INFRARED COLORS OF THE γ-RAY BLAZARS

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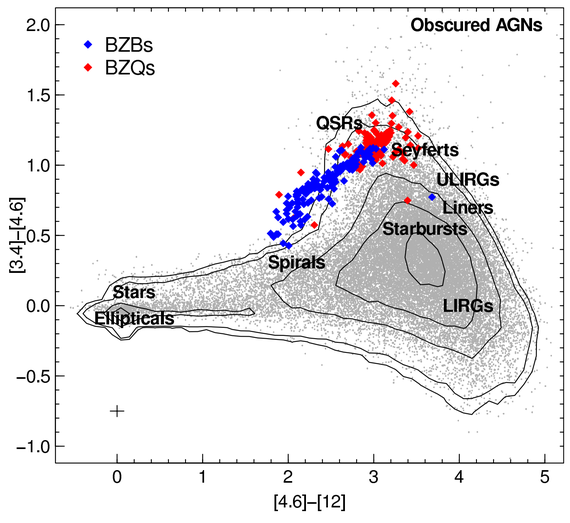
1 Introduction

Blazars constitute the most interesting and enigmatic class of extragalactic gamma-ray sources dominated by non-thermal emission. We present how the *WISE* IR data make possible to identify a distinct region of the [3.4]-[4.6]-[12] μm color-color diagram where the sources dominated by the thermal radiation are separated from those dominated by non-thermal emission, in particular the blazar population. We show the relation between the IR and gamma-ray emission for a selected sample of ROMA-BZCAT blazars associated with Fermi sources, for which WISE archival observations are available.

2 The γ-ray strip

As recently shown by D'Abrusco et al. (2011), **the γ-ray blazars, dominated in the IR by their non-thermal emission, lie in a distinct region of the [3.4]-[4.6]-[12] μm color-color diagram.** We selected 14 not-overlapping, random regions of 4 deg^2 each for a total 56 deg^2 at high Galactic latitude (Massaro et al. 2011), within the 116 deg^2 considered in the WSPC Curti et al. (2011). We collected all the 453420 sources detected by *WISE* in its 1st year catalog (hereinafter called *WISE* thermal sources because most of them are dominated by thermal emission in the IR energy range), having SNR>7 in at least one band.

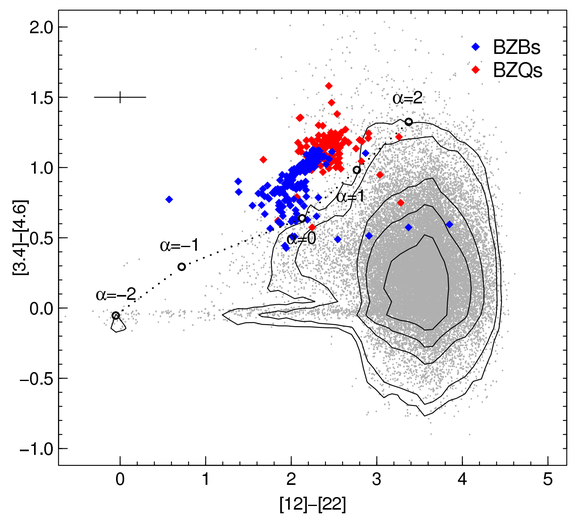


We built the [3.4]-[4.6]-[12] μm color-color diagrams from the Vega magnitudes reported in the *WISE* catalog for all the *WISE* thermal sources in the 56 deg^2 area described above, and for all the sources in the *Fermi* - *WISE* blazars sample. In Figure 1 we also show the location of different classes of objects, and overlaid to four levels isodensity contours for all the *WISE* thermal sources in the 56 deg^2 region. The relative errors the IR colors are less than 10% for 97% of the *Fermi* - *WISE* blazars sample.

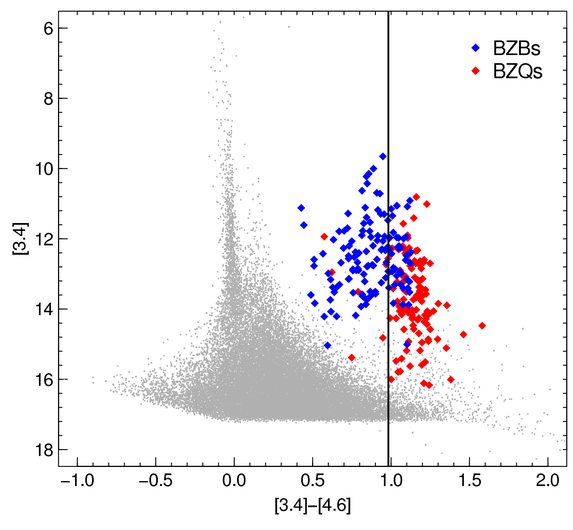
3 The infrared colors of the *Fermi* blazars

Assuming that the IR non-thermal spectrum of the sources in the *Fermi* - *WISE* blazars sample can be described as a simple power-law, we derive the relation between the IR colors and the spectral slope α_{IR}.

In Figure 2, built with the two *WISE* independent colors, we report the line corresponding to a power-law spectrum of different indices α_{IR}. Finally, we present a color-magnitude diagram for the three *WISE* bands with highest sensitivity, (Figure 3), where the flux limit of the *WISE* survey is clearly visible.



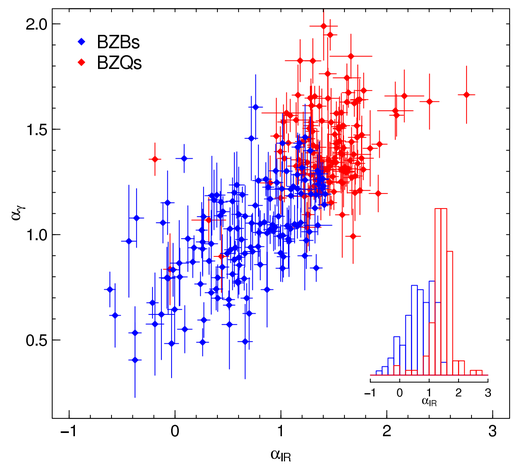
In this plot all *Fermi* - *WISE* blazars sample sources lie well above the value of the limiting magnitude at 3.4μm. The sources of the *Fermi* - *WISE* blazars sample are separated from the *WISE* sources even in this color-magnitude plot, but the region of the plane occupied by the blazars is less compact and well defined than the *WISE blazar Strip* visible in the [4.6]-[12] μm vs [3.4]-[4.6] μs color-color plane (Figure 1).



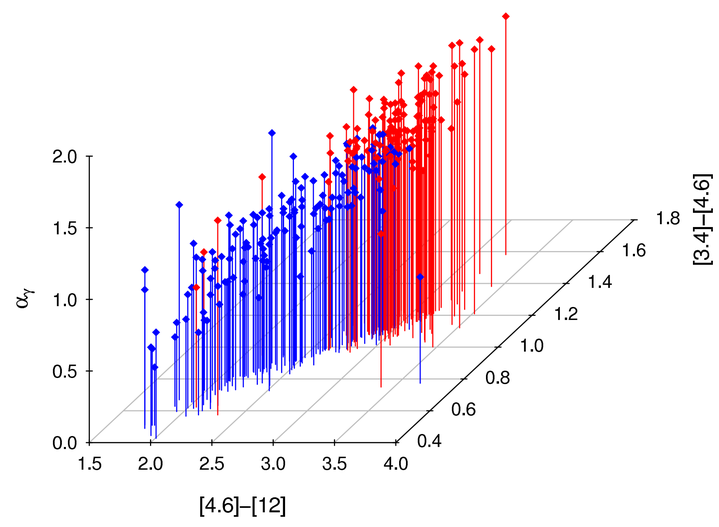
All the BZQs have [3.4]-[4.6] color lower than the value of the color associated with a power law spectrum of spectral index 1. This implies that these sources manifest their peak of the first component (i.e., the synchrotron emission) in the *WISE* spectral range.

4 The $\alpha_{IR} - \alpha_\gamma$ correlation

According to the SSC or the EC scenarios, usually adopted to interpret the blazars emission, the particles (i.e., electrons) that are emitting via synchrotron radiation at radio and IR frequencies are also those that are scattering the photons to high energy, in the X-rays and in the γ-rays, via inverse Compton emission. Consequently, **an empirical correlation between the spectral indices and the fluxes in the IR and in the γ-ray energy range is expected**, since they originate from the same electron distribution. A correlation between IR and γ-ray in the spectral range covered by *WISE* had not been observed to date. This could be mainly due to the lack of observations for a large number of blazars, now resolved by the availability of *Fermi* γ-ray data.



In Figure 4 we report the $\alpha_{IR} - \alpha_\gamma$ scatterplot with the line obtained by linear regression on the two spectral indices. The associated correlation coefficient is $r_s = 0.71$, corresponding to a negligible p-value; this implies that the two spectral indices are correlated at a very high level of significance. **The dichotomy between the BZB and BZQ classes of objects is evident.**



We also report in Figure 5 the 3-dimensional plot of the two main IR colors used to build the [3.4]-[4.6]-[12] μm color-color diagram and the γ-ray spectral index α_γ, to highlight the distinction between the two classes of blazars.

5 Summary

We find that the blazars in the *Fermi* - *WISE* blazars sample cover a very limited region of the [3.4]-[4.6]-[12]-[22] μm color-color plane, tighter than the similar locus found for the complete blazars population of the ROMA-BZCAT seen by *WISE* (Massaro et al. 2011). **Investigating the properties of the relation between the *gamma*-ray and the IR spectral indices, we found a clear trend between them consistent with the expectations of the SSC or the EC scenarios. In particular, in the $\alpha_{IR} - \alpha_\gamma$ plot the dichotomy between the two main classes of blazars, BZBs and BZQs is apparent.** The complete characterization of the IR colors for γ-ray selected blazars is given in D'Abrusco et al. (2011).

Acknowledgments

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