THE WARPS X-RAY SURVEY OF GALAXIES, GROUPS, AND CLUSTERS

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1. Introduction

We have embarked on a survey of ROSAT PSPC archival data searching for all detected surface brightness enhancements due to sources in the innermost $R \leq 15'$ of the PSPC field of view in the energy band 0.5–2.0 keV. This project is part of the Wide Angle ROSAT Pointed Survey (WARPS) and is designed primarily to measure the low luminosity, high redshift, X-ray luminosity function of galaxy clusters and groups. Accurate measurements of the high redshift XLF would allow the form of the XLF evolution to be determined via the position of the Schechter function break. This would help discriminate between luminosity and density evolution, and discriminate between different hierarchical models, *e.g.*, those including a different mix of fundamental particles, a flat power spectrum of the initial fluctuations, and reheating of the intracluster gas at high redshifts.

2. Data Analysis

Our source detection method, Voronoi Tessellation and Percolation or VTP, represents a significant advance over conventional methods and is particularly suited for the detection and correct quantification of extended and/or low surface brightness emission which could otherwise be missed or wrongly interpreted. We also use energy dependent exposure maps to estimate the

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fluxes of sources which can amount to corrections of as much as 15%. We have nearly complete sky coverage for clusters out to a redshift of $z \simeq 1$, with 50% coverage at a redshift of $z \sim 1.4$. We have 80% coverage for groups (or faint, small clusters) to $z \sim 0.2$ and for galaxies to about $z \sim 0.1$.

In an ongoing optical follow-up program, we are obtaining both CCD imaging and spectroscopic data of the extended sources and selected point-like VTP sources (specifically those with galaxy counterparts). The follow-up procedure has been designed to minimize incompleteness and misidentifications of the X-ray source candidates (catalogue in preparation). Classification based solely on X-ray criteria may be in error at low fluxes like those used in WARPS. We have found that only 70–80% of our VTP extended sources are clusters. Imaging will also allow determinations of the richnesses and morphologies of the clusters and correlation of optical and X-ray properties of clusters.

3. Results

The first results for for an initial 91 fields (17.2 deg^2) at fluxes $> 3.5 \times 10^{-14}$ erg s^{-1} cm^{-2} are presented in detail by Scharf *et al.* (1996). The sky density of extended objects with detected flux $> 3.5 \times 10^{-14}$ erg sec^{-1} cm^{-2} is 2.8–4.0 ($\pm$0.4) deg^{-2}. A comparison with a point source detection algorithm has demonstrated that our VTP approach typically finds 1–2 more objects deg^{-2} to this flux limit, suggesting that the conventional method fails to detect a significant fraction of extended objects. The surface brightness limit of the WARPS cluster survey is $\sim 1 \times 10^{-15}$ erg sec^{-1} cm^{-2} arcmin^{-2}, approximately 6 times lower than the Extended Medium Sensitivity Survey (EMSS). The WARPS LogN-LogS (which currently represents a lower limit) shows a significant excess over previous measurements for S $\gtrsim 8 \times 10^{-14}$ erg sec^{-1} cm^{-2} (0.5–2 keV). We attribute this mainly to a larger measured flux from extended sources as well as new detections of low surface brightness systems in the WARPS.

For further information and preprints of WARPS papers, see the WARPS home page at

`http://lheawww.gsfc.nasa.gov/~caleb/warps/warps.html`.

References

Scharf, C.A., *et al.* Astrophys. J., in press