eROSITA and the solar neighborhood: nearby stars in X-rays

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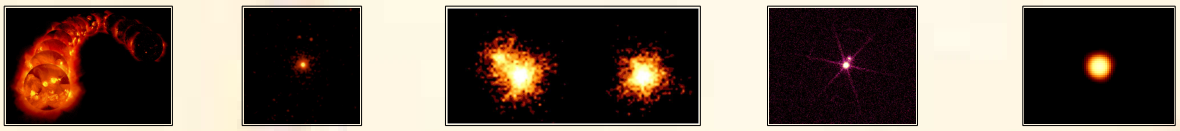
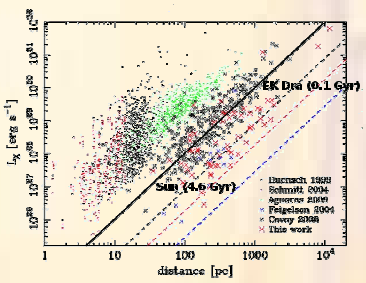
The eROSITA all-sky survey (eRASS) will enable the study of nearby stars in an unprecedented fashion, given its high sensitivity, good spectral and angular resolution and eightfold sky-coverage. Due to their proximity even X-ray fainter objects will be detected, leading to a very diverse sample of many thousands magnetically active stars. that allows to address a large variety of science topics including stellar population and evolution studies down to very low masses and very low activity levels, the solar-stellar connection or variability studies like the search for X-ray activity cycles.



The stellar content of the eROSITA all-sky survey



eRASS sensitivity with two Suns (adapted from Wright+ 2010). eRASS (thick black line) vs. ROSAT: survey + pointings (dots), *Chandra*: CDF-N, ChaMP, COSMOS (crosses).

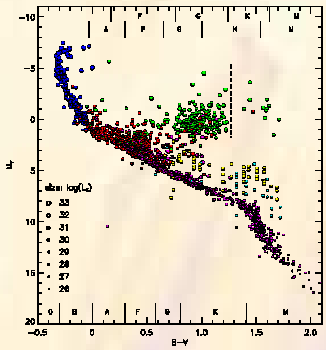
Stellar basics:

eROSITA will detect ≈ 0.3 – 0.5 Mio. stars
(Besancon X count model, Guillout et al. 1996)

- av. stellar densities:
  30 per deg^2 (gal. plane) to 5 per deg^2 (pole)
- X-ray horizon: Sun (30 pc)
  young solar analog (1 kpc)
- $F_{\rm X\,lim} \approx 1 \times 10^{-14}$ erg cm^{-2} s^{-1}
- $L_{\rm X\,min} \approx 1.0 \times 10^{24} \times d^2$ (pc) erg s^{-1}

eRASS vs. RASS:

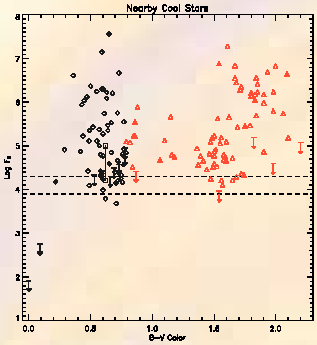
- 20 – 30 higher sensitivity at 0.3 – 2.0 keV
- even better for hard/absorbed sources
- improved spatial + spectral resolution



The X-ray HRD (compiled by Güdel 2004).

Classical regimes of stellar X-ray emission and their presence in the solar neighborhood (d $\lesssim$ 30 pc):

- **cool stars (late A to late M-type)** ✓
  - X-rays from magnetic activity (coronae)
  - $L_{\rm X} \propto 1/R_{\rm o}^2$ (dynamo efficiency), $L_{\rm X}/L_{\rm bol} \approx -3 \ldots -7$
  - includes active binaries (RS CVn, Algol...)
- hot stars (O to early B-type) ✗
  - X-rays from wind shocks, $L_{\rm X}/L_{\rm bol} \approx -7$
- **evolved & peculiar stars (giants, WDs, Ap/Bp)** ✓
- **substellar objects (BDs)...** ✓
- pre-main sequence stars (Class 0/I, T Tauri stars, HAeBe stars) ✗



The solar neighborhood as seen by ROSAT (Schmitt 1997, diamonds: F/G stars, triangles K/M stars. squares: solar range (min/max), dashed lines: solar coronal hole.)

Time evolution of magnetic activity
⇒ $L_{\rm X}$ decreases strongly with age

Stellar population studies
- activity vs. age, rotation, mass, $T_{\rm eff}$
- $L_{\rm X}$, $L_{\rm X}/L_{bol}$, $F_{\rm X}$, $T_{\rm X}$ correlations along stellar sequence

Dynamo theory
- study of (super-) saturation effects and Lx/Lbol evolution
- transition effects at fully convective boundary

Local star formation history & galactic structure
- young nearby stellar population
- early evolution of planetary systems

Nearby stars: faint X-ray sources, time variability and spectral studies

Virtually complete X-ray detection of the nearby stellar population in eRASS

$\sim$ 4000 stars in the GJ catalog (d $\leq$ 25 pc)
$\sim$ 350 stars in RECONS 10 pc sample,
2/3 are M dwarfs

Faint sources ($\log L_{\rm X} \lesssim 27$ erg s^{-1})

- very low mass stars ($\gtrsim$ M7)
- weakly active solar-type stars ($\log L_{\rm X}/L_{bol} < -5$)
- hot magnetically active stars (A7-A9)

Bright sources ($\log L_{\rm X} > 28$ erg s^{-1}):

- young active solar-type stars
- flare stars
- active binaries
- variability & spectroscopic studies for $\gtrsim 10^4$ sources

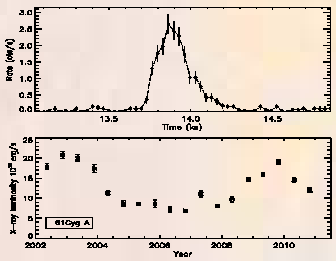
Spectroscopic studies:

- basic coronal properties for many thousand stars
- active stars allow detailed spectroscopic studies
- time resolved and multi-temperature modeling
  - AD Leo, EV Lac: M dwarfs at 5 pc, ≈ 40000 counts
  - Algol, active binary at 28 pc, ≈ 250000 counts

Variability studies:

Stars are variable on all eRASS timescales:

- **minutes/hours:** bursts/flares
  ⇒ PMS + low mass stars, $L_{\rm X}/L_{\rm bol} \simeq -1$
- **hours/days:** long duration flares, rotational modulation
- **months/years:** activity cycles, long-term trends



Top: **Flare on the M8.5 dwarf SCR 1845-6357,** *bottom:* **activity cycle of the K5 dwarf 61 Cyg A; XMM data.**

Transient phenomena are well covered in nearby stars: quasi-quiescent state and flare of SCR 1845 ($d = 3.5$ pc) would be detected by eROSITA; the activity state of 61 Cyg A ($d = 3.5$ pc) will be measured eight times.

Top legend: Sun (Yohkoh), Proxima Centauri (Chandra), Alpha Centauri A/B (XMM-Newton), Sirius A/B (Chandra), Altair (XMM-Newton)

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