields.

OBSERVATIONS AND RESULTS

HD 143352 was serendipitously observed by XMM on 2017-02-23 (Observation ID 0793183601; PI: Schartel) and 2018-01-30 (Observation ID 0800420201; PI: Zhekov) while targeting the recurrent nova T CrB for 61 ks and 25 ks, respectively, with the XMM pn detector. HD 143352 appears very close to the edge of the field of view of the XMM pn camera, and thus is likely impacted by vignetting and off-axis aberrations to the PSF. The star was detected in the XMM Serendipitous Source Catalog (SSC; Webb et al. 2020) with a 0.2-12.0 keV detection likelihood value (EP_8_DET_ML = 21) above the threshold used for entry into the SSC (EP_8_DET_ML = 6), and a count rate of 7 ± 2 cnt ks⁻¹. We assumed an optically-thin thermal plasma model ($T_X = 1$ MK) with intervening absorption ($N_H = 10^{20}$ cm⁻²) to convert the SSC count rates into physical flux units, which are displayed in Figure 1 along with the multiwavelength spectral energy distribution (SED) of the star². Based on this conversion, the total flux is $F_X \sim 5 \times 10^{-15}$ erg cm⁻² s⁻¹ and, assuming the Gaia parallax distance of 179 pc (Gaia Collaboration et al. 2016, 2018), the X-ray luminosity is $L_X \sim 2 \times 10^{28}$ erg s⁻¹.

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¹ Initial RV Tau sample selection was based on classification by the Simbad database (<https://simbad.u-strasbg.fr/simbad/sim-fsam>) using a criteria query with `otype=RV*`.

² The multiwavelength SED of the star was obtained from the Vizier photometry service: <http://vizier.unistra.fr/vizier/sed/>.

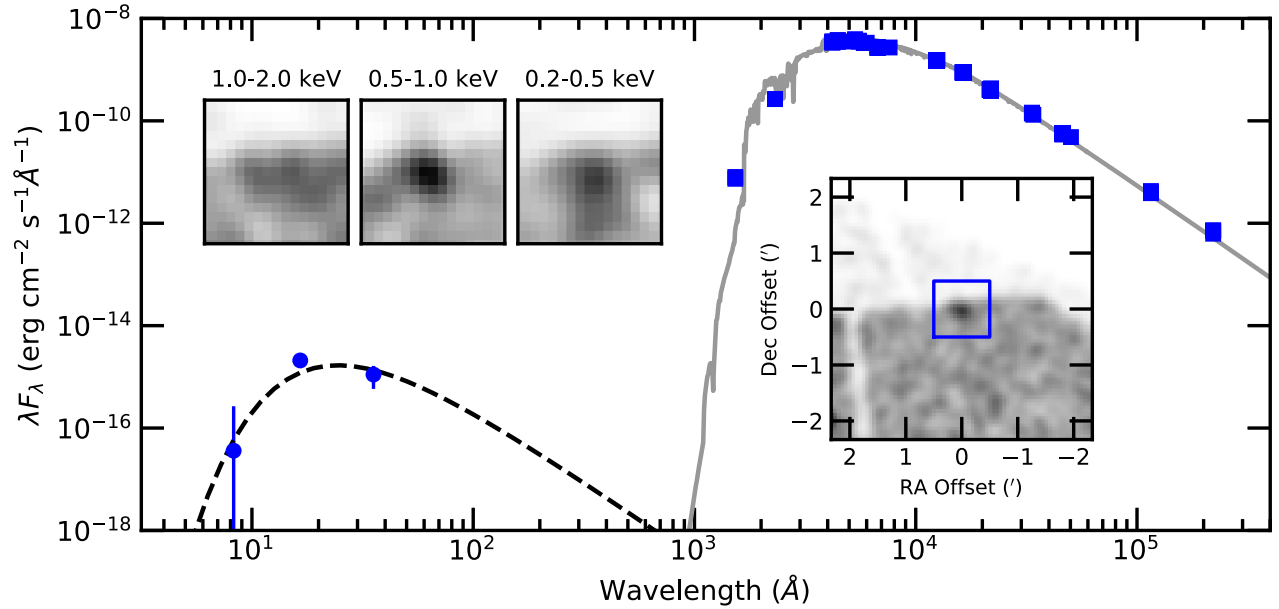


Figure 1. X-ray and multiwavelength emission from HD 143352. The X-ray to mid-infrared SED is shown along with a 1.5 MK blackbody curve (black dashed line) and a ~ 6890 K F2V stellar atmosphere model (solid gray line; [Castelli & Kurucz 2003](#)), to represent the X-ray (blue filled circles) and stellar (blue filled squares) emission, respectively. The larger inset shows the 0.2-2 keV XMM detection; the three smaller insets show a $1' \times 1'$ region filtered to the energy bands plotted in the SED. X-ray images were produced with only PATTERN zero events and smoothed by a Gaussian kernel with a FWHM of $15''$.

DISCUSSION AND CONCLUSIONS

The L_X/L_{bol} is commonly used to characterize the origin of X-ray emission from stars. We can estimate L_{bol} from the available measurements of HD 143352. Assuming the GAIA parallax distance and the Tycho-2 V -band magnitude (9.33 ± 0.02 mag; [Høg et al. 2000](#)), we determine $M_V \approx 3.1$ mag. We immediately recognize that this is quite faint for a luminous post-AGB star. In fact, given the temperature estimate of $\sim 6500 - 7000$ K, this faint M_V value and a main sequence bolometric correction gives $M_{\text{bol}} \approx 3.2$ mag, or $L_{\text{bol}} \approx 4 M_{\odot}$, placing HD 143352 directly on the main sequence. Naturally, at this moment, one second-guesses and double-checks their calculations, followed by a scramble to find any error in their methods. Finding no errors in our methodology, we turned to a deeper investigation into the historical classification of HD 143352.

Classification of an RV Tau variable star is based on the spectral types and light variations with alternating minima. HD 143352 was originally classified as a F2-type star by Annie Jump Cannon and Edward Pickering in the early 1900s as part of the Henry Draper Memorial catalog ([Cannon & Pickering 1921](#)). While making visual observations of the nearby recurrent nova T CrB, Roger S. Kolman serendipitously observed the variable nature of HD 143352—a strong parallel to our own study, where we have identified the serendipitous detection of HD 143352 in an X-ray observation targeting T CrB ([Zhekov & Tomov 2019](#)). Based on its apparent color (“yellowish-white”) and variability by almost a magnitude, Kolman suggested HD 143352 could be a new RV Tau variable ([Kolman 1965](#)). The General Catalog of Variable Stars ([Samus’ et al. 2017](#), and previous versions) lists HD 143352 as an uncertain RV Tau variable (‘RV:’) citing Kolman’s observations. Later, HD 143352 was considered to be “very likely post-AGB” in the Torun Catalog of post-AGB stars ([Szczerba et al. 2007](#)). In [Bódi & Kiss \(2019\)](#), the authors note that the sample of RV Tau variables in Simbad is contaminated by misclassified objects, though they provide no specific scrutiny of HD 143352.

Based on our analysis, we conclude that HD 143352 is a nearby F-type main sequence star misclassified as an RV Tau variable. Our conclusions are supported by the recent spectral analysis of APOGEE-2/SDSS-IV Data Release 16, which reports $T_{\text{eff}} \sim 6770$ K and $\log g \sim 4.2$ ([Jönsson et al. 2020](#)). Thus, HD 143352 is not the closest RV Tau variable star, nor is it the second RV Tau variable star detected in X-ray, and our search for X-ray emission from other RV Tau stars continues.

ACKNOWLEDGMENTS

S. G. acknowledges support from the NSF REU grant AST-1757321 and from the Nantucket Maria Mitchell Association. S. G. and R. M. express gratitude to the Curator of Astronomical Photographs at the Center for Astrophysics | Harvard & Smithsonian, Lindsay Smith Zrull, for providing an image of the spectral plate used to classify HD 143352 from the Harvard College Observatory Plate Stacks, Gary Walker and Dr. Regina Jorgenson, of the Nantucket Maria Mitchell Association, for discussions on optical observations of HD 143352 and review of our manuscript, respectively. This research has made use of data, software and/or web tools obtained from the High Energy Astrophysics Science Archive Research Center (HEASARC), a service of the Astrophysics Science Division at NASA/GSFC and of the Smithsonian Astrophysical Observatory’s High Energy Astrophysics Division. This research has made use of data obtained from the 4XMM XMM-Newton Serendipitous Source Catalog compiled by the 10 institutes of the XMM-Newton Survey Science Centre selected by ESA.

REFERENCES

- Bódi, A. & Kiss, L. L. 2019, *ApJ*, 872, 60.
doi:10.3847/1538-4357/aafc24
- Cannon, A. J. & Pickering, E. C. 1921, *Annals of Harvard College Observatory*, 96, 1
- Castelli, F. & Kurucz, R. L. 2003, *Modelling of Stellar Atmospheres*, 210, A20
- Gaia Collaboration, Prusti, T., de Bruijne, J. H. J., et al. 2016, *A&A*, 595, A1. doi:10.1051/0004-6361/201629272
- Gaia Collaboration, Brown, A. G. A., Vallenari, A., et al. 2018, *A&A*, 616, A1. doi:10.1051/0004-6361/201833051
- Høg, E., Fabricius, C., Makarov, V. V., et al. 2000, *A&A*, 355, L27
- Jönsson, H., Holtzman, J. A., Allende Prieto, C., et al. 2020, *AJ*, 160, 120. doi:10.3847/1538-3881/aba592
- Kolman, R. S. 1965, *AAVSO Abstracts*, October, p. 11.
- Samus’, N. N., Kazarovets, E. V., Durlevich, O. V., et al. 2017, *Astronomy Reports*, 61, 80.
doi:10.1134/S1063772917010085
- Szczerba, R., Siódmiak, N., Stasińska, G., et al. 2007, *A&A*, 469, 799. doi:10.1051/0004-6361:20067035
- Vega, L. D. et al. 2021, *ApJ*, 909 138.
doi:10.3847/1538-4357/abe302
- Webb, N. A., Coriat, M., Traulsen, I., et al. 2020, *A&A*, 641, A136. doi:10.1051/0004-6361/201937353
- Zhekov, S. A. & Tomov, T. V. 2019, *MNRAS*, 489, 2930.
doi:10.1093/mnras/stz2329