

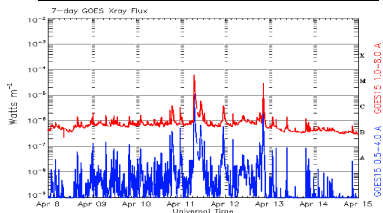
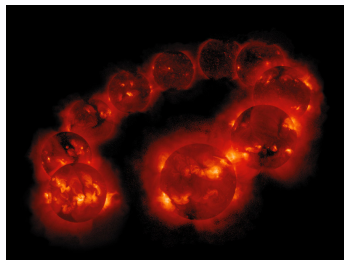
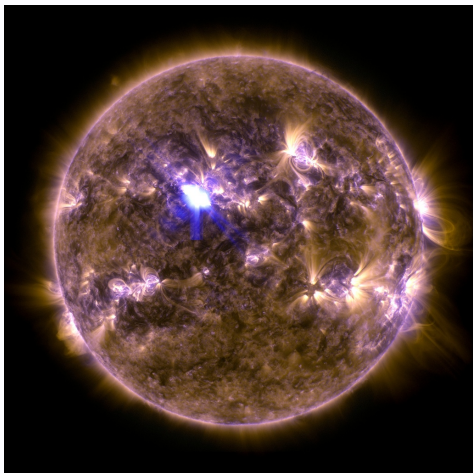
eROSITA - stellar variability

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Hamburger Sternwarte

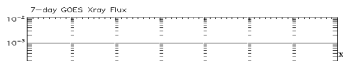
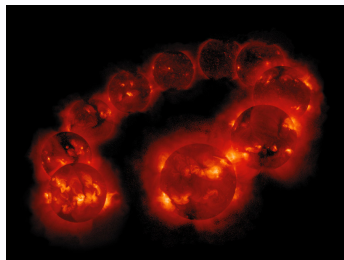
eROSITA meeting, Potsdam, 15-17 Sept. 2014

Stellar Variability



The Sun in X-rays (SDO, Yohkoh, GOES)

Stellar Variability



The time domain of stellar eRASS sources:

- virtually all stars are X-ray variable
- stars are variable on all relevant time scales
- large range in amplitude, brightness and frequency
- predominantly magnetic activity (+ accretion, rotation...)

GOES15 0.5-4.0 Å GOES15 1.0-8.0 Å

Basics of stellar X-ray flares

- **Solar classification:** related to flaring structure, i.e.
 - compact flares - individual loop(s), fast decay, high density
 - long-duration / two-ribbon flares complex and larger mag. structures, low density
- **Stellar flare diagnostics:** identify flaring structure, e.g. via
 - rise and decay time
 - peak temperature
 - EM - T evolution ('chromospheric evaporation')
 - density measurements
- Does (scaled) solar classification hold for stars?
stronger \iff larger \iff hotter

Caveat: most above diagnostics not available in eRASS data.

Sampling, scales and sensitivity:

- eRASS: 8 all-sky scans (each 250+ s)
- minimum of 6 scans per all-sky scan with ~ 40 s each
- timesampling: 15 Ms (0.5 yr), 15 ks (4 h), 1-50 s
- about 50000 (5000) stars with $\gtrsim 200$ (1000) counts
 - flux accuracy $\gtrsim 20\%$ per eRASS-scan
 - spectral signatures
- short-term variability common
 - flares \longleftrightarrow flickering \longleftrightarrow quasi-quiescence
- long-term and phased variability

eRASS types of stellar variability

- **Bursts, short flares**

- timescale: seconds - minutes; amplitude: 2 - 100+
- **eRASS** signature: enhanced single scan

- **Flares, active periods**

- timescale: minutes - hours - days; amplitude: 2 - 100+
- **eRASS** signature: variable scans, short-term, possible pattern

- **Flickering & phased emission**

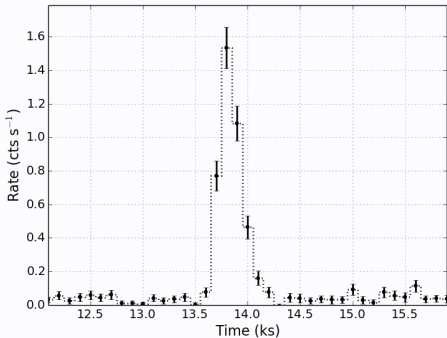
- timescale: hours - days - months; amplitude: 0.2 - 2.
- **eRASS** signature: variable scans, overall property

- **Activity cycles, long-term variability**

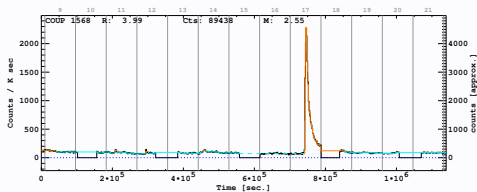
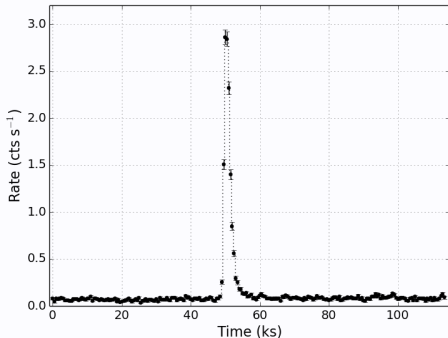
- timescale: months - years; amplitude: 2 - 10
- **eRASS** signature: var. between all-sky scans

No strict physical separation, multiple variabilities possible

Flares and bursts

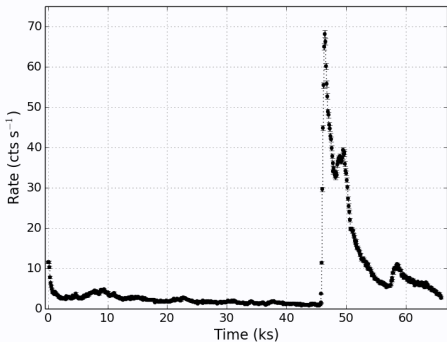


late M star, A0p star, T Tauri star

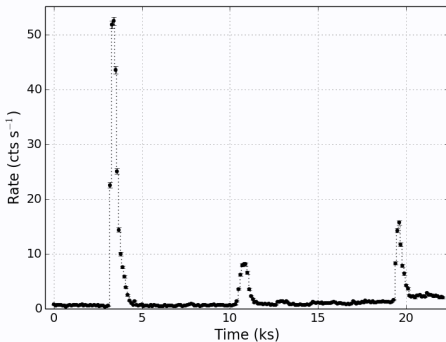


- single scan sources, transients
- elevated scan
- intra-scan variations

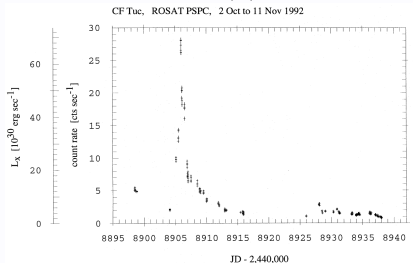
Flares and active periods



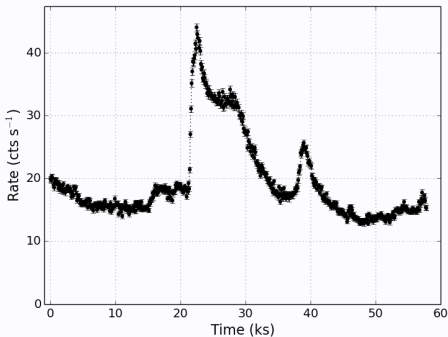
M star, M star, RSCVn



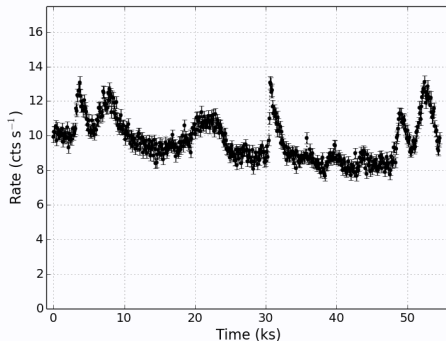
- strongly variable scans
- 'typical' lc-pattern
- intra-scan variations



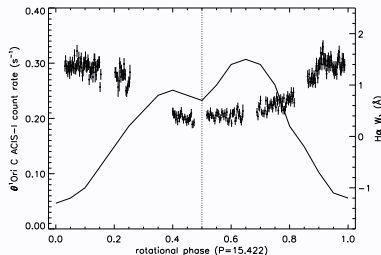
Flares, flickering & phased emission



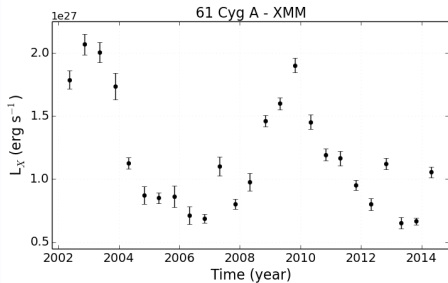
K star, M star, magn. O star



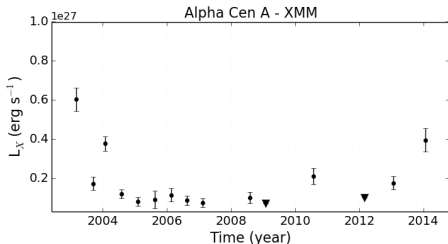
- frequent variability at moderate level
- phase-folded variations (rot. modulation, viewing angle)



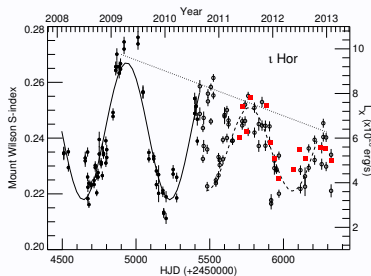
Activity cycles & long-term variability



K star, G star, F star



- smooth cyclic variations
- irregular & 'pseudo-cyclic' variations
- long-term trends



What to look for?

- identify flaring stars and stellar populations
- determine flare/variability properties
- phased emission sources
- long-term trends and activity cycles
- optical follow-up? only in exceptional cases
- supplementary data useful (activity & youth indicators, periods...)

What can be studied?

- coronal physics and energy release
- flares and activity trends
- solar-stellar connection
- high-energy irradiation of (exo)-planets