ChaMP and the High Redshift Quasars in X-rays

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Abstract. *Chandra* X-ray Observatory, (formerly known as AXAF), will observe down to the flux limit of 2×10^{-16} erg s^{-1} cm^{-2}. In its first year of operation *Chandra*'s CCD detectors will observe over 1500 quasars serendipitously in the soft (0.5–3.5 keV) band. Over 200 quasars will be detected in X-rays in the redshift range $3 < z < 4$ and over 400 quasars in $2 < z < 3$. This will enable us to determine the high redshift X-ray luminosity function. This is the contribution by unabsorbed sources only. The total numbers would be larger by $\sim 60\%$.

1. Introduction

NASA's *Chandra* X-ray Observatory was launched on July 23, 1999. The *Chandra* Multiwavelength Project (ChaMP) will combine radio to X-ray observations of serendipitous *Chandra* sources, with emphasis on optical identification. The ChaMP is superior to previous X-ray surveys because of (1) unprecedented X-ray positional accuracy ($\sim 1''$), (2) X-ray flux limits 20 times deeper than current wide area surveys (down to $f(0.5 - 3.5keV) \sim 2 \times 10^{-16}$ erg s^{-1} cm^{-2}), (3) larger sky coverage (~ 8 deg^2) per year than current deep surveys.

2. Prediction of Redshift Distribution of Quasars in ChaMP Fields

The X-ray Luminosity Function at $z = 0$ is described as

$$\Phi(L_X) = \Phi_1^\star L_{44}^{-\gamma 1} \quad for\ L < L^\star(0)$$

[1]The Chandra Multiwavelength Project (ChaMP) is an independent scientific collaboration for followup studies of serendipitous X-ray sources in Chandra X-ray images. The ChaMP Web site is http://hea-www.harvard.edu/CHAMP.

$$\Phi(L_X) = \Phi_2^\star L_{44}^{-\gamma 2} \qquad for\ L > L^\star(0)$$

where L_{44} is the X-ray luminosity in 10^{44} erg s^{-1}. The redshift evolution of the luminosity function is characterized by

$$L_X(z) = L_X(0)(1+z)^k$$

Continuity of the luminosity function at the break luminosity requires that

$$\Phi_1^\star = \Phi_2^\star {L_{44}^\star}^{\gamma 1 - \gamma 2}$$

The total number N of quasars in the sample is obtained by integrating the luminosity function over luminosity and volume, i.e.,

$$N = \int\int \Phi(L_X, z)\Omega(L_X, z) dV(z) dL_X$$

Here $\Omega(L_X, z)$ is the solid angle covered by the survey as a function of redshift and luminosity. The parameters of the X-ray luminosity function determined by Boyle et al. (1993) are as follows: $\gamma 1 = 1.7 \pm 0.2$, $\gamma 2 = 3.4 \pm 0.1$, $\log L^\star(0) = 43.84$, $\Phi_1^\star = 5.7 \times 10^{-7} Mpc^{-3} (10^{44} erg\ s^{-1})^{\gamma 1 - 1}$. Following Comastri et al. (1995), we have used k=2.6 and increased the the normalization $\Phi_1^\star$ by 20%.

The X-ray logN-logS Curve: Using the above luminosity function we derived the number density of quasars as a function of observed flux. The luminosity function was integrated over the luminosity range $10^{42} < L_X < 10^{48}$ erg s^{-1} and the redshift range $0 < z < 4$. $H_0 = 50$ and $q_0 = 0$ were assumed throughout. The predicted logN-logS curve is shown in figure 1.

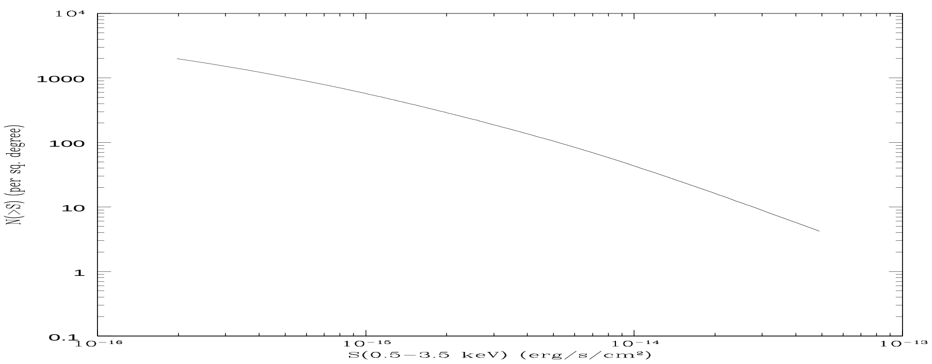

Figure 1. The predicted number counts in the soft band for unabsorbed quasars.

Since the unabsorbed sources dominate at the faint end in the soft X-ray range, and since they are likely to be observed at high redshift, in the present analysis we will concentrate on unabsorbed sources only. The absorbed sources would contribute an additional $\sim 60\%$ (Comastri et al. 1995), making the total number consistent with the extrapolation of the empirical determination of logN-logS (Hasinger et al. 1993). The flux of unabsorbed quasars is given by $f \propto E^{-\alpha}$ and in the soft X-ray band, α is typically 1.3.

The ChaMP Sky Coverage: The ChaMP Cycle 1 consists of 85 extragalactic fields, —b—> 20^o. From all the Chandra cycle 1 fields we have excluded (1) deep fields of PI survey observations, (2) fields with extended sources & planetary targets, (3) ACIS sub-arrays and continuous clocking modes. See figure 2 for ChaMP sky coverage as a function of flux limit.

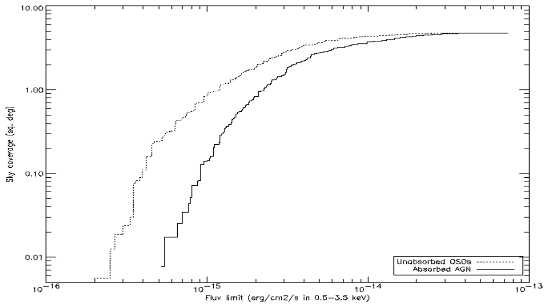

Figure 2. The total sky coverage of ChaMP fields as a function of flux limit in the soft band.

Cumulative Number Distribution in ChaMP: Integrating the predicted logN-logS over the ChaMP sky coverage, we obtained the cumulative number distribution of quasars in the ChaMP fields (figure 3). The total number in soft band is expected to be over 1500 for unabsorbed sources and over 2500 total.

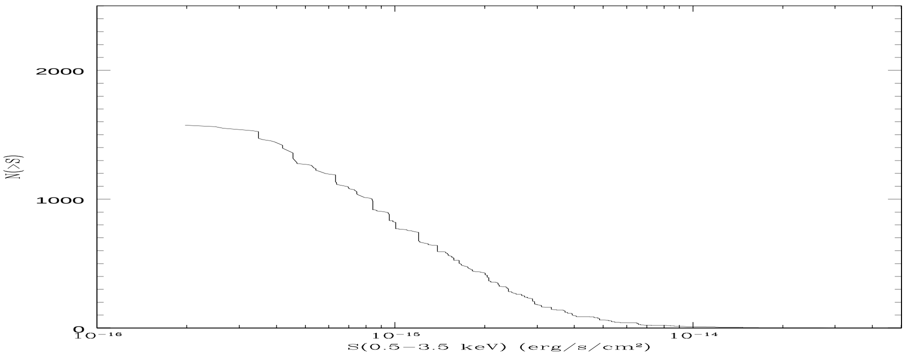

Figure 3. Expected cumulative source counts. Unabsorbed sources only.

Predicted Redshift Distribution: The histogram (figure 4) shows the predicted number distribution of quasars in ChaMP fields. Over 200 quasars will be detected in the redshift range $3 < z < 4$ and over 400 quasars in $2 < z < 3$.

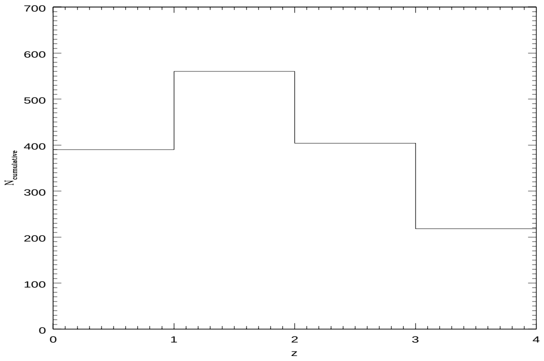

Figure 4. Redshift distribution of the unabsorbed sources expected to be detected in ChaMP fields.

3. Comparison with Previous X-ray Surveys

Survey	Total number of Sources	Quasars at $z > 2$
EMSS	835	< 5
(Gioia et al.)		
ROSAT Deep	661	12
(Hasinger et al.)		
ROSAT	89	< 10
(Boyle et al.)		
ChaMP	> 1500	> 600
(soft band, unabsorbed)		

We will be able to determine the X-ray luminosity function and its redshift evolution with unprecedented accuracy.

References

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