The Extreme-UV Radiation Environment of M dwarf Planet Hosts

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Background

- This research is the next major step in the HAZMAT project to analyze the evolution of the high-energy radiation environment of M dwarf planetary systems and its impact on the habitable zone
- High levels of extreme ultraviolet (EUV; 100-900 Å) radiation can drastically alter the atmospheres of terrestrial planets through ionizing, heating, expanding, chemically modifying and eroding them during the first few billion years of a planetary lifetime
- This work uses the stellar atmosphere code, PHOENIX [1,2], to create upper atmosphere models of M dwarf stars with prescriptions for the hot, low density atmospheric layers: the chromosphere, transition region and corona

Motivation

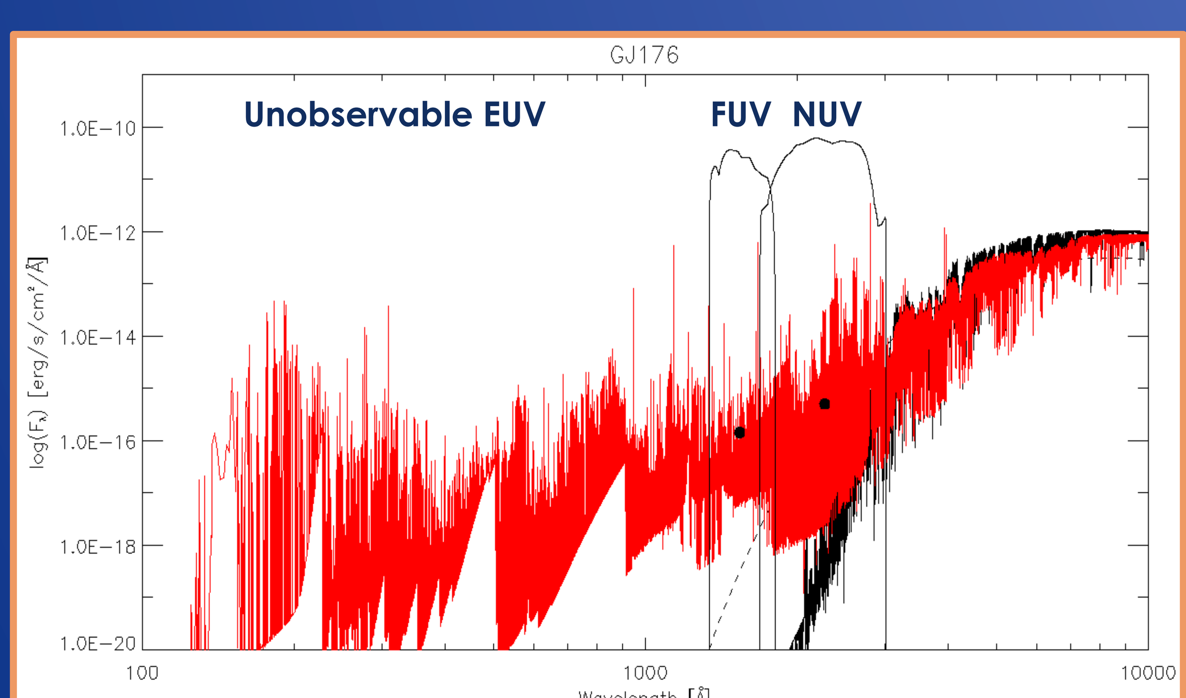

Figure 1. Model spectra of M dwarf GJ176 (T_{eff}=3416 K). The dashed black curve is a blackbody model, the solid black curve is a standard model without an upper atmosphere and the red curve is a combination photosphere and upper atmosphere model. GALEX FUV and NUV filter profiles are shown.

It is difficult to observe in the EUV spectral range due to optically thick interstellar hydrogen shortwards of 911 Å, and since the completion of the EUVE space mission, it is impossible to observe stars in this spectral range. Estimating EUV fluxes from pre-existing models is also unreliable because they under-predict emission at UV wavelengths due to a lack of prescription for the star's chromosphere, transition region, and corona.

Non-LTE Species Set

Due to the high temperatures and low densities characteristic of the plasma making up the upper atmospheres of stars, radiative transfer in this region is dominated by non- LTE effects. These models use species and background opacities provided by the PHOENIX and CHIANTI v7 [3] databases. The complete set of non-LTE species and ionization stages used for these models is given in the table below.

H I																	He I-II
													C I-IV	N I-V	O I-V		Ne I-II
Na I-III	Mg I-III											Al I-III	Si I-IV	P I-II	S I-III	Cl I-III	Ar I-III
K I-III	Ca I-III		Ti I-IV	V I-III	Cr I-III	Mn I-III	Fe I-IX	Co I-III	Ni I-III								

Models without Corona: Models with Corona:

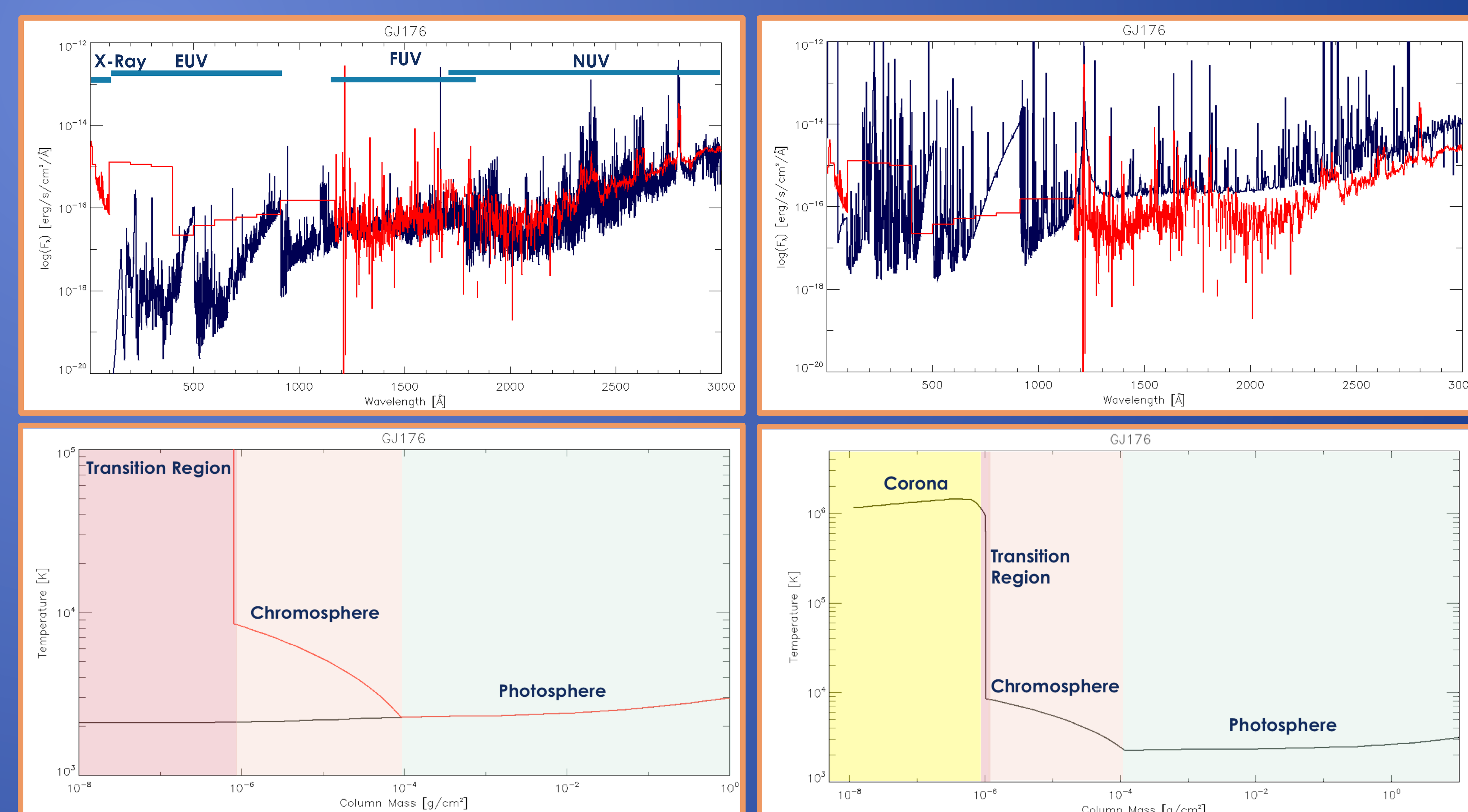

Figure 2. (Top) Comparisons of PHOENIX model spectra (black) without (left) and with (right) a corona to the MUSCLES HST Treasury Survey spectra (red) [4] of GJ176. The MUSCLES spectra include observed Chandra/ XMM X-ray spectra, empirically derived relations to compute the EUV spectra, and observed HST COS and STIS spectra covering the FUV and NUV regions. The left-side PHOENIX models include a prescription for the chromosphere and transition region, but underestimate the X-ray observations due to a lack of prescription for the corona. The right-side PHOENIX models include a prescription for the full upper atmosphere. (Bottom) Accompanying temperature-column mass structures for the model spectra.

References

[1] Hauschildt et al. 1997, ApJ, 483, 390. [2] Short et al. 2005, ApJ, 618, 926.
[3] Landi et al., 2012; ApJS, 744, 99 [4] France et al. 2016, ApJ 820, 89.