[P121] 20 Years of Chandra Science Symposium : 2019 Dec 3-6 **TANAGRA: Timing Analysis of Grating Data**

A Spectro-temporal archive of Chandra Coronal Sources

The high spectral resolutions and long durations of Chandra grating observations allow for deep dives into the data. We have built a system of interlocking spectro-temporal algorithms that operate on emission line spectra. We compute 2D change points in (λ,t) space; detect lines and compute their fluxes over time segments, and estimate the contribution of weak flares to light curves in temperature separated passbands. Web-based access to these results is under development.

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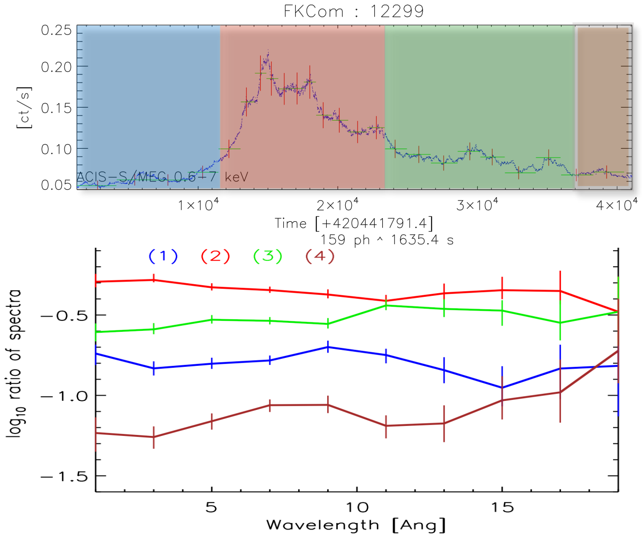
2D Changepoints

We have devised a method to detect 2D change points in (wavelength,time) space (Wong et al. 2016, AOAS, 933). The spectrum is modeled non-parametrically using a combination of 3rd-degree polynomial radial basis functions and δ-function lines, and the number of change points in time are determined via Minimum Description Length (MDL, loosely related to information entropy).

`https://github.com/astrostat/Automark`

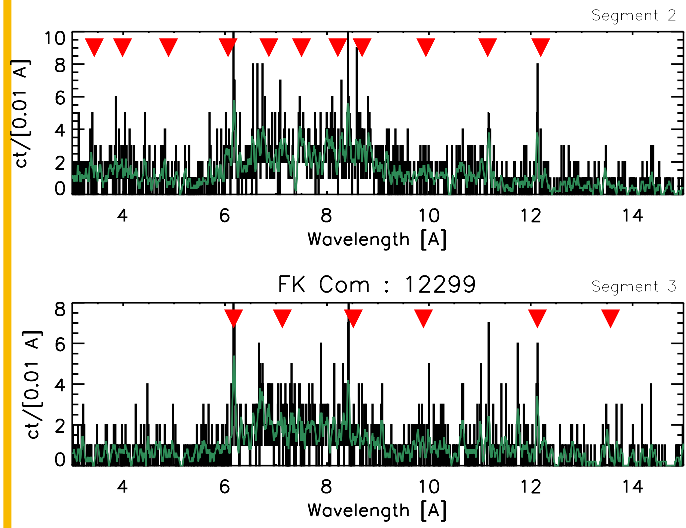


Demonstrating `Automark` on an ACIS-S/HETG FK Com observation with a large flare. The smoothed light curve (top) is segmented into 4 distinct periods, with the coarsely binned spectral ratios (bottom) showing that *both* intensity and spectral hardness vary. The code is currently a combination of R, python, IDL, and bash scripting; we are continuing to work to fully automate its functioning. We are also working to extend its applicability to low-resolution spectra.

Line Detection

We have developed a wavelet-based heuristic to find lines in a grating spectra that minimizes false positives in the low-counts regime while minimizing false negatives in the range with high density of lines. We compute wavelet coefficients using a symmetrized Haar wavelet, and after filtering on large deviations in the coefficients, check for several properties (scale at which detection is strongest; whether adjacent pixels are well-behaved; and finally S/N) to discard false positives.

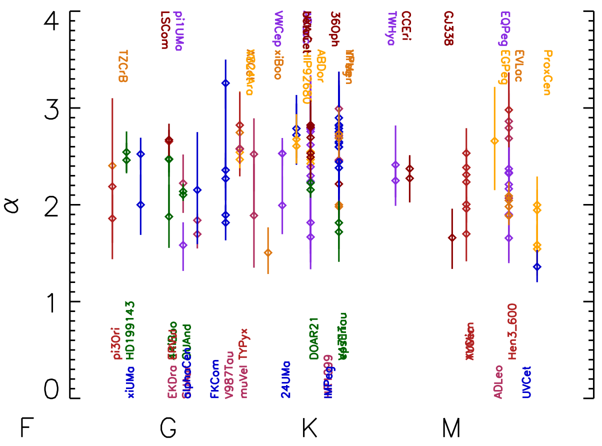
`https://github.com/vkashyap/PINTofALE/blob/master/pro/find_lines.pro`



The spectra of Segments (2; top) and (3; bottom) from the `Automark` segmentation of FK Com. The spectra binned at 0.01Å are shown as black histograms, along with a smoothed version overlaid in green. The red downward arrows mark the locations of detected lines with *S/N>3*. Note that the spectra are in the extreme low counts regime, but the line locations are still found robustly. They are found to be where concentrations of photons appear rather than at spikes from fluctuations.

μFlares

The energy outputs of Strong flares are known to be distributed as power-laws both on the Sun and on other stars. This is believed to be a consequence of a scale-free Self-Organized Criticality (SOC) process. On the Sun, the index of the power law is uniformly α=1.8, while for some stars it can be >2. We fit the distribution of photon arrival time differences and the distribution of binned light curve intensities, using a combination of MCMC and Approximate Bayesian Computation methods.



Scatter plot of α for a variety of active stars in the Chandra gratings archive. While no trend is discernible with spectral type or activity level, measured α's cover a broad range, from solar like α≈1.6 to α >3. Smaller α are easier to describe with SOC models, and larger α's signify a fundamental departure from the solar analogy. A plasma temperature correction is being developed, and it can, e.g., bring ProxCen's α's to stability across cycle phases.

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