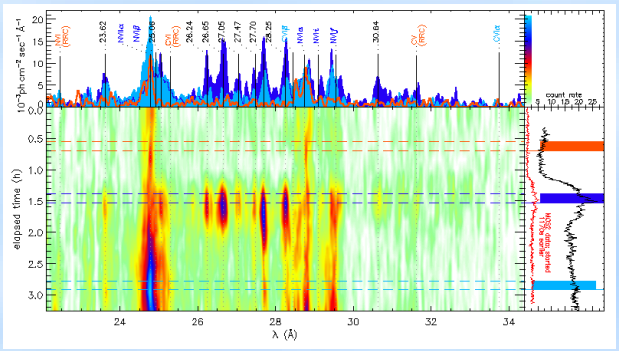
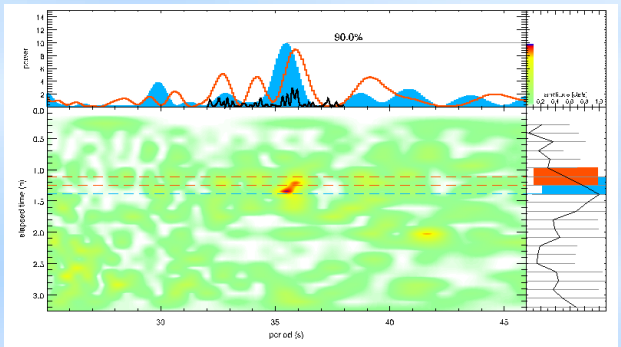
Dynamic energy/power spectra from X-ray spectra and light curves

Jan-Uwe Ness
XMM-Newton Science Operations Centre
ESAC, Madrid, Spain
juness@sciops.esa.int

Dynamic spectra give a graphical illustration of the time evolution of 2-dimensional data such as a spectrum (energy/count rate) or a power spectrum (frequency/power).

The graphs below consist of four panels which can be read as follows:
1) Top left: The 2-dimensional data of either the complete data set or from time slices. The colours of filled areas correspond to the horizontal dashed lines in the panel below and the filled areas in the bottom right panel where the same colours are used.
2) Top right: The horizontal colour bar gives the values on the y axis of the top panels (e.g. counts rates) corresponding to the colours used in the bottom left panel.
3) Bottom left: Colour-coded dynamic spectrum. Horizontal axis is same as top left while time is running down. Colours scale (not necessarily linearly) with the y-axis units in the top (see top right panel).
4) Bottom right: Time series of count rates (light curve) or evolution of oscillation amplitudes in case of power spectra. Time is running down on the same axis as in the bottom left and count rates run across with axis label in the top.





XMM-Newton observations of the Recurrent Nova RS Oph on day 26.5 after outburst:

Time evolution of XMM-Newton RGS spectrum.
An intensity rise in the soft X-ray light curve by a factor ~3-4 is caused by the appearance of short-lived emission lines between 23.5Å-30Å.
Some of them disappear after only ~30 minutes while at the same time the NVII/NVI lines at 24.8Å become much stronger.

Time evolution of Lomb-Scargle power spectrum around 35s period.
Coincident with the intensity rise (left), a 35-s period appears for a short time.
This period was seen in Swift data during the Super-Soft-Source phase and might reflect a nuclear burning instability.

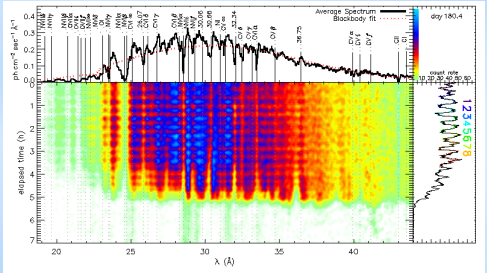
Classical nova V4743 Sgr

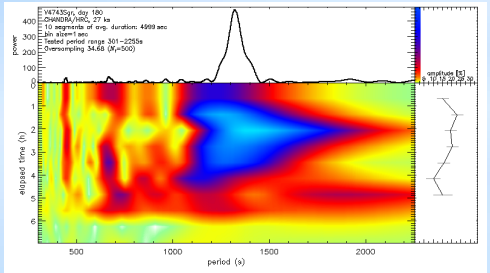
Top left: On day 180.4 after outburst, the source was highly variable in soft X-rays. The light curve started with high-amplitude periodic oscillations. 8 cycles are marked from which the folded light curve in the bottom was constructed.. After ~4 hours, the source disappeared in front of Chandra's eyes! A faint emission line spectrum was left behind.

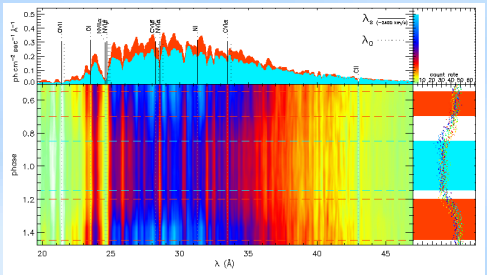
Top right: Evolution of power spectrum with amplitudes (rel. to count rates) right. Two overtones can be identified. Periodic oscillations are not detectable after the source faded.

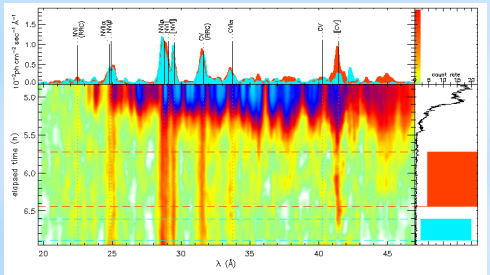
Bottom left: Spectral evolution along the Phase-folded light curve as a function of phase. What varies is the continuum. During minimum phase, the spectrum is much more structured, apparently with more emission lines on top of the continuum.

Bottom right: Evolution of the faint emission lines which are not constant. The CV line at 41.5Å is highly variable.









Recurrent Nova U Sco

Long-term spectral evolution determined with Swift.

Short snapshot observations with large gaps in between are difficult to illustrate.
In the right is an attempt using linear interpolation between groups of snapshots.

One can clearly see how the effective temperature increases with time.