The Cosmic Radio Background and AGN Connection

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The recently characterized Cosmic Radio Background provides a unique perspective in which to study the non-thermal Universe, and in particular properties and cosmological evolution of active galaxies and their outflows. As much as 1/3 of the total intensity of the radio background can be due to emission resulting from classical jet processes in radio galaxies and radio quiet quasars. Furthermore, weak jet activity in Seyferts and ordinary starforming galaxies may also be important.

The CRB

Recent results from the ARCADE 2 project reveal a cosmic radio background several times brighter than previously assumed.[2] The extragalactic background, detected from 22 MHz to 8 GHz, has a synchrotron power law spectral index of 0.6 and a brightness temperature of 1.17 K at 1 GHz, corresponding to an intensity of 7x10^4 Jy/sr at 1.4 GHz.

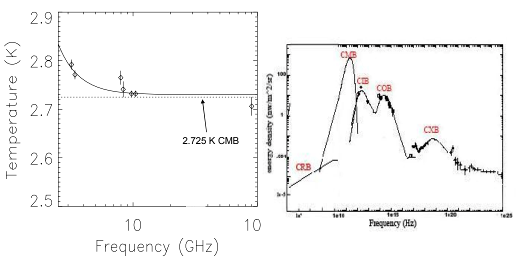

Figure 1: The left panel shows the ARCADE 2 data with a distinct rise in the extragalactic temperature at frequencies below where the CMB dominates. The right panel shows the CRB in context of the other photon backgrounds

Limits on diffuse emission

Because the same electrons that produce the synchrotron radiation of the CRB are subject to inverse-Compton scattering, the observed level of the x-ray / γ-ray background therefore places an lower limit on the average magnetic field in regions producing the CRB. Given the IGM magnetic fields, the CRB is not produced very far from galaxies.

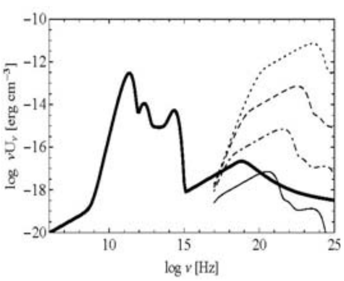

Figure 2: The observed EBL along with the calculated x-ray / γ-ray background arising from IC scattering of the other backgrounds,, for the observed CRB and given average magnetic fields ranging from 1 μG (thin solid) to 1 nG (dotted)

The two radio populations

Radio source counts from a variety of interferometric surveys tell a consistent story. A high flux population of large radio galaxies, associated with powerful jets, dominates at the ~1 Jy level.

A second population of radio quiet AGN and ordinary galaxies emerges at fluxes below 1 mJy. Integrating the flux from the high flux population gives ~15% of the surface brightness of the CRB arising from systems with powerful jets.

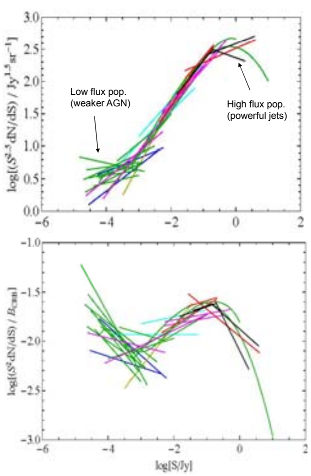

Figure 3: Radio source counts compiled from the literature, representing a variety of frequencies and resolutions. The bottom panel shows the integrated fractional contribution to the CRB per log flux bin

Number of low flux objects needed

Given that the CRB must be made from discrete sources, the rest of the background must come from sources below the flux limits of current source count surveys. The number of objects necessary to make the background is ~10^{10}, perhaps only a factor of 10 less than the total number of non-dwarf galaxies in the Universe.

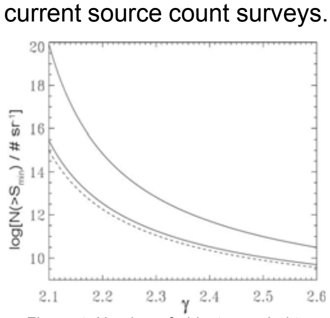

Figure 4: Number of objects needed to make the observed CRB as a function of the source count faint end slope

Low flux galaxies and jet emission

Given the number of objects necessary to make the background, and the observed spectrum, ordinary starforming galaxies likely form the bulk of the CRB. This is possible only if the radio-far infrared correlation[3] evolves with redshift, so as not to overproduce the observed far infrared background.[4] Some observational results suggest an evolving correlation. Several mechanisms could cause the radio-far infrared correlation to evolve – among them would be weak central AGN activity becoming proportionally more important.

it is well known that a large fraction of nearby spiral galaxies show weak AGN activity.[5] Several authors have argued that supermassive black holes (SMBHs) were spinning more rapidly at early epochs.[6] For spiral-hosted SMBHs the effect may be even stronger than for the elliptical hosted SMBHs that give rise to quasars.[7] In the framework of the spin paradigm for jet production[8], one could therefore expect more powerful jets, and therefore more AGN-related radio emission (for the same accretion luminosity) at higher redshifts in these systems.

Conclusions: Jets and the CRB

There is a strong link between AGN jet processes and the CRB. The large radio galaxies associated with powerful jets are responsible for 15 to 25% of the radio background. AGN with less powerful jets, the radio quiet quasars, contribute another few percent. The bulk of the radio background is made by ordinary starforming galaxies characterized by an evolving radio- far infrared correlation. One likely cause for an evolving correlation is that weak central AGN activity becomes proportionally more important, even in ordinary spirals. For a further discussion, see [1].

References: [1]J. Singal, L. Stawarz, A. Lawrence, & V. Petrosian, 2010, *MNRAS*, 409, 1172; [2]D. Fixsen, et al. 2011, *ApJ*, in press (arXiv: 0901.0555);
[3]E. Dwek. & M. Barker, 2002, *ApJ*, 575, 7D; [4]G. Marsden, et al. 2010, *ApJ*, 707, 1729; [5]L. Ho, 2008, *ARA&A*, 46, 475; [6]J. Wang, et al. 2009, *ApJL*, 697, 141;
[7]M. Volonteri, et al., 2007, *ApJ*, 667, 704; [8]M. Sikora, et al,. 2007, *ApJ*, 658, 815