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The ROSAT X-ray Database from All-Sky Survey and Pointed Observations

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Abstract. During the 8.5 years of operations ROSAT performed the first all-sky survey in soft X-rays and more than 9200 pointings with the Position Sensitive Proportional Counter (PSPC) and High Resolution Imager (HRI). All of the original data and derived products as there are various source catalogs and thousands of X-ray images have been released to the public. These products are briefly described in this paper.

1. Introduction

The ROSAT All-Sky Survey and pointed observations have led to a dramatic increase of our knowledge of the X-ray sky. The total number of publications based on ROSAT is larger than 3,000; they concern almost all astrophysical fields from comets to cosmology.

ROSAT was launched on June 1, 1990. Four concentric parabolic-hyperbolic mirror pairs form the ROSAT Wolter Type-I telescope with a focal length of 2.4 m. Its mirror surfaces have a residual roughness of less than 3 Å, which is responsible for the excellent contrast of the ROSAT telescope. Another important feature of ROSAT is the low intrinsic background of the PSPC.

The total number of new X-ray sources discovered by ROSAT during the all-sky survey and pointed observations is larger than 150,000 (see, *e.g.*, Figure 1 for their distribution), which is more than a factor of 20 larger compared with the number of X-ray sources known before ROSAT. The source lists were produced automatically by the Standard Analysis Software System (SASS). For each X-ray source the following properties are calculated: detection likelihood, source position, source and local background count-rates, exposure time, hardness ratios, source extent and corresponding likelihood. To produce reliable source catalogs, an automated as well as a visual screening procedure of individual sources was applied to some of the data sets.

2. The Catalogs and the X-ray Background Maps

The results from our analysis of the soft X-ray background as well as the detected sources from the ROSAT All-Sky Survey (covering 99.9% of the sky) and from the First ROSAT Source Catalog of pointed observations (covering 15.2% of the sky) are summarized in Table 1 and explained in the following.

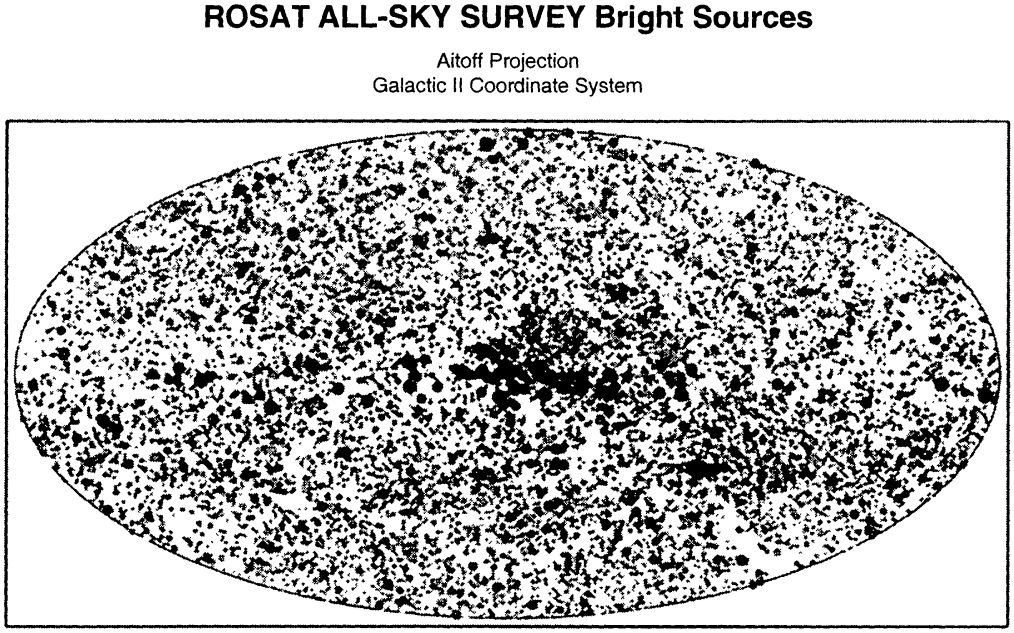

Figure 1. The RASS-BSC sources above a count-rate of 0.05 cts s^{-1} in the energy band 0.1–2.4 keV. The original color coded hardness ratio is translated into a grey scale (light grey: spectrally soft and black: spectrally hard sources). The size of the symbols scales with the logarithm of the count-rate.

The first **ROSAT-1RXP** catalog of pointed observations with the PSPC contains more than 74,000 entries from 2,917 pointed observations performed over 3 years. Compared to the RASS-BSC this catalog is less reliable with respect to source parameters like extent, count-rate and position (see Figure 2).

The X-ray source catalog **WGACAT** is also constructed from 3 years of ROSAT pointed observations and contains about 69,000 sources. The main difference to the ROSAT-1RXP catalog is the use of a different source detection algorithm. The source counts for WGACAT are calculated for three energy bands: low-band (0.1–0.4 keV), mid-band (0.4–0.9 keV), high-band (0.9–2.0 keV).

The first ROSAT source catalog of pointed observations with the high resolution imager (covering 1.2% of the sky) **(ROSHRICAT)** contains arcsecond positions and count rates of detected sources from more than 2,000 public ROSAT HRI observations, including more than 5,700 bright sources (S/N > 4).

ROSAT all-sky survey maps of the diffuse X-ray background are produced in up to 7 energy bands, and have various angular resolutions between $12'$ and $40'$ with and without point-source exclusion.

The **RASS-BSC-1RXS** catalog is a visually screened derivative of the RASS II catalog. By applying a threshold to the count-rate at 0.05 cts/s (0.1–2.4 keV) a list of approximately 25,000 entries was generated. A careful visual inspection and the setting of a threshold on the source-likelihood ($\geq$ 15) and

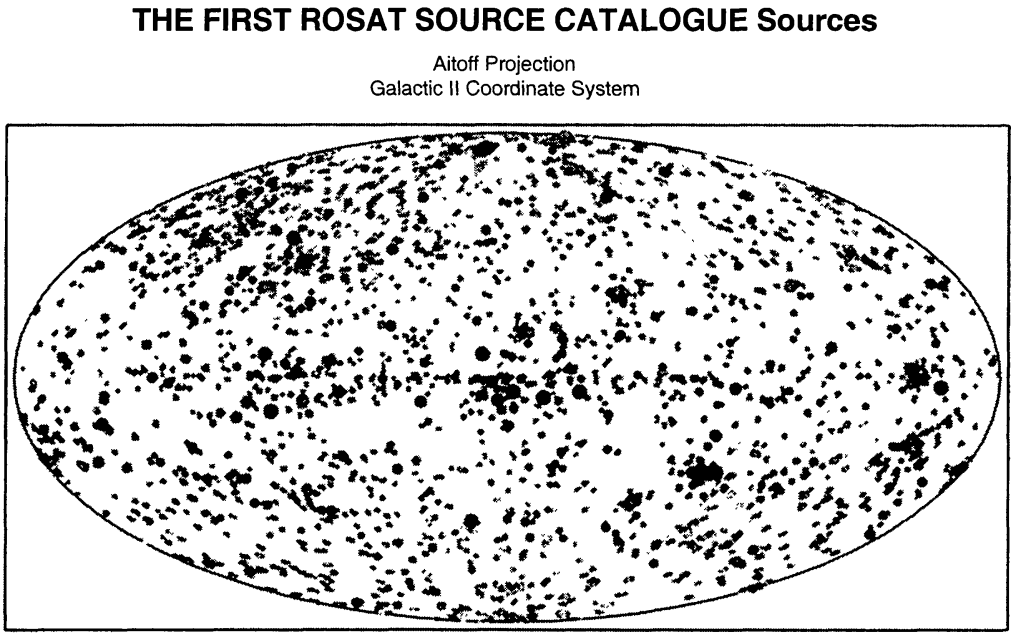

Figure 2. The ROSAT-1RXP sources (see also Figure 1).

counts ($\geq$ 15), resulted in a final bright source list of 18,811 entries (see Figure 1).

The **RASS-FSC-1RXS** catalog is an automatically screened derivative of the RASS II catalog. Setting a threshold on the source-likelihood ($\geq$ 7) and counts ($\geq$ 6), resulted in a final faint source list of 105.924 entries.

The foundation for the RASS-BSC and the RASS-FSC, the **RASS II** catalog is based on a source detection likelihood threshold of 7 and contains 145,060 entries.

The ROSAT variable source catalog **ROSAT-VSC** was generated by correlating the RASS I and RASS II catalogs created from the RASS data and the ROSAT-1RXP. Additionally, the Photon Event Files from the RASS and from public ROSAT pointings were used to determine upper limit values. From the Pointed versus Survey detection **1,062** sources exceed a factor of variability above 3, whereas from the Pointed versus Pointed detections **1,451** sources were found to show variability above a factor of 3.

3. The ROSAT All-Sky Survey Photons

The ROSAT all-sky survey reprocessing (RASS3) has been recently completed and the data-products have been released to the scientific community. (ROSAT-News of 22-MAR-2000).

There are 1378 RASS3 fields each 6°.4x6°.4 covering the whole sky. Neighboring fields are overlapping by at least 0.23 degrees. Each field can be identified by an equatorial latitude zone number (1 to 33) and an equatorial longitude segment number (1 to 64, depending on the zone number).

Catalog or Map	Number of Sources	Detection Likelihood	Sky Coverage
ROSAT PSPC Pointing (ROSAT-1RXP)[a]	74,407	≥ 10	15.2%
WGACAT Pointing[b]	68,907	opt. χ^2	14.0%
ROSHRICAT HRI Pointing[c]	5,700	S/N ≥ 4	1.2%
40′ RASS Diffuse X-ray bkg maps[d]	3 bands		100.0%
12′ RASS Diffuse X-ray bkg maps[e]	7 bands		100.0%
RASS Bright Source (RASS-BSC-1RXS)[f]	18,811	≥ 15	99.9%
RASS Faint Source (RASS-FSC-1RXS)[g]	105,924	≥ 7	99.9%
ROSAT Variable Source (ROSAT-VSC)[h]	$\sim$ 2,000	≥ 10	15.2%

Table 1. ROSAT catalogs and maps

[a]Voges *et al.* (1996)
[b]White *et al.* (1994)
[c]ROSAT Collaboration (1998)
[d]Snowden *et al.* (1995)
[e]Snowden *et al.* (1997)
[f]Voges *et al.* (1999)
[g]Voges *et al.* (2000)
[h]Voges *et al.* (1998)

Accordingly there are 1378 directories in the ROSAT Data Archive each containing a README file and 10 standard FITS files. The names of the data directories have been adapted to match other ROSAT archival data. A 6-digit number (ROR number) is followed by 'p' for the detector used (PSPC). The ROR number consists of '93' as the first two digits ('9' for the ROR category 'other and survey data','3' stands for RASS3), digits 3 and 4 correspond to the zone number, 5 and 6 to the segment number. RASS FITS data files start with the 2 characters "rs" to indicate survey data. There are several ways to retrieve the ROSAT all-sky survey data; they are listed in the help file to be found on our web page[1].

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[1]http://wave.xray.mpe.mpg.de/rosat/survey

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[2]ftp://ftp.xray.mpe.mpg.de/rosat/catalogues/1rxp

[3]http://wave.xray.mpe.mpg.de/rosat/catalogues/rass-bsc/

[4]http://wave.xray.mpe.mpg.de/rosat/catalogues/rass-fsc/

[5]ftp://ftp.xray.mpe.mpg.de/rosat/catalogues/1wga

Part 3

Computer Science & Statistics for a Virtual Observatory