The Disconnect Between UV and White-Light Flares in Low-Mass Stars

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Abstract

Contemporary studies of exoplanet habitability use white-light measurements to calculate the ultraviolet (UV) effects of stellar flares, often by assuming a 9000K blackbody for the bolometric flare spectrum. We have combined *TESS* and archival *GALEX* photometry to test the UV predictions of white-light flare rates using the 9000K model. We have found that the UV predictions of white-light flare rates do not accurately reflect the NUV or FUV flaring activity of low-mass stars and are working to quantify the scale of this disconnect.

UV Flares and Exoplanet Habitability

Their intense optical and UV irradiation has given flares a pivotal role in the habitability of planets around low-mass stars. Flare UV emission can alter atmospheric chemistry [1], but may also provide the UV flux required for abiogenesis [2]. In order to fully assess the habitability of exoplanets around low-mass stars, accurate knowledge of the UV energies and occurrence rates of their flares is essential.

Current habitability studies often use white-light flare rates from *TESS* to anchor or predict UV activity, often assuming a 9000K blackbody flare model [3]. This model lacks UV emission lines and underestimates the peak flare temperature, causing discrepancies between the UV predictions of white-light flare rates and the true UV flare activity. However, the scale of this disconnect is not yet fully understood and tests of the UV predictions of white-light rates are needed.

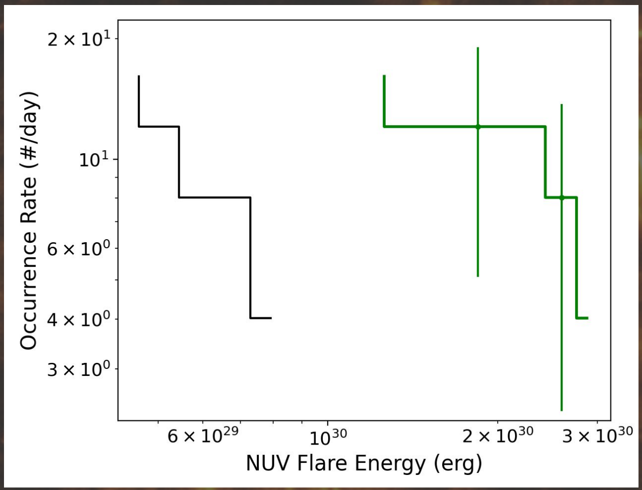

Figure 2. An example of our recovery and injection process for G166-49. The green line is the observed *GALEX* NUV flare occurrence rate and the black line is an example result from our *GALEX* injection and recovery tests, and represents the behaviour predicted by extrapolating the *TESS* flare occurrence rate to the NUV. For this test the predicted NUV flare activity underestimates the observed flare energies by a factor of 5, something that would propagate into habitability studies.

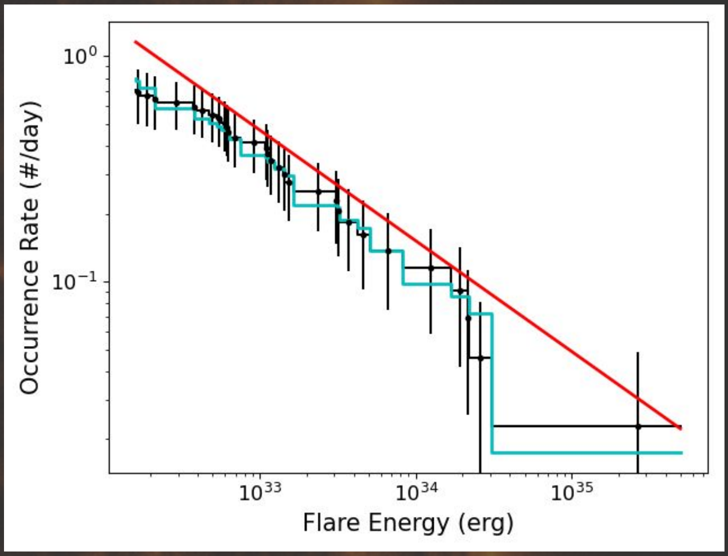

Figure 1. Example of the white-light flare occurrence rate for the M4V dwarf G166-49, from 2-minute cadence *TESS* observations. The black and cyan lines are the observed and fitted occurrence rates, using the method from [5] to account for the efficiency of the flare detection method. The red line is the intrinsic flare rate that we use to predict the NUV and FUV flaring behaviour.

TESS & *GALEX*

We are combining 2-minute cadence observations from the *TESS* primary mission with *GALEX* NUV & FUV lightcurves made using the gPhoton Python package [4]. *GALEX* observed the UV variability of stars over two-thirds of the sky at NUV and FUV wavelengths, visiting stars for up to 30 minutes at a time. By measuring white-light flare rates from TESS observations and using them to predict the number and energies of flares in *GALEX* UV lightcurves through flare injection and recovery techniques, we are testing whether white-light flare studies that use the 9000K flare blackbody model can accurately predict UV flaring activity while avoiding the need for expensive simultaneous observations.

Our preliminary results suggest that the 9000K blackbody model consistently underestimates the true UV flaring activity of low-mass stars. We are currently testing whether we can calculate correction factors for the UV predictions of white-light flare rates, along with working on expanding our sample to include the 2 minute and 20 second cadence observations from the *TESS* extended mission.

References

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