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Blazars and Cosmic Backgrounds

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Abstract We discuss here the constraints on the Dark Matter (DM) nature that can be obtained from a multi-frequency study of the annihilation of DM particles in cosmic structures on large scales. We discuss specifically the predictions of SUSY neutralino models.

Key words: cosmology: dark matter — galaxies: galaxy clusters: dwarf galaxies

1 THE COSMIC BACKGROUND RADIATION

The study of the extragalactic background radiation has a long and remarkable history. Some of the landmarks in this history include the discussion by de Vacouleurs (1949) of the extragalactic contribution to the mean optical surface brightness of the sky, the discovery by Giacconi et al. (1962) of the X-ray background (XRB) radiation and the discovery by Penzias & Wilson (1965) of the cosmic microwave background (CMB) radiation.

The last few decades have shown that this subject has reached a very rich level in the description of the origin and structure of the various cosmic background radiations, over the whole electromagnetic (e.m.) spectrum, from radio waves to gamma-rays (see Fig. 1).

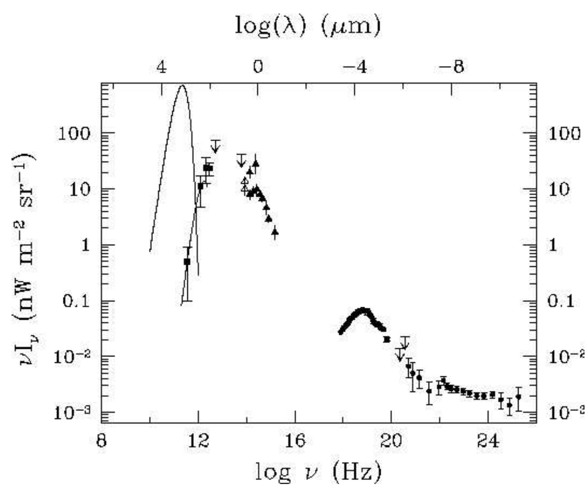

Fig. 1 The spectral energy distribution of the extragalactic background radiation from 10^8 to 10^{26} Hz. Figure from Hasinger (2000).

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In fact, the advent of high-resolution and high-sensitivity experiments like Chandra allowed to look in depth at typical patches of the sky (e.g. the Chandra Deep Field south) and have shown that the XRB actually consists mainly of discrete sources (predominatly active galaxies and moderate X-ray luminosity galaxies). The XRB has been indeed at the forefront of X-ray astronomy over the last 40 years. This constrasts with the situation in the radio band where the background has been frustratingly hard to measure and has attracted relatively little interest. The reasons for this situation are that: i) in the radio band the foreground galactic contribution is strong, rendering difficult to isolate the true extragalactic component; ii) the different technologies allowed to identify the strongest extragalactic radio sources early on, whereas it took several years after the discovery of the XRB before any individual extragalactic sources were reliably identified.

In this respect, the radio background resembles the Gamma-Ray Background (GRB). The EGRET all-sky survey (the only one we have so far at $E \gtrsim 100\,$MeV) indicate that the dominant high-energy γ-rays come from a specific subset of the AGNs: the Blazars, with their relativistic jets pointing almost directly towards us. However, the poor spatial resolution and sensitivity of the EGRET experiment do not yet allow to derive a definite estimate of the total contribution of Blazars to the GRB. This contribution depends mostly on an uncertain extrapolation of the Blazar counts towards fainter objects, an issue which is still under exploration (see the discussion in Sect.3).

The background in the optical band - which amount to ~ 100 times the energy density in the XRB - is also due primarily to galaxies, as the HST follow-up of the Chandra deed field south clearly shows. The UV background due to massive stars has a flat spectrum and relates directly to the amount of heavy elements produced. Thus, unless there are a lot of hidden heavy elements, most of the total UV and optical background light must be accounted for by faint galaxies.

The final band that we are going to discuss here is the far infra-red and microwave part of the spectrum, where recent technological and theoretical advance has been spectacular. The FIRAS experiment revealed that the CMB displays no deviations from a black body spectrum, even at the level of $\mathcal{O}\,(10^{-4})$. This sets strong limits on the amount of Comptonization in the hot Inter Galactic Medium, thereby ruling out a diffuse medium that could contribute significantly to the XRB. Contrary to the other principal cosmic backgrounds, the CMB is known to be of truly diffuse and primordial origin, since it is a *relic* left over from a time when the universe was hot and dense enough for baryonic matter (made of protons, neutrons, and electrons) and radiation to exist in a state of thermal equilibrium with each other. The CMB shows deviations from isotropy (anisotropies) at a level of $\mathcal{O}\,(10^{-5})$ on a variety of angular scales, and the pattern of these anisotropies can tell us interesting things about the cosmological parameters describing our universe, the nature of dark matter and the origin and distribution of large-scale structure in the universe.

Below the radio band frequencies, we approach the zero frequency limit, i.e. the "DC" component of the e.m. background radiation or - in other words - the cosmic magnetic field. These are ubiquitous, but it is still a mystery how they get started. Amplification mechanisms could operate on various scales but a "seed" field is nonetheless required. The origin of such seed magnetic field is still uncertain and it would be an important ingredient in various astrophysical and cosmological contexts.

To summarize, we know that there is a true cosmological background (the CMB) produced at the recombination epoch ($z \sim 1100$) and that the other cosmic backgrounds are mostly produced by cosmic structures on large scales (galaxies of normal and/or active nature). Because of its primordial peculiar nature, the CMB has the relevant potential to tell us about our early history (the original quantum fluctuation spectrum and the inflationary phase), the origin of our gravitating domesdays (the origin of galaxies, the structure formation scenario, the Dark Matter distribution and the baryon history) and the fate of our existence (the future evolution of our universe and of its main constituents). All of this is based on the detailed study of CMB anisotropies (both in temperature and polarization) on large to small scales.

However, since we know that there are many extragalactic sources shining on all scales and contributing to the XRB and other cosmic backgrounds, a non-trivial question may come to our attention: *how much of the CMB anisotropy specrum (both in temperature and polarization) is due to the cosmic structures which mostly produce the other cosmic backgrounds?*

In the following we will try to tackle this issue.

2 THE SPECTRAL ENERGY DISTRIBUTION OF COSMIC STRUCTURES ON LARGE SCALES

Cosmic structures on large scales show a variety of spectral energy distributions (SEDs). Normal galaxies have typical SEDs peaking at ~ 2 and ~ 100 μm, while starburst galaxies show a flatter SED in the range $\sim 1 - 10$ μm with a strong peak at ~ 100 μm (see, e.g., Andreani et al. 2003). Clusters of galaxies show usually a diffuse, bright thermal emission concentrated in the X-ray region (0.1 to 10 keV) and non-thermal diffuse emission features which are visible in the radio frequency range, and possibly in the Extreme UV (0.06 – 0.1 keV) and hard X-ray (20 – 80 keV) ranges. Moderate diffuse γ-ray emission is also expected from clusters at $E \gtrsim 100$ MeV.

There is, finally, a specific class of extragalactic sources which are extremely bright, that populate almost uniformly vast regions of the cosmological volume over wide cosmic ages and have SEDs which are extended - in some peculiar cases - over the entire range of the e.m. spectrum: these are the Active Galaxies, with the Blazar sub-class being characterized by a highly beamed emission with their jets pointing almost directly towards us.

Blazars are a class of radio loud AGNs distinguished by their extreme properties. These include large amplitude rapid variability, apparent superluminal motion, high level of polarization and emission of radiation across the entire e.m. spectrum, from radio waves to gamma–rays, up to TeV energies in some cases. This peculiar behaviour is thought to be due to physical phenomena observed under very special circumstances such as the emission of radiation from a relativistic jet of material ejected by a radio galaxy in the direction of the observer and seen at small angle with respect to the line of sight (see, e.g., Urry & Padovani 1995). The broad band SED of Blazars [usually represented in a $\nu f(\nu)$ vs. ν plane] starts with a rising function of frequency (corresponding to a flat radio spectrum, $f(\nu) \sim$ constant, widely assumed to be synchrotron radiation) and increases with ν up to a maximum that is normally located at $10^{12} - 10^{14}$ Hz but can even reach $\sim 10^{17}$ Hz in some extreme cases. Above this peak the spectrum falls sharply until Inverse Compton (IC) emission emerges and rises again to form a second peak which is typically located at frequencies $\nu \approx 10^{17} - 10^{19}$ Hz (see, Fig. 2 for a typical Blazar SED; many other examples of Blazar SEDs can be found at www.asdc.asi.it/wmap/).

There are two families of Blazars: the BL Lacs, showing an almost featureless spectrum (i.e., with no broad emission lines), which are rare and do not show a strong cosmological evolution, and the Flat Radio Spectrum QSOs (FSRQ), which have broad lines in their optical spectrum, are much more abundant in flux limited surveys and evolve strongly on cosmological times (see, e.g., Urry & Padovani 1995). FSRQs and BL Lacertae objects are thought to be the beamed counterparts of high and low luminosity radio galaxies, respectively.

In addition, other sources that are not accounted for in Blazar surveys have been detected, as a minority population but still in fair numbers, which are radio galaxies with extended emission and steep radio spectrum, that outshines a much flatter spectrum nuclear component which may emerge and dominate the emission above a few tens of GHz.

Intensity and spectral variations of Blazars are conspicuous at optical frequencies and become even larger at higher frequencies. Variability in the radio part of the e.m. spectrum can reach factors ~ 2 to 10 on typical time-scales of weeks to years with a clear tendency to become more pronounced and more frequent at higher frequencies.

Polarization at radio frequencies is often present in Blazars at a level of a few percent and in some case up to 10% (see, e.g., Hughes et al. 1992). The polarization degree is even higher at optical frequencies, indicating an increasing level of the polarization degree from radio to microwaves.

Due to their specific SED's, Blazars are the dominant type of extragalactic sources in the microwave region of the e.m. spectrum where the CMB power peaks, and in the gamma–ray/TeV region. We will explore, in the following, the impact of Blazars on different frequency regions of the spectrum of the cosmic background radiation.

3 BLAZARS AND COSMIC BACKGROUNDS

In this section we will review the extragalactic backgrounds to which Blazars may contribute in a significant way: these are the CMB, the XRB and the GRB. Such a discussion is extensively presented in Giommi et al. (2005) and we refer to this paper for further technical details.

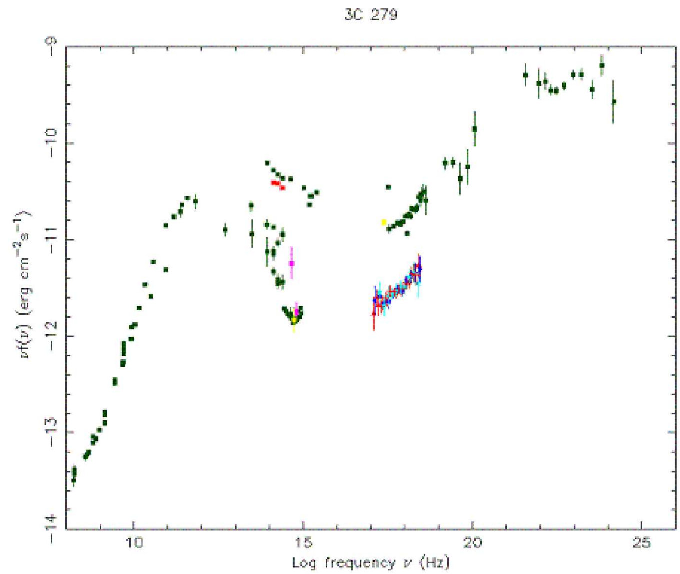

Fig. 2 The spectral energy distribution of the typical, well known Blazars 3C279 covers the whole e.m. spectrum, from the radio to the γ-rays where it has been observed by EGRET. The flux variability observed from this Blazar in the radio frequency range seems to increase in the optical and X-ray ranges, reaching its maximum level in the γ-ray band.

3.1 Blazars and the CMB

The contribution of Blazars to the CMB has been estimated in the past from different viewpoints (see, e.g. Toffolatti et al. 1998, Giommi & Colafrancesco 2004). The Blazar contribution to the CMB at different frequencies can be calculated as

$$I = \int_{S_{\min}}^{S_{\max}} S \, \frac{dN}{dS} \, dS \; , \tag{1}$$

where $dN/dS \propto S^{-(\alpha+1)}$ is referred to as the differential $\log N - logS$. We derived the Blazar $\log N - \log S$ at the frequency of 5 GHz and then we extrapolated it at higher frequencies assuming the proper radio spectral slope distribution of Blazars shown in Giommi & Colafrancesco (2004). We use here our new estimate of the Blazar $\log N$-$\log S$ to update the results presented in Giommi & Colafrancesco (2004). Figure 3 shows that the Blazar $\log N$-$\log S$ can be represented by a broken power law model with $\alpha = 1.65$ down $S \approx 15$ mJy and then with a flatter power low whose definite spectral index remains to be determined. The integrated background intensity due to Blazars therefore can be expressed as

$$I_{\rm Blazars} = \int_{0.1\rm mJy}^{1\rm Jy} S \, \frac{dN}{dS} \, dS \; . \tag{2}$$

The value of 0.1 mJy for $S_{\min}$ is likely to be conservative since Blazars with radio flux near or below 1 mJy are already included in the *Einstein* Medium Sensitivity Survey BL Lac sample (Rector et al. 2000). We found that the contribution to the microwave background intensity from Eq.(2) ranges between 5×10^{-5} to 5×10^{-6} of the CMB intensity, producing an apparent temperature increase of 5–80 μK deg (depending on the observing frequency) and causing a corresponding bias in the Gaussianity of the primordial CMB fluctuation spectrum.

Blazars, in fact, have a non-negligible contribution to the CMB anisotropy power spectrum. For a Poissonian distribution of point sources, the angular power spectrum, $C_{\ell,\rm Blazar}$, contributed by these sources

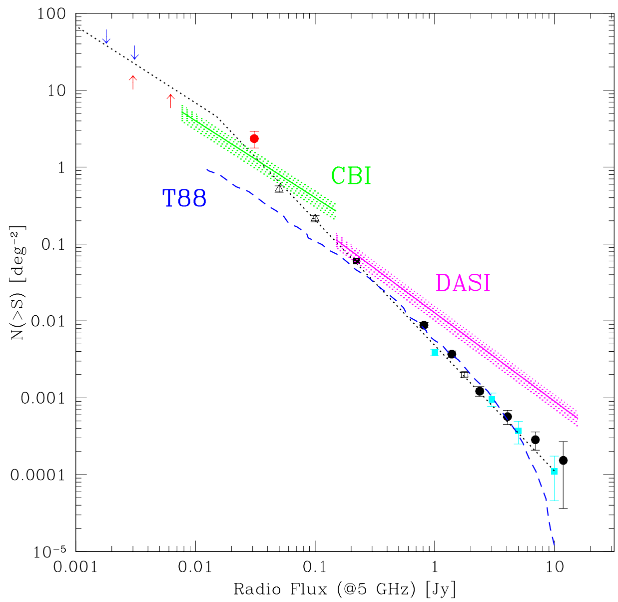

Fig. 3 The 5 GHz (integral) $\log N$-$\log S$ of Blazars built with data from the NVSS-RASSS 1Jy survey, DXRBS point at 0.1 and 0.05 Jy, quarter-Jy survey and the ASDC-XMM survey (from Giommi et al. 2005). The dotted line is a power-law with slope ≈ 1.65, which after the break at $S \approx 0.15$ mJy flattens to ≈ 1. We also show lower limits from the ASDC-XMM survey (red up-arrows) and upper limits obtained from the assumption that all NVSS sources are Blazars (blue down-arrows). We also show the source counts derived by DASI (magenta shaded area), CBI (green shaded area) with their flux rescaled down to 5 GHz, WMAP (cyan data points) and the model of Toffolatti et al. (1998) (blue dashed curve).

is given by

$$C_{\ell,\rm Blazar} = \int_{S_{\rm min}}^{S_{\rm max}} dS \, \frac{dN}{dS} \, S^2 \;, \tag{3}$$

(e.g., Tegmark & Efstathiou 1996, Scott & White 1999, Giommi & Colafrancesco 2004). The quantity at right hand side in Eq.(3) is the usual Poisson shot-noise term (see, e.g., Peebles 1980) and a further term, $\omega(I)^2$, adds to it if the clustering of sources is not negligible (Scott & White 1999). This last clustering term can be even a factor ~ 10 larger than the Poissonian term at large and intermediate angular scales, $\ell < 1000$ (see, e.g., Scott & White 1999). Figure 4 shows our predictions at frequencies ranging from 30 to 350 GHz. We have already presented specific predictions for the case of the WMAP 41 GHz channel elsewhere (see Giommi & Colafrancesco 2004).

Notice that these estimates of $C_{\ell,\rm Blazar}$ are a firm lower limit to the level of CMB fluctuation induced by the Blazar population. In fact, the value of the Poissonian term $C_{\ell,\rm Blazar}$ is likely to be higher by a factor at least $\gtrsim 2-3$ considering both the Blazar variability and the contribution of steep-spectrum sources at low frequencies, radio-galaxies and possibly starburst galaxies at lower fluxes (see discussion in Giommi & Colafrancesco 2004). We also stress that allowance for an appropriate clustering term might enhance substantially the angular power spectrum of the point-like sources and hence increases the level of contamination of the CMB power spectrum at low ℓ, i.e. at large angular scales.

It is also important to stress that Blazar variability is likely to increase with increasing frequency and, consequently, that flux variation at millimeter wavelengths may be substantial, higher and possibly more frequent than the factors 3–10 on time scales of weeks to months seen at cm wavelengths. This definitely increases the level of contamination of CMB maps when these are built over long integration periods as in satellite experiments.

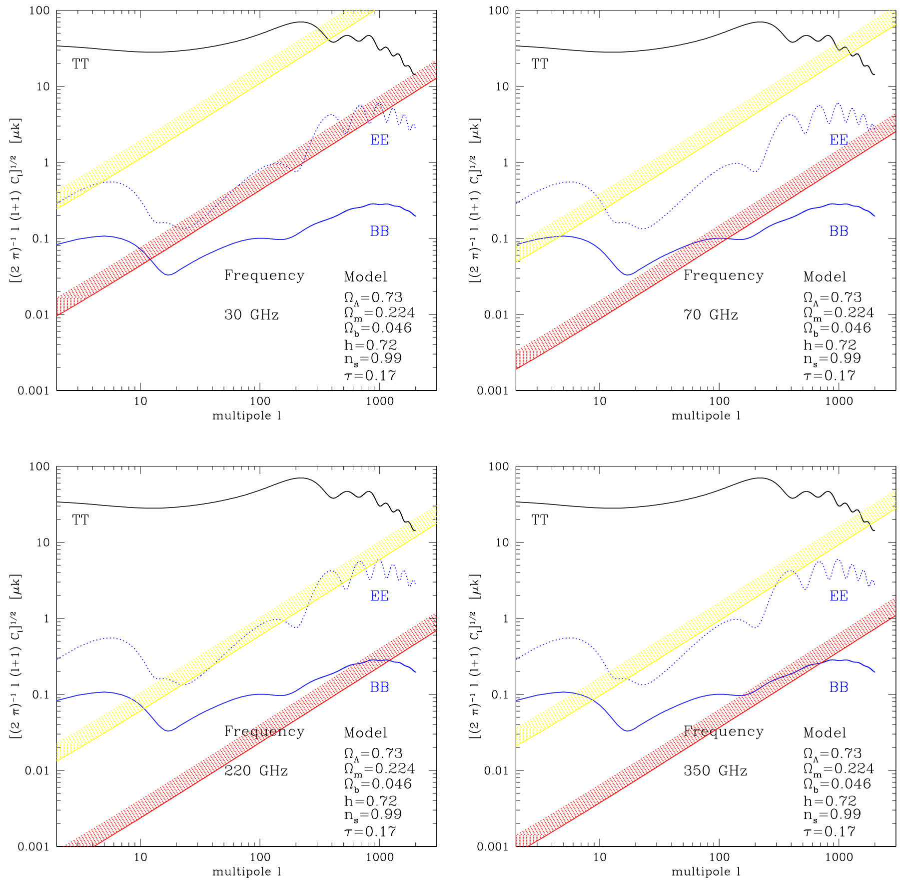

Fig. 4 The CMB power spectrum of the temperature (TT) and polarization (EE and BB mode) fluctuations is shown together with the power spectrum produced by Blazars at different frequencies: 30, 70, 220 and 350 GHz. We plot specifically the quantity $(2\pi)^{-1}\ell(1+\ell)C_\ell$ versus the multipole ℓ for the temperature (upper shaded bands) and polarization (lower shaded bands) fluctuations. A concordance cosmological model with the parameters shown in the figures is adopted. The dashed bands represent the level of variation of the Blazar spectrum due to the effects of variability and to the inclusion of steep-spectrum sources.

3.2 Blazar and the CMB Polarization

The observed pattern of the CMB intensity across the sky has told us much about our universe, including its history, age, geometry, density and ionization history (see, e.g., Hu & White 1997). However, we still know very little, especially about the earliest moments of the cosmic history. We can learn about the first fraction of a second by studying the polarization pattern of the CMB. It was realized - in fact - soon after the discovery of the CMB that this cosmic background radiation can also get polarized (see, e.g. Rees 1968). The polarization of the CMB arises because of the Thomson scattering of the photons and electrons at recombination, because the Thomson cross section depends on the polarization. However, the scattering of the radiation which is isotropic or which has a dipole asymmetry is not capable of producing polarization. The incoming radiation needs to have a quadrupole anisotropy. We refer to Hu & White (1997) for a review on the general features of the CMB polarization.

Of all the active extragalactic sources, the Blazar class exhibits the most extreme behaviour in variability and polarization (see, e.g., Ulrich et al. 1997). Degree of linear polarization up to $\sim\ 40\%$ seem to be common in radio jets at centimeter wavelengths, and local values $\gtrsim\ 50\%$ are not unusual while jets with low $\lesssim\ 5\%$ are exceptional (see, e.g., Bridle & Perley, 1984 and references therein). The UMRAO database interface (available at *http://www.astro.lsa.umich.edu/obs/radiotel/umrao.html*) provides examples of polarization light-curves for a few Blazars in the frequency range 4.8 – 15 GHz. The few Blazars listed in this sample show polarization levels $\sim 2\% - 6\%$ with the BL Lac object reaching $\sim\ 10\%$. The polarization degree in the core of these sources is expected to be $\sim\ 10\%$. There are also several reasons to expect that polarization increases at higher frequencies. At low frequencies (up to ≈ 10 GHz) a substantial depolarization can be induced by Faraday rotation of order $\sim 10^3$ rad m^{-2} (Taylor 2000, Pentericci et al. 2000). Moreover, as the observing frequency increases, regions which are closer and closer to the nucleus are probed: these regions are likely to contain magnetic fields which are ordered and ordered with, consequently, higher and higher polarization degrees.

As a consequence of the non-negligible Blazar contamination of the CMB maps, the primordial polarization patterns of the CMB itself could be heavily contaminated by these polarized sources (see Colafrancesco & Giommi 2005 for details). This is, in fact, the case as it is shown in Fig.4. Blazars heavily contaminate teh E and B-mode polarization spectra at $\nu \lesssim 100$ GHz and at $\nu \gtrsim 400$ GHz for multipoles $\ell \gtrsim\ 100$. The B-mode polarization spectrum is only marginally unaffected at $\ell \lesssim 50$ in a quite narrow frequency range around $\nu\ \sim\ 220$ GHz, the frequency at which the Blazar contamination is minimal. The predictions presented in this figure are, however, computed under the minimal assumption that the Blazar polarization does not change with the frequency. It should be noticed that even a mild increase of the level of polarization would enhance the contamination of the primordial polarization spectrum by a large factor (see discussion in Colafrancesco & Giommi 2005 for details).

In conclusion, we point out that a significant contamination of CMB fluctuation maps and the non-negligible fraction of residual unresolved sky brightness induced by Blazars will complicate both the analysis of the primordial fluctuation spectrum and the detection of primordial polarization fluctuations, since these are expected to be present only at a very low level, i.e. at a level $\sim\ 20 - 50$ lower than the primary CMB fluctuations.

3.3 From Microwaves to X-rays

The power density emitted by Blazars in the microwave region is almost similar to that emitted in the X-rays (see Fig.2). This observed feature of the Blazar SEDs allows to estimate the contribution of Blazars to the XRB moving from - and checking the results with - the CMB side. The contribution of Blazars to the XRB can be estimated using two methods (see Giommi et al. 2005): a) converting the radio flux intensity calculated with Eq.(1) into X-ray flux using the observed distribution of $f_{\rm x}/f_{\rm r}$ flux ratios; and b) converting the Blazar contribution to the CMB into X-ray flux through the use of the distribution of $\alpha_{\mu x}$, the microwave (94 GHz) to X-ray (1 keV) average slope defined as

$$\alpha_{\mu x} = \frac{\log(f_{\rm 1keV}/f_{\rm 94GHz})}{\log(\nu_{\rm 1keV}/\nu_{\rm 94GHz})} = \frac{\log(f_{\rm 1keV}/f_{\rm 94GHz})}{6.41} \; , \tag{4}$$

and estimated from the subsample of Blazars detected by WMAP in the 94 GHz channel and for which an X-ray measurement is available taking into account that the dominant population of Blazars at radio and microwave frequencies is that of LBL objects (see Giommi et al. 2005 for details).

The two methods prove to be quite efficient and converge to give a total Blazar contribution to the XRB of $(2.7 - 2.9) \times 10^{-12}$ erg cm^{-2}s^{-1}deg^{-1} in the ROSAT 0.1–2.4 keV energy band, which turns out to be $\sim\ 11\% - 12\%$ of the XRB intensity. The strong correlation between X-ray and microwave Blazar flux indicates that deep X-ray surveys are an optimal tool to estimate and control the microwave region of the Blazar SEDs, where the next coming CMB experiments like PLANCK will operate.

3.4 From Microwaves to γ-rays

The number of sources detected at energies higher than the soft X-rays is still rather low and building reliable flux ratio or spectral slope distributions similar to that of $f_{\rm x}/f_{\rm r}$ and $\alpha_{\mu x}$ is not currently possible. In order to estimate the Blazar contribution to high energy cosmic backgrounds ($E\ >$100 keV) we have followed a different approach based on the extrapolation of hypothetical Self Synchrotron Compton (SSC) SEDs scaled so that the predicted integrated intensity at microwave frequencies is equal to the contribution of Blazars to the CMB.

3.4.1 Hard X-ray – Soft Gamma-ray Background

Figure 5 shows the CMB, XRB and GRB spectra together with three predicted SED from a simple homogeneous SSC model that are constrained to pass through the expected integrated flux at 94 GHz to have the $\alpha_{\mu x}$ slope equal to the mean value of the WMAP Blazars ($\alpha_{\mu x}$ = 1.07) and spectral slope in the radio equal to the average value in the WMAP sample.

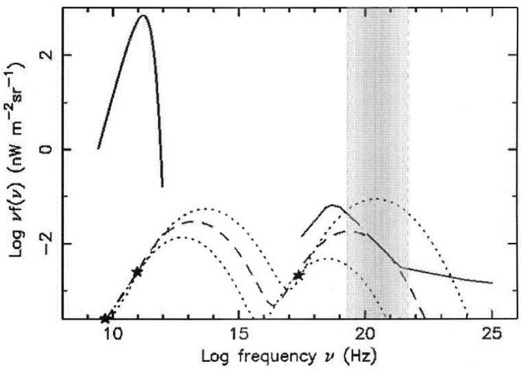

Fig. 5 The possible contribution of LBL Blazars to the Hard X-ray/soft Gamma-Ray background, as shown by the shaded region. The three SSC curves corresponds to different $\nu_{\rm peak}$ values (log $\nu_{\rm peak} = 12.8, 13.5$ and 13.8 in the observer reference frame) and are constrained by the total contribution of Blazars to the CMB at 94 GHz (8×10^{-6} CMB), the average 5 GHz to 94 GHz($\alpha_{5-94\rm GHz}$ = 0.2) and the point at 1 keV set equal to the flux predicted by the average slope between 94 GHz and 1 keV ($\langle\ \alpha_{\ \mu x}\ \rangle = -1.07$). These constraints are indicated by asterisks in the figure.

The three curves are characterized by different values of the synchrotron peak energy, $\log(\nu_{\rm peak}) = 12.8$, 13.5 and 13.8 Hz. From Figure 5 we see that a too high value of ($\nu_{\rm peak}$) over-predicts by a large factor the Hard-X-ray to soft Gamma-ray ($10^{20} - 10^{22}$ Hz or 500 keV – 50 MeV) cosmic background, whereas a too low value of ($\nu_{\rm peak}$) predicts a negligible contribution. The case $\log(\nu_{\rm peak}) = 13.5$ Hz predicts most or all the cosmic background. Since the $\log(\nu_{\rm peak}$) values of Blazars in the 1Jy-ARN survey and WMAP catalog peak near 13.5 and range from 12.8–13.7 within one sigma from the mean value, we conclude that the data presently available indicate that Blazar could produce a large fraction, possibly even 100% of the Hard-Xray/Soft Gamma cosmic background. This issue has to be combined with the possible contribution of Supernovae in the region 10 keV – 1 MeV (see, e.g., Zhang & Beacom 2004), where it seems that the two (and perhaps three) components are coming together.

3.4.2 Gamma-ray Background

The SSC distributions in Figure 5 predict a negligible Blazar contribution to the GRB in the range 100 MeV–100 GeV (see Fig.6). It is nevertheless well known that Blazars are the large majority among the extragalactic γ-ray ($E > 100$ MeV) sources detected by the EGRET (see, e.g. Hartman et al. 1999) experiment aboard the Compton Gamma-ray Observatory, and therefore are likely to contribute significantly to the GRB. Earlier estimates by Padovani et al. (1993) indicate that Blazars should make a large fraction, if not the totality, of the extragalactic GRB (see also Stecker & Salamon 1996). However, these calculations relied on a small database and had to assume no strong variability, a characteristic that has been later demonstrated to be very common in gamma-ray detected Blazars (see Giommi et al. 2005). Instead of considering simple average values of the radio to γ-ray flux ratio, we investigate the Blazar contribution to the GRB using the full set of Blazar SEDs. Specifically, we estimate the contribution to cosmic backgrounds in different parts of the e.m. spectrum normalizing the Blazar SED in the microwave region and scaling it to the integrated flux expected from the entire Blazar population as calculated in Sect. 2. We applied this method to the sample of the 34 Blazars detected by WMAP and EGRET (see Giommi et al. 2005 for details). This approach shows that, while at X-ray frequencies the contribution to the XRB ranges from a few percent to over 10%

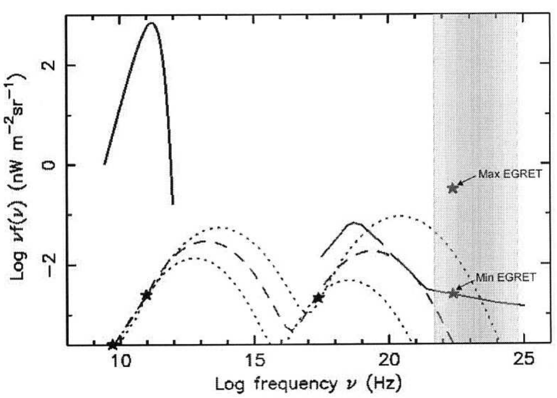

Fig. 6 The possible contribution of LBL Blazars to the GRB, as shown by the shaded region. The three SSC curves are the same as in Figure 5. The asterisks mark the maximum and the minimum flux reached by the Blazars detected by EGRET (see Giommi et al. 2005 for details).

in the higher states, the flux at γ-ray frequencies far exceeds the observed cosmic background intensity, a result which is mainly due to the large variability of Blazars seen in the X-ray and γ-ray bands. This large excess implies that either EGRET Blazars (like 3C279) are highly non-representative of the class of Blazars, despite their contribution to the XRB, $\approx$ 10%-13% is consistent with other estimates, or their duty cycles at γ-ray frequencies are very low.

3.4.3 TeV Background

All Blazars so far detected at TeV energies are of the HBL type. This is readily interpreted in the SSC scenario since only objects where the synchrotron radiation reaches very high energies can produce a corresponding Inverse Compton flux that is detectable at TeV energies, at least assuming a single scattering. In the following we estimate the Blazar contribution to the TeV background in a graphical way as in the previous Sect. 3.4.3 for the case of the GRB but only considering the HBL component and not the whole Blazar population. From a comparison between the normalization of the $\log N$-$\log S$ of Figure 3 and that of the Sedentary survey (Giommi et al. 1999), which is representative of the extreme HBLs, we estimate that these objects are about 0.1% of the Blazar population. Despite HBLs are a tiny minority even among the rare class of Blazars, their integrated X-ray flux makes a fair fraction of the XRB and that their TeV emission may produce a significant amount of extragalactic light. We note however that since extreme HBL are very rare ($\sim$ one object with flux above a few mJy in several thousand degrees), the integrated light at TeV energies is due to a relatively small number of discrete sources (located degrees apart) rather than an apparently diffuse light due to the superposition of many discrete sources as in the other cosmic backgrounds.

4 CONCLUSIONS

Studies of the contribution of large-scale cosmic structures to cosmic backgrounds are crucial to distill from the background radiation the relevant cosmological information and to determine the confidence of the extraction of cosmological parameters.

Non-thermal emission in Blazars is strong across the entire electromagnetic spectrum, and in some energy bands (e.g. the microwaves and the γ-rays) is orders of magnitude stronger than that of other types of AGNs. At these frequencies, despite their low space density, Blazars, and objects with similar SEDs, are the dominant population among extragalactic sources and therefore are obvious candidates as major discrete constituents of the extragalactic background radiation. The investigation of the Blazar contribution to the cosmic background radiation at these frequencies is becoming increasingly important since some of these energy windows, e.g. the microwave, the γ-ray and the TeV band, are going to be intensively studied by a new generation of astronomy satellites and ground based Cherenkov telescopes. In this context, multifrequency deep surveys are the key to understand the details of the low angular-scale structure of the cosmic background radiation across the entire e.m. spectrum. These surveys will also provide crucial information on the foreground emission from other relevant cosmic structures like normal and starburst galaxies and galaxy clusters.

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