X-RAY BACKGROUND CONSTRAINTS ON THE LOG N–LOG S RELATION FOR AGN

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The most definitive information presently available on X-ray source populations comes from surveys carried out with the HEAO program (i.e., the all-sky HEAO-1 mission and the HEAO-2 Einstein Observatory) and EXOSAT. The large-sky/low-sensitivity survey (LSS) at high galactic latitudes performed with the HEAO-1 A2 experiment (Piccinotti et al. 1982) is complete and optically identified down to the level of about a millicrab. The LSS overlaps in spectral coverage (2–50 keV) with observations of the cosmic X-ray background (CXB) obtained with the same detectors (Boldt 1987). CXB surface brightness fluctuations observed in this band have been used to set constraints on the Log N–Log S relation for sources an order of magnitude fainter than those resolved in the LSS (Shafer 1983).

Deep sky surveys over limited angular regions of the sky with imaging detectors at the focus of grazing incidence X-ray telescopes have resolved sources substantially fainter than a millicrab. In particular, the high sensitivity survey (HSS) with HEAO-2 (Giacconi et al. 1979; Griffiths et al. 1983) has a source detection threshold S_o (1-3 keV) which, when extrapolated to higher energies, corresponds to about 2 microcrabs. The medium sensitivity survey (MSS) with HEAO-2 (Gioia et al. 1984) and the high latitude survey with EXOSAT (Giommi and Tagliaferri 1987) have used serendipitous source detections to obtain relatively large samples of objects at a reduced sensitivity from that of the HSS. The HEAO-2 IPC (imaging proportional counter) is sensitive to surface brightness and has been used to set upper limits on CXB fluctuations over arc-minute pixels devoid of resolved sources, albeit at energies (< 3 keV) where our knowledge of the CXB is relatively uncertain. Under the assumption that the residual CXB (i.e., that unresolved in the HSS) is not diffuse and that it ultimately arises from discrete objects Hamilton and Helfand (1987) conclude that the number of point sources needed would have to exceed 5×10^3 degree^{-2}.

Relating source counts obtained in various different spectral bands involves using a standard underlying spectrum. Apart from BL Lac type objects, AGN (active galactic nuclei) tend to exhibit power-law X-ray spectra characterized by an energy index $\alpha \approx 0.7$; CXB fluctuations observed with the HEAO-1 A4 experiment suggest that this power-law extends to > 100 keV (Gruber et al. 1988). However, a spectral complication is that relatively low luminosity AGN tend to exhibit pronounced absorption effects below a few

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keV (Lawrence and Elvis 1982); this is obviously very important for the interpretation of surveys carried out with the HEAO-2 Einstein Observatory and EXOSAT as well as with future soft X-ray survey missions (e.g., ROSAT).

An extrapolation of the MSS Log N–Log S result for canonical AGN yields that the number to be expected in the LSS is 8 as compared with the 29 actually observed. To investigate the origin of this discrepancy we examine surface brightness fluctuations in the unresolved CXB observed in the course of carrying out the LSS over the same spectral band. The greatest constraint on the Log N–Log S relation placed by these fluctuations is on sources an order of magnitude in flux below those resolved in the LSS; as such, this sort of analysis addresses the sensitivity regime of the MSS, albeit referred to the spectral band of the LSS. The resulting consistency with the LSS implies that the MSS Log N–Log S relation represents an underestimate reflecting a systematic bias (e.g., such as could arise from a significant population of AGN with highly absorbed X-ray spectra).

The average flux from unresolved sources is obtained by considering the residual CXB spectrum (Boldt 1987). The associated lower limit of 5×10^3 sources/degree^2 implies that $<S>$ corresponds to less than 0.03 S_o (where S_o is the threshold sensitivity for the HSS). Using a recent estimate of the present epoch density of AGN (Persic et al. 1988) as the comoving density at earlier epochs as well, we find that their number density on the sky would be sufficiently large provided the integration over lookback times extends to greater than 80% of the Hubble time (i.e., $z>2$). However, canonical AGN do not exhibit the requisite X-ray spectra for the CXB. On the other hand, if the residual CXB is due to spectrally suitable young "precursor" AGN at $z>3$ (with the same comoving density as present-epoch AGN) they could be sufficiently numerous for the case where they exist over a lookback time interval that is about a tenth of the Hubble time. In such a scenario, their X-ray luminosities would be $\sim 10^{45}$ ergs s^{-1}, comparable to the bolometric luminosity of present-epoch AGN (Boldt and Leiter 1987).

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