ROSAT All-Sky Survey

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The Russian-German mission, Spektr-Röngten Gamma (SRG) is on the verge of revolutionizing X-ray astronomy. One of the instruments, eROSITA, will be undertaking an imaging survey of the X-ray sky. Each six-month the entire sky will be covered to a sensitivity which is ten times better than the previous such survey (ROSAT). After eight semesters SRG will undertake pointed observations. I provide a condensed history so that a young student can appreciate the importance of SRG/eROSITA.

The first all sky survey was undertaken by the Uhuru (aka SAS-1; 1970) satellite. This was followed up by HEAO-1 (aka HEAO-A; 1977) surveys. These surveys detected 339 and 843 sources in the 2–10 keV band. For those interested in arcana, 1 Uhuru count/s is $1.7 \times 10^{-11}\,\mathrm{erg\,cm^{-2}\,s^{-1}}$ in the 2–6 keV band.

The next major mission was HEAO-2 (aka Einstein; launched in 1978). This was a game changer since, unlike the past missions which used essentially collimators or shadow cameras, the centerpiece of Einstein was a true imaging telescope. Furthermore the mission carried an amazing complement of imagers and spectrometers in the focal plane. The mission coincided with my graduate school (1978-1983).

Röntgensatellit (ROSAT) was a German mission to undertake an X-ray *imaging* survey of the entire sky – the first such survey. Launched in 1990 it lasted for eight years. It carried two Positional Sensitive Proportional Counter (PSPC; 0.1–2.4 keV), a High Resolution Imager (HRI) and the Wide Field Camera (WFC; 60–300 Å). The PSPC, with a field-of-view of 2 degrees, was the primary work horse for the X-ray sky survey and was > 100 more sensitive than the pioneering Uhuru and HEAO-A1 surveys.

The effective area provided by the telescope system was $400\,\mathrm{cm}^2$ (on-axis). However, the off-axis performance decreases rapidly and so an effective area for the sky survey is closer to $100\,\mathrm{cm}^2$. The quantum efficiency of the gas proportional counter was 0.75. Thus a counting rate of $1\ \mathrm{s}^{-1}$, assuming photons at 1 keV, corresponds to $1.6 \times 10^{-11}\,\mathrm{erg\,cm^{-2}\,s^{-1}}$ which is almost one mCrab – and almost the limit of the Uhuru HEAO-A1 survey!

The ROSAT All-Sky Survey Bright Source Catalog (RASS-BSC) had 18,811 cataloged

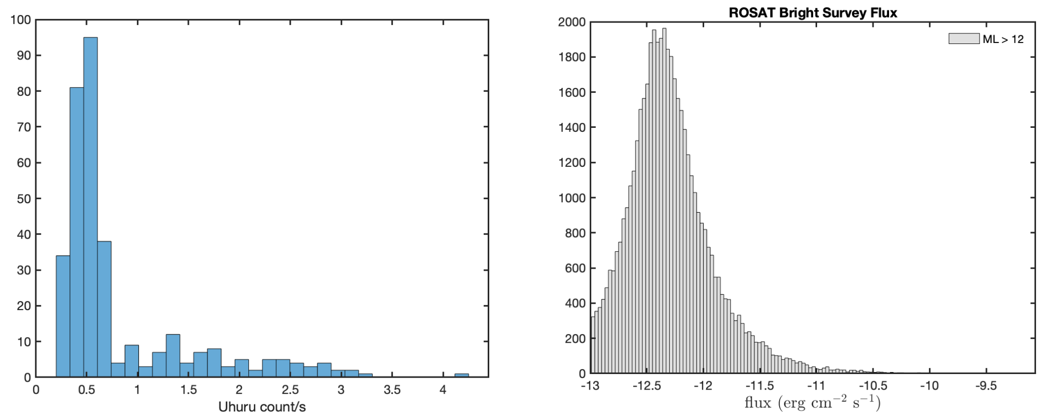

Figure 1: Histogram of source fluxes for Uhuru (left) and ROSAT (restricted to maximum likelihood > 11).

sources, down to a limiting count rate of $0.05\,\mathrm{s}^{-1}$ (in the 0.1–2.4 keV). The criterion for inclusion in the catalog was detection likelihood of > 15 or 15 source counts (Voges et al. 1999). At a brightness limit of $0.1\,\mathrm{s}^{-1}$ there were 8,547 sources or about 1 source per 4 square degrees. The 1RXS survey combined RASS-BSC along with the faint source catalog (FSC). Voges et al. (2000) reported 105,924 sources down to likelihood limit of 6.5

2RXS was the revision of RASS. Boller et al. (2016) report 135,000 sources at a likelihood of 6.5 (with an estimated 30% spurious fraction), 71,000 sources at a threshold of 9 (spurious fraction of 5%). The authors estimate that the spurious fraction is 1% for a likelihood of 11. This paper also presents cross-matches between the XMM Slew survey and 2RXS. They conclude "The 2RXS catalogue provides the deepest and cleanest X-ray all-sky survey catalogue in advance of eROSITA."

A rough conversion of count rate to flux integrated over ROSAT bandpass is given by Voges et al. (1999):

$$\mathrm{flux} = (5.3 \times \mathrm{HR1} + 8.3) \times 10^{-12} \mathcal{C}\,\mathrm{erg\,cm^{-2}\,s^{-1}} \tag{1}$$

where HR1 is hardness ratio and $\mathcal{C}$ is the count rate (s^{-1}). Inspection of the data shows HR1 can vary from -1 to $+1$. So the correction can be substantial. For maximum likelihood greater than 12 we have 49,772 sources, the mode of the count rate is $0.04\,\mathrm{s}^{-1}$ and the corresponding integrated flux is $4 \times 10^{-13}\,\mathrm{erg\,cm^{-2}\,s^{-1}}$.

References

Th. Boller et al., A&A 588, pp A103 (2016)

W. Voges et al., A&A 349, pp 389 (1999)