THE EXOSAT HIGH GALACTIC LATITUDE SURVEY

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ABSTRACT. We have performed a survey of $\sim$570 square degrees of high galactic latitude sky using a large number of EXOSAT X-ray images. 130 serendipitous sources were detected and $\sim$60% of them have been identified with catalogued objects. The large majority of the remaining sources have faint optical counterparts on POSS or ESO plates and are expected to be extragalactic. The comparison of our results with those of the Einstein Medium Sensitivity Survey and an analysis of the correlation between the spatial distribution of EXOSAT serendipitous sources and the amount of galactic Hydrogen column density indicate that the average spectral index of extragalactic X-ray sources is steeper than the canonical AGN slope.

The EXOSAT High Galactic Latitude (HGL) Survey is derived from the search for serendipitous X-ray sources in a sample composed of a large number (> 400) of EXOSAT CMA fields (see Taylor et al. 1981 and De Korte et al. 1981 for a description of the instrumentation). The EXOSAT CMA is characterised by a limiting sensitivity in the range 1.E-13 - 2.E-12 erg/cm^2/sec in the very soft energy band 0.05-2 keV. The instrument response is approximately constant in the central part of the field of view (a circular region of radius 12 arcminutes) and rapidly changes at larger off-axis angles until the sensitivity becomes one tenth of the central value at about 45 arcminutes from the centre. The conversion between CMA counts and X-ray flux is a strong function of the Hydrogen column density (N_H) along the line of sight. In order to properly calculate the limiting sensitivity of the Survey for each field we have estimated the appropriate amount of N_H from the 21 cm measurements of Stark et al. 1986. The area of sky covered by the EXOSAT Survey is plotted in fig. 1 as a function of limiting sensitivity for different assumptions on the source spectral slope. For comparison the sky coverage of the Einstein Observatory Medium Sensitivity Survey (MSS) (Gioia et al. 1984) is also plotted in fig. 1 as a dashed line.

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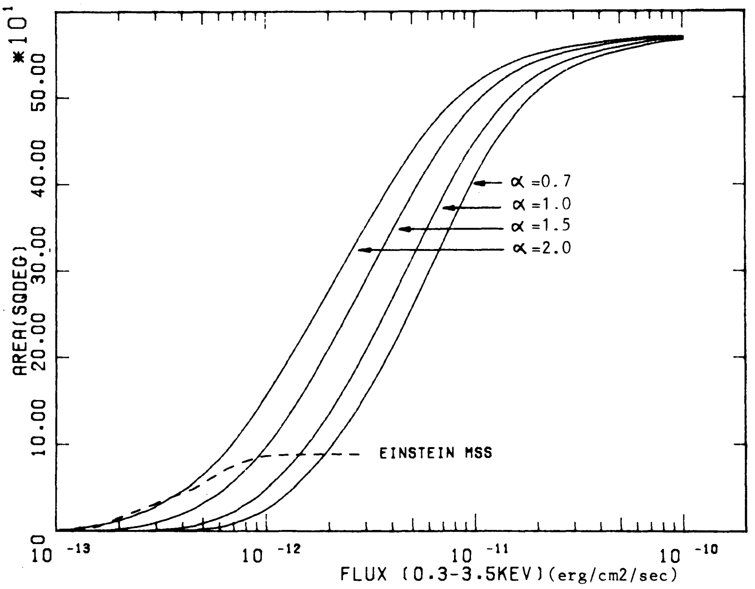

Fig. 1.

Sky coverage of the EXOSAT High Galactic Latitude Survey for different assumptions of the extragalactic sources energy spectral slope (solid lines). The sky coverage of the Einstein Medium Sensitivity Survey is shown as a dashed line.

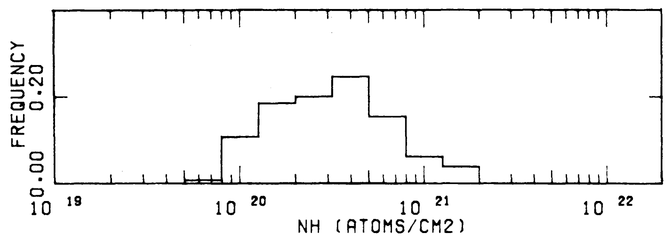

Fig. 2a.

NH distribution of all the fields in the EXOSAT High Galactic Latitude Survey.

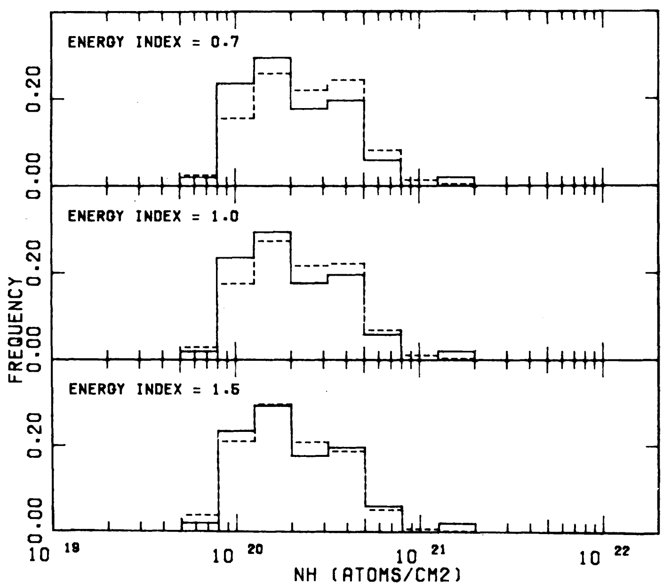

Fig. 2b.

NH distribution of extra-galactic or unidentified sources with mv 15 (solid histogram) and predicted distributions for three different values of the spectral index (dashed histogram).

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130 serendipitous sources were detected above a threshold that was chosen so that only a small fraction of detections could have been missed because of the non-optimal efficiency of the automatic source detection algorithm near the sensitivity limit. 74 sources have been identified with previously catalogued objects (56 Stars, 2 Catacylsmic Variables, 1 Galaxy, 11 AGN and 4 BL-Lacs), the remaining 56 are still unidentified.

Using the Log N-Log S derived by Gioia et al. 1984 we have estimated the number of extragalactic objects expected in the EXOSAT HGL Survey assuming that the source energy spectrum is well represented by a power law in the energy range 0.05-3.5 keV. The results are summarised in table 1.

TABLE 1

Energy Index	# of sources (extragalactic)
0.50	18.1
0.75	26.2
1.00	37.5
1.25	53.5
1.50	74.8
1.75	103.0

Since the expected number of sources is a strong function of the assumed spectral index, the comparison between expectations and actual results provides information on the average spectral slope of extragalactic serendipitous sources.

Only about 60% of the sources in our sample have been so far identified. However, we note that the large majority of the EXOSAT HGL serendipitous sources have optical counterparts with mV 15 or fainter on POSS or ESO plates. From the Einstein MSS we know that, with very few exceptions, X-ray serendipitous sources with optical magnitude in the range 15-21 are extragalactic (Stocke et al. 1983). If we assume that all unidentified sources with mV $\geqslant$ 15 in our sample are extragalactic, the total number of extragalactic objects is 57. This number, when compared to the expectations of table 1 indicates that the average energy spectral index of these sources is > 1, steeper than the canonical slope of 0.7 found in samples of AGN in the 1-20 keV band (Mushotzky et al. 1980, Rothschild et al. 1983, Petre et al. 1984, Reichert et al. 1985).

Since the EXOSAT CMA is so sensitive to interstellar absorption extragalactic serendipitous sources are preferentially detected in fields where the amount of N_H is low. The fraction of extragalactic sources expected in a given interval of N_H is a function of the Log N-log S

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slope and of the source spectral shape. Starting from the Log N-log S of Gioia et al. 1984 we have calculated the predicted distribution shown in fig. 2b (dashed histograms) for three different assumptions on the source spectral index. The actually measured distribution of serendipitous sources is shown in fig. 2b (solid histogram). The agreement between predictions and measurement is acceptable only for very steep energy indices ($\sim$1.5) confirming the indications obtained before. The N_H distribution of all fields in the Survey is shown in fig. 2a.

The percentage of stars in the EXOSAT HGL Survey is $\geqslant$43% and is significantly higher than the value found in the Einstein MSS (25% Stocke et al. 1983). This result was however expected and it is mainly due to the very soft energy band pass of the CMA. A similar effect has to be expected also in the future ROSAT whole sky survey, which will be performed in the 0.1-2.0 energy range (Trümper 1984).

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DISCUSSION

VERON: How have you assigned an optical magnitude to the unidentified X-ray sources?

GIOMMI: By measuring the diameter of the candidate optical counterpart on Palomar or ESO plates.

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CANIZARES: Two comments. First, I presume that most of your objects ought to be at low z, given your flux limits and the results of the Medium Survey, so your objects are not the ones that make up the bulk of the X-ray background. Second, we have been using Einstein data to study the composite spectra of high z quasars and the preliminary result is that both radio loud and radio quiet quasars have reasonably flat spectra - closer to the canonical 0.7. These are objects with $z > 1$, so our spectra correspond to ~1-10 keV in the quasar rest frame.

GIOMMI: Yes, many of our sources are expected to be at low redshift. In addition, a non-negligible fraction of them is expected to be BL Lac objects, i.e. sources with steep spectra that evolve less than quasars.

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