X-RAY SURVEYS AS TOOLS TO INVESTIGATE THE COSMOLOGICAL EVOLUTION OF QUASARS, BL LAC OBJECTS AND CLUSTERS OF GALAXIES

Isabella M. Gioia[1,2], Tommaso Maccacaro[1,2] and Anna Wolter[1]

1) Harvard-Smithsonian Center for Astrophysics, Cambridge, MA

2) CNR - Istituto di Radioastronomia, Bologna, Italy

ABSTRACT

We present a progress report on a major extension of the Einstein Observatory Medium Sensitivity Survey (MSS). The basic properties of the extragalactic sources identified with Active Galactic Nuclei (AGN) and clusters of galaxies are discussed. Results from previous work are briefly summarized.

1. INTRODUCTION

In the last two years a major extension of the MSS has been carried out at the Center for Astrophysics. The Medium Survey consists of X-ray sources serendipitously discovered with the Image Proportional Counter on board the Einstein Observatory, in the energy range 0.3-3.5 keV, at fluxes between 10^{-11} and 10^{-13} ergs cm^{-2} s^{-1}. A detailed description of the survey and of its selection criteria can be found in Maccacaro et al. 1982 and Gioia et al. 1984.

2. PUBLISHED MSS

While some investigations can be successfully carried out utilizing incompletely identified samples or samples not well defined, some types of studies are possible only with completely identified and homogeneously selected samples. The optical identification of all the sources (112) in the MSS allowed us to extract modestly-sized but complete samples of astronomical objects which have been used for the following purposes:

(a) to derive the LogN-LogS relationship for the extragalactic population as a whole and for AGN and clusters of galaxies separately (Gioia et al. 1984);

(b) to determine the AGN X-ray luminosity function and cosmological evolution and their contribution to the diffuse X-ray background (XRB) (see Maccacaro, Gioia and Stocke 1984);

(c) to study the relationship between X-ray selected and optically selected AGN (Franceschini, Gioia and Maccacaro 1986);

(d) to show, despite the small numbers of BL Lacs in the survey (5), that their number-count relationship differs significantly from that of AGN (Maccacaro et al. 1984).

We have been so far prevented from studying the cluster luminosity evolution by the small number (18) of clusters detected in the published survey.

For AGN, the X-ray selection favors the discovery of relatively low luminosity, low redshift objects (i.e. high luminosity Seyfert galaxies), a subset of AGN not easily found by other means. For clusters of galaxies, the X-ray selection is an effective method to discover high redshift clusters (up to $z = 0.5$). This should allow us to compare their dynamical and morphological properties with those of nearby clusters as well as distant clusters found through optical searches.

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For BL Lac objects, X-ray selection offers the opportunity to obtain a well defined, flux limited sample of objects, and to compare their properties with those of optically or radio selected quasars. Moreover, an X-ray survey is perhaps the best technique to find, if they exist, radio quiet BL Lacs. With these motivations in mind we have undertaken a large program of extending the Survey.

3. EXPANDED MSS

Over the last two years we have been working at this project by analyzing new IPC fields from the Einstein Data Bank. The gathering of the X-ray data has been now completed. The identification process for the new sources found and the collection of information at other wavelengths, such as radio or infrared, is still under way. The expanded MSS not only has a larger number of sources but it is also qualitatively better than the published survey. The reprocessing of the data uses improved software and calibrations which allow a better determination of the IPC background and of the source flux density. For each field a background map has been generated, which takes into account the non-uniformities of the detector. This and the results from an extensive simulation analysis (Maccacaro, Romaine and Schmitt, this volume) have allowed us to lower our detection threshold to include the 4 σ sources and to utilize for the survey a much larger portion of the IPC field. Table 1 presents the relevant parameters of the expanded MSS.

TABLE 1

Expanded Medium Survey

IPC images analyzed	**1439**	**(345)**
Area for IPC field (sq.deg.)	**0.54**	**(0.2)**
Total area of sky (sq.deg.)	**780**	**(90)**
Sources detected	**836**	**(112)**
Significance of detection	**$\geq$4**	**($\geq$5)**
Sources identified*	**434**	**(112)**
Sources with radio data*	**311**	**(102)**
Active Galactic Nuclei:*	**189**	**(56)**
BL Lacs or candidates:*	**16**	**(5)**
Clusters of galaxies:*	**56**	**(18)**
Normal galaxies:*	**14**	**(3)**

*** As of August 1986**

Numbers in parenthesis refer to published MSS

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4. BASIC PROPERTIES OF THE EXTRAGALACTIC SAMPLES

As of today only half of the sources have been identified. Their properties are thus somewhat biased in favor of the apparently brighter objects, or in favor of objects which are active also at other wavelengths.

The X-ray selected AGN are low-luminosity, low-redshift objects ($<m_v> = 17.6$; $<z> = 0.4$; $<M_v> = -23.7$). At the beginning, the identification of "serendipitous" sources with this type of object was considered somehow disappointing. However, it is now clear that it is important to study the evolution properties of these low-luminosity AGN and compare them with the properties of high luminosity quasars to better understand the AGN phenomenon. As expected from the fact that they are X-ray selected, the MSS AGN are strong X-ray emitters with luminosities in the range 10^{42} - 10^{47}. Most of them, however, do not have enough counts to allow a determination of their spectral parameters, either because detected off-axis, or just above the threshold of the detector. It would be very interesting to analyze their X-ray energy distribution since quasars and Seyfert galaxies are the major contributors to the diffuse XRB and the XRB spectrum is at variance with the spectrum of the very few AGN for which a spectral determination exists. To this end we have undertaken to extract the available information on the AGN energy distribution from their hardness ratio (HR), which is a measure based on two X-ray "colors".

X-ray selection favors the detection of high redshift clusters. Of the 56 identified clusters, 44 have already a redshift determination ($<z> = 0.18$). Thirteen clusters have a $z > 0.2$, seven have a $z > 0.3$. When the identification process will be completed the number of X-ray selected clusters will be large enough (about 100 expected) to allow the study of their evolutionary properties.

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