Astrophysical Noise and a Search for Star-Planet Interactions in Ultraviolet Time-Series

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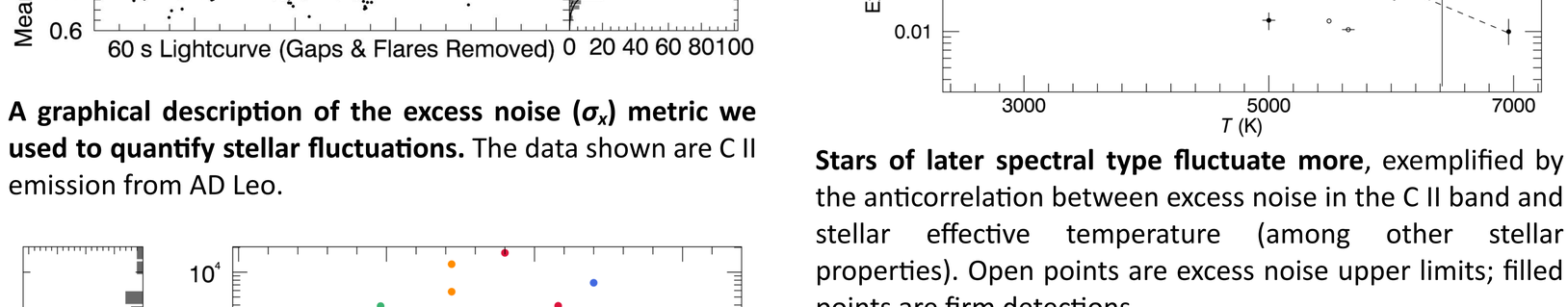
HST Spectrophotometry of Ultraviolet Fluctuations and Flares

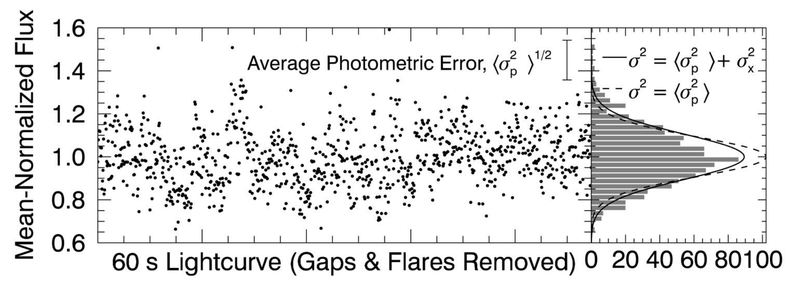
Motivation: What limits will astrophysical noise (fluctuations and flares in stellar emission) place on transit measurements in UV emission lines? How does variability in UV emission correlate with stellar parameters?

Methods: We assembled a sample of 38 F-M stars from existing *HST* STIS and COS time-series data, then identified flares and measured the level of fluctuations in the integrated C II, Si III, Si IV, and continuum separately.

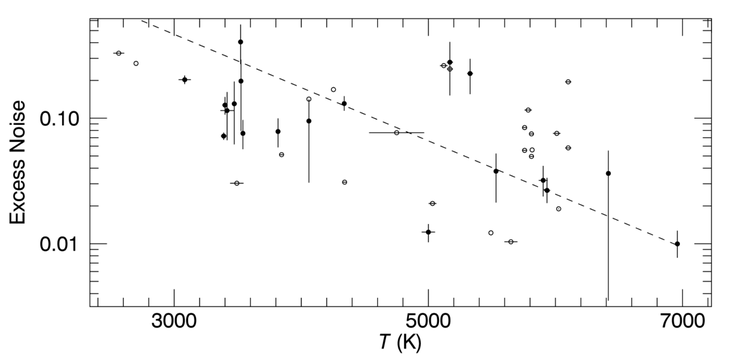
Results: Flares occurred once per 2.5 h of data overall and once per 5 h in sources not identified as flare stars. These were mostly short, 50% lasting ≤ 4 min, with most capable of annihilating the integrated signal of an Earth transit. Stellar fluctuations at a 60 s cadence ranged from < 1% to 41%. Consequent limits on detectable photometric signals hover around Jupiter transits, but reach as low as super-Earth transits for some M-dwarfs.



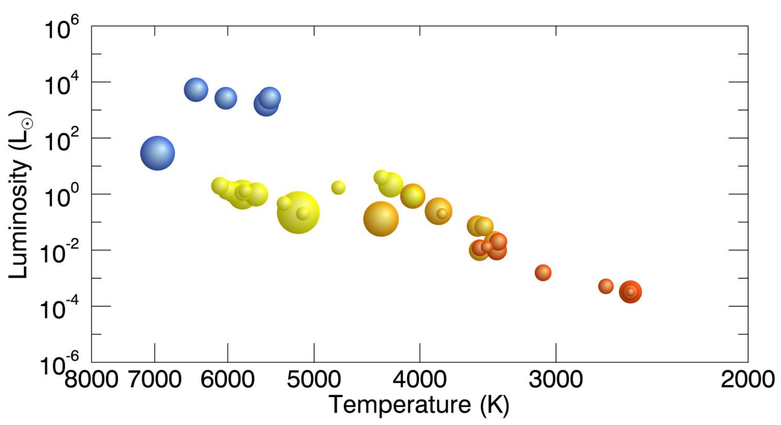
Example Si IV photometry of Proxima Centauri from STIS E140M, showing flare points in red. (The y-axis is clipped at 10.)



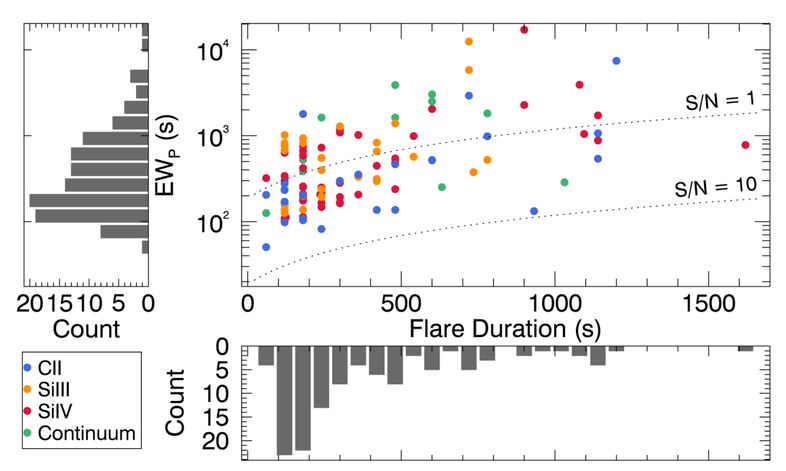
A graphical description of the excess noise (σ_x) metric we used to quantify stellar fluctuations. The data shown are C II emission from AD Leo.



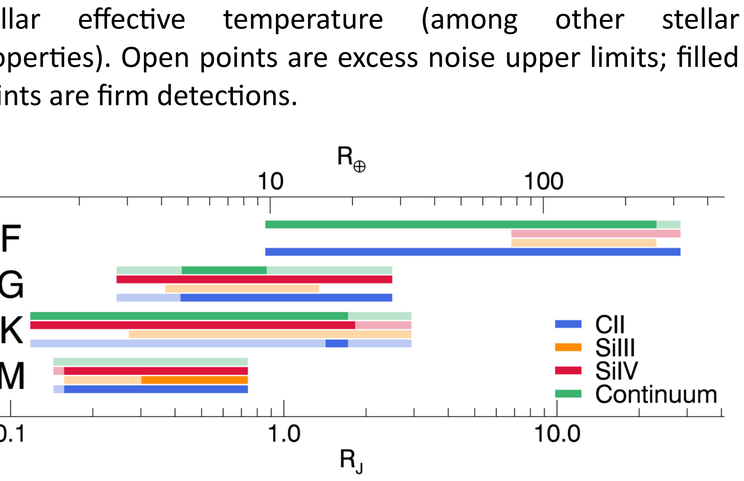
Stars of later spectral type fluctuate more, exemplified by the anticorrelation between excess noise in the C II band and stellar effective temperature (among other stellar properties). Open points are excess noise upper limits; filled points are firm detections.



HR diagram of the 38 stars in the *HST* sample. Bubble area is proportional to the stellar equatorial rotation velocity, ranging from 0.3 to 163 km s^{-1} and colors correspond to spectral types F (blue), G (yellow), K (orange), and M (red).



The population of identified flares in duration and photometric equivalent width, EW_P (a measure of flare energy relative to the stellar luminosity). Dotted lines delineate example sensitivity limits.



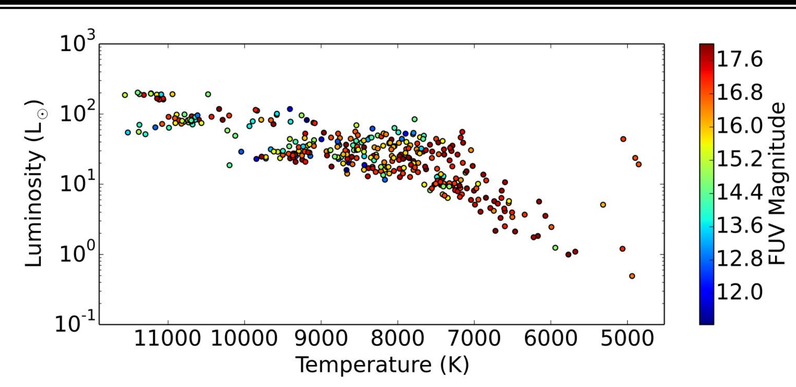
Detection limits (1-σ) in radius of an occulting body for a single 3.5 h transit observation. Solid bars show the range of excess noise detections and translucent bars show the range of upper limits, grouped by spectral type.

GALEX Broadband Photometry: Looking for Evidence of SPIs

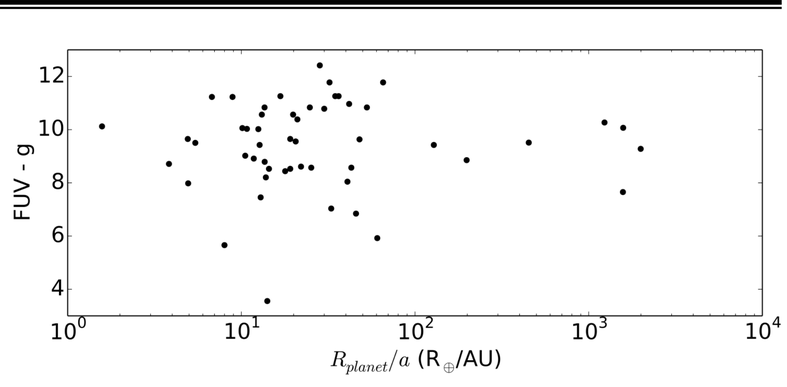
Motivation: Does the amplitude of time-variability in hot-Jupiter host UV emission show a trend with planet mass and proximity? Will specific hosts show flux variations in phase with the planet's orbit? Does time-variability in the broadband UV correlate with UV - visible color (i.e. activity)?

Methods: Every photon detection ever recorded by *GALEX* will soon be available through the gPhoton archive. Building on our tools from the above analysis, we are constructing a pipeline to (1) quantify the time-variability of all overlapping *GALEX* and *Kepler* stars in search of a relationship to the presence or proximity of a planet and (2) search for modulations in the flux of hot-Jupiter hosts at the planet's orbital period.

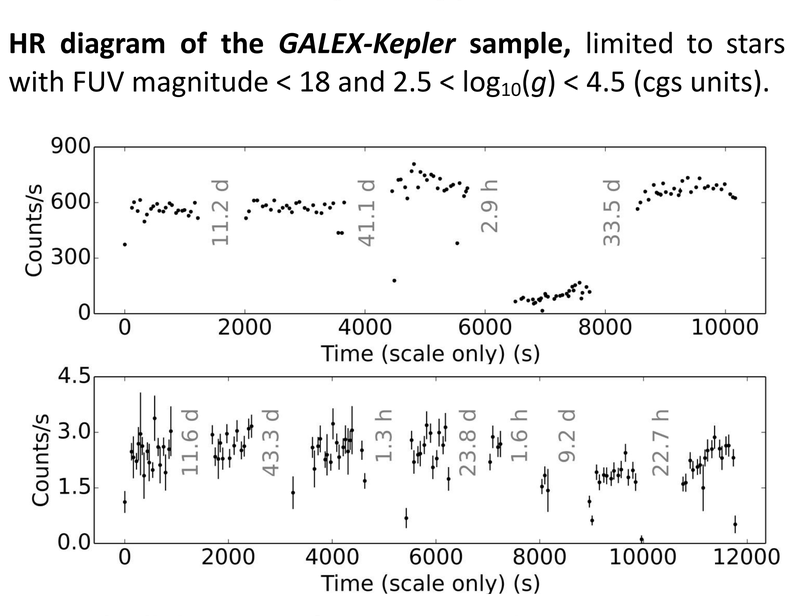
Preliminary results: The limited amount of *GALEX* photon-event data currently available prevents the identification of any trends.



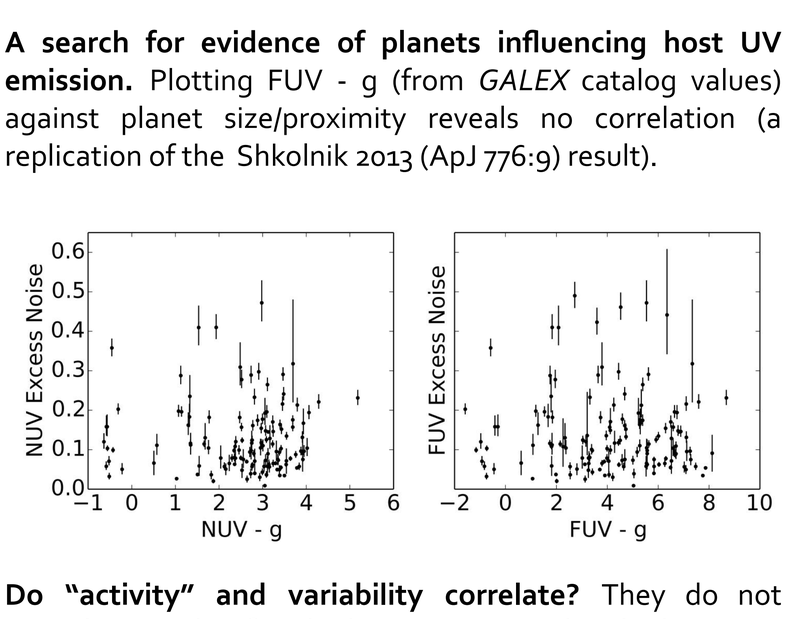
HR diagram of the *GALEX-Kepler* sample, limited to stars with FUV magnitude < 18 and 2.5 < $\log_{10}(g)$ < 4.5 (cgs units).



A search for evidence of planets influencing host UV emission. Plotting FUV - g (from *GALEX* catalog values) against planet size/proximity reveals no correlation (a replication of the Shkolnik 2013 (ApJ 776:9) result).



Example lightcurves from *GALEX* data. Top: An FUV bright star; FUV = 12, T_{eff} = 8435 K. Bottom: A fainter star; FUV = 18, T_{eff} = 10,333 K.



Do "activity" and variability correlate? They do not according to this first look at noise vs color (high UV - g implies lower activity). However, when the gPhoton archive is complete, improved sensitivity may reveal correlations.