RESOLVING THE 10-40 KEV COSMIC X-RAY BACKGROUND WITH CONSTELLATION-X

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ABSTRACT

The energy density of the Cosmic X-ray background (XRB) peaks around 30 keV (see Figure 1), an energy not yet probed by focusing imaging instruments. The first hard X-ray telescope due to fly on a space mission will be that on board Constellation-X. The imaging capability, besides providing an improvement of several orders of magnitude in sensitivity over current passively collimated detectors, will permit for the first time to resolve a fraction of the XRB at this most crucial energy. Synthesis models of the XRB based on obscured AGN predict that at least 40% of the 10–40 keV XRB will be resolved by Constellation-X.

KEYWORDS: X-rays: galaxies; galaxies: nuclei

1. THE CONSTELLATION X-RAY MISSION

The Constellation X-ray mission is a high throughput X-ray facility emphasizing observations at high spectral resolution (E/Δ=300–3000) while covering a broad energy bandpass (0.25–40 keV). Constellation-X will provide a factor of nearly 100 increase in sensitivity over current high resolution X-ray spectroscopy missions. The large collecting area is achieved with a design utilizing several mirror modules, each with its own detector system. Each (or a few) science unit will fly on a separate spacecraft.

Two telescopes will be on-board: the low-energy Spectroscopy X-ray telescope (SXT), operating simultaneously with a 2 eV resolution calorimeter and a set of reflection gratings; a high-energy system (HXT), that will be the first focusing telescope system operating at several tens of keV, where the energy density of the XRB peaks (Figure 1).

The Baseline Mission Characteristics are:

• Effective Area: 15000 (6000, 1500) cm² at 1 (6.4, 40) keV
• Angular resolution: 15" HPD from 0.25 to 10 keV; 1’ HPD at 40 keV
• Band Pass: 0.25 to 40 keV

More information can be found at: [HTTP://CONSTELLATION.GSFC.NASA.GOV/](http://constellation.gsfc.nasa.gov/)
2. THE XRB SYNTHESIS MODEL

To evaluate the fraction of hard XRB resolved by the HXT onboard Constellation-X, we first developed a synthesis model based on the standard assumption that the XRB is mostly made by a combination of type 1 and 2 AGN (Setti & Woltjer 1989; Comastri et al., 1995, and references therein). Details on the model can be found in Pompilio, La Franca & Matt (1999 and this volume). Here we summarize the main features of the model.

1. AGN spectra
   (a) type 1 (AGN1) spectrum:
   • power law ($\alpha = 0.9$) + exponential cut-off ($E_c = 400$ keV);
   • Compton reflection component (accretion disk, $\theta_{obs} \sim 60^\circ$);
   (b) type 2 (AGN2) spectrum (Matt, Pompilio & La Franca, 1999):
   • primary AGN1 spectrum obscured by cold matter: $10^{21} \leq N_H \leq 10^{25}$ cm$^{-2}$, $dN (\log N_H) / d(\log N_H) \propto \log N_H$;
   • Compton scattering within the absorbing matter fully included.

2. Cosmological evolution
   (a) PLE ($\Phi^*(z = 0) = 1.45 \times 10^{-6} Mpc^{-3} (10^{44} \text{erg s}^{-1})^{-1}$);
   (b) power law evolution for the break-luminosity:
   $L^*(z) \propto (1 + z)^k$ up to $z_{max} = 1.73$, with
   $L^*(z = 0) = 3.9 \times 10^{42} \text{erg s}^{-1}$ and $k = 2.9$ (model H of Boyle et al., 1994);
   (c) the redshift integration is performed up to $z_d = 4.5$.

3. PREDICTIONS

We are now able to predict the fraction of the Cosmic XRB which can be resolved by Constellation-X in the 10–40 keV energy range. Our estimate is based on the baseline spatial resolution, i.e. 1’ HPD, which is a rather conservative value. Any improvement in this resolution will of course increase the fraction of XRB resolved.

The predictions are:

1. Number densities of type 1 and type 2 AGN detected in the 10–40 keV band down to a flux limit of $10^{-14} \text{erg cm}^{-2} \text{s}^{-1}$ (reachable with an exposure time of the order of a few thousand seconds, Harrison et al. 1999):
   • AGN1 $\rightarrow 53.3 \text{ deg}^{-2}$;
   • AGN2 $\rightarrow 123.4 \text{ deg}^{-2}$;
FIGURE 1. The spectrum of the Cosmic X–ray Background after Gruber (1992). The $\nu F_\nu$ representation shows that the energy density peaks at 30 keV.
70% are absorbed sources. (Note that these numbers implied a density of about a source per 20 beams, which should ensure a tolerable level of confusion. If the final spatial resolution will be better than 1', as it appears likely, confusion problems will be of course less severe).

2. Integrated XRB spectrum in the 10-40 keV band:

- measured value \( \rightarrow I(10 \, \text{–} \, 40 \, \text{keV}) \approx 9.4 \times 10^{-8} \, \text{erg cm}^{-2} \text{s}^{-1} \text{sr}^{-1} \) (HEAO-1 A2 data, Marshall et al. 1980);
- fraction of XRB down to a flux of \( 10^{-14} \, \text{erg cm}^{-2} \text{s}^{-1} \) \( \rightarrow I_{\text{Const}-X}(10 \, \text{–} \, 40 \, \text{keV}) \approx 4.0 \times 10^{-8} \, \text{erg cm}^{-2} \text{s}^{-1} \text{sr}^{-1} \);

\( \Rightarrow \sim 40\% \, \text{of the 10–40 keV XRB will be resolved by Constellation-X.} \)

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REFERENCES

- Oke B.J., Shanks T., Georgantopoulos I., Stewart G.C., Griffiths R.E., 1994, MNRAS, 271, 639
- Bestri A., Setti G., Zamorani G., Hasinger G., 1995, A&A, 196, 1
- Truber D.E., 1992, in “The X–ray Background”, X. Barcons and A.C Fabian eds., Cambridge University Press, p.45
-arrison F., et al., 1999, SPIE Proc., 3765, 104
- arshall F.E., et al., 1980, ApJ, 235, 4
- atti G., Pompilio F., La Franca F., 1999, New Astron., 4, 191
- otti G., Pompilio F., La Franca F., Matt G., 1999, A&A, in press (astro-ph/9909390)
- otti G., Woltjer L., 1989, A&A, 224, 21