HD 63021: An Ae Star with X-ray Flux

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Subject headings: stars: circumstellar matter – stars: emission-line – stars: individual (HD 63021) – stars: variables: general – X-rays: stars

1. Spectroscopic Variability

Balmer and Fe II (42) multiplet emission were discovered in a spectrum of HD 63021 on 10 April (UTC), 2018. Subsequent observations revealed variability in both photospheric absorption lines and Balmer line emission.

Figure 1(a) shows Hα observations over the course of 18 nights. The emission morphology changes on a nightly basis; additional spectra not exhibited show that emission changes perceptibly on the scale of hours.

Three optical spectra (Figure 1(b)) demonstrate the spectral type, A1V(e), and photospheric absorption line variability. We determined the spectral type primarily from the Balmer line wing shape and metal line absorption strengths. The absorption line strength variability is on the ~ 20 % level for the Ca ii K, Fe i, Fe ii/Ti ii, and Mg ii lines labeled. We do not detect such variability in the Si ii λ 4128-4130 and Ca i λ 4226 lines, among others. The presence of such pronounced Fe i lines is unusual for A1V stars, as they are usually indicative of slightly later spectral types (e.g., A3-5V).
2. Archival Data

We plot the available infrared photometry using 2MASS, WISE, and AKARI data in Figure 1(c) to show that there is a substantial infrared excess beginning in the near-infrared that roughly follows the stellar Rayleigh-Jeans tail.

Photometric surveys have been used to estimate fundamental parameters for this star, with varying results. The McDonald, Zijlstra, & Bover (2012) and Cotten & Song (2016) surveys of stars with infrared excesses claim that this is an ∼A6 star with a surface temperature of ∼7300-7400K. Gaia DR2 (Gaia Collaboration 2018) quotes a large \( A_G \) (∼0.43 magnitude) and a similarly low temperature. The Tycho-2 photometry (Wright et al. 2003), however, claims a surface temperature of 10,500 K and a spectral type of B9. Since extinction correction is an issue we pulled the Geneva photometry (Rufener & Nicolet 1988; Mermilliod et al. 1997), and plot the reddening-free parameters \( g \) and \( \Delta \) in Figure 1(d) against spectral standards of low vsini (“lo”) and high vsini (“hi”) from Gray & Garrison (1987); Garrison & Gray (1994). This plot shows that HD 63021 is located between A0V and B9V stars. Since the observed spectral type is A1V, this is a bit of a
Using the Gaia DR2 parallax, the observed V-band magnitude from \textit{Høg et al.} (2000), and our derived $A_V$ of 0.146, we determine an absolute magnitude of $M_V = 0.76$. This is very close to the B9.5V absolute magnitude from \textit{Pecaut & Mamajek} (2013).

In addition, HD 63021 is an X-ray source. Its X-ray luminosity is $1.02 \times 10^{31}$ erg/s, using XMM Newton band 8 (0.2-2.0 keV) data \textit{(XMM-SSC 2017)} and the Gaia DR2 parallax.

### 3. Discussion and Future Work

The H\alpha emission exhibits rapid V/R variability, a near-constant emission line strength, and narrow peak separation. The constant emission line strength suggests to us a star that is continuously feeding its decretion disk, which in turn suggests a star spinning close to its break-up speed. Since the absorption lines are narrow and the H\alpha peak separation is small, it seems likely that we are viewing this source at low inclination.

The H\alpha V/R variability is coupled with photospheric absorption line strength changes, possibly from filling in by circumstellar disk continuum emission. In addition, the strong excess in the near-IR suggests free-free emission from gas that is quite hot \textit{(Reig 2011)}. We wonder whether the Tycho-2 and Geneva photometry suggests a higher surface temperature because of the hot circumstellar gas, a binary companion, or both.

The X-ray luminosity is much higher than other A-type stars that emit X-rays ($\sim 10^{22–24}$ erg/s; \textit{Schröder & Schmitt 2007}). One possibility is that the stellar wind is very strong, similar to that of B-type stars \textit{(Cassinelli et al. 1994)}. Another option is an X-ray binary \textit{(Reig 2011)}. In the case of an X-ray binary, then there would be a compact source associated with HD 63021.

We will be conducting an optical spectroscopic monitoring program to look for signs of periodicity, analyses of lightcurves from ground-based surveys and the space-based TESS mission, and will additionally create a comparison sample of X-ray sources of similar spectral type from available archives. New infrared observations would also be beneficial, in order to make a contemporary SED.

This work would not have been possible without the Adams Observatory at Austin College. We have made use of data from the European Space Agency (ESA) mission \textit{Gaia} \texttt{(https://www.cosmos.esa.int/gaia)} processed by the \textit{Gaia} Data Processing and Analysis Consortium (DPAC, \texttt{https://www.cosmos.esa.int/web/gai...})
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