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Comparison of spectral properties of microwave background inhomogeneities on Planck maps with spectral properties of sources of RCR, NVSS and Planck catalogues

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A study of the spectral properties of positive spots on multifrequency Planck maps near RCR sources showed their identity with the spectral properties of NVSS sources and closest objects of the Planck catalogue associated with them. In both cases, a linear correlation was found between spectral indices of radio sources in the range of 0.15 - 3.94 GHz and spectral indices of closest spots (of Planck objects) in the frequency range 30 - 217 GHz. The compare of the combined spectra of RCR sources and closest positive spots with the combined spectra of NVSS sources and associated with them objects from the Planck catalogue suggests that the spots found near RCR sources may be manifestations of them in the sub-millimeter range, and most of the spots are extragalactic in nature. Part of the combined spectra of RCR objects and nearby positive spots can be explained by the variability of radio sources. The spectrum of averaged temperatures of hot spots detected near RCR sources was constructed, which showed a quantitative excess over those obtained earlier by modeling, which can be explained by the influence of synchrotron background or the contribution of radio source to radiation in the submillimeter range. The contribution of these unaccounted for radio sources to the foreground background can affect the resulting map of the cosmological microwave background.

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1. Dependences of spectral indices of positive spots at the Planck maps and of spectral indices of sources from RCR, NVSS and Planck catalogues

In the works [1, 2] it was shown that in the range of 30 - 217 GHz, positive fluctuations (spots) on the Planck frequency maps, coinciding with radio sources from the RCR catalog, can be manifestations of these sources or their parent galaxies in the submillimeter wavelength range. Their spectra in this frequency range similar to the spectrum of synchrotron radiation. To clarify nature of these spots, we compared their spectral indices in this range (α_{Pl}) with the spectral indices of the closest RCR sources at frequencies of 3.94 GHz ($\alpha_{3.94}$) and 1.4 GHz ($\alpha_{1.4}$), as well as the spectral indices of NVSS sources in the range of 0.15 - 3.9 GHz ($\alpha_{0.15}$) with the spectral indices of the nearest objects Planck catalogue in the range of 30 - 217 GHz (α_{Pl}). The comparison results are shown in Fig. 1 A linear correlation was found both between the spectral indices of radio sources and closest spots, and between spectral indices NVSS sources and spectral indices of nearby objects Planck catalogue. The Pearson correlation coefficient for the ascending branches of dependencies was 0.67 - 0.75. The differences of inclinations of the approximating lines of these dependencies ranged from 8 to 21%.

2. Combined spectra of RCR sources and the nearest positive spots and of NVSS sources and the nearest objects of the Planck catalogue

Combined spectra are constructed for RCR sources and the nearest positive spots (Fig. 2) as well as for NVSS sources and the nearest objects of the Planck catalogue (Fig. 3). The combined spectra can be divided into three groups: the first – the spectrum of the nearest spot (Planck source) is a continuation of the RCR (NVSS) source spectrum, the second – the spectral indices of a spot (Planck source) and a RCR (NVSS) source are close in magnitude, but the flux densities of spots (Planck source) are higher than the flux densities of RCR (NVSS) sources extrapolated to the microwave region of the spectrum. The third group includes those sources that in the range of 100 MHz - 8 GHz have inversion spectra. It is assumed that sources with a maximum in the spectrum are either young radio sources (HFP) or sources with a high degree of variability, in which the emission of compact jets predominates. The discrepancies that take place in the second group of spectra of RCR-sources and nearby spots may be due inaccuracy of calibrations, a random coincidence of their coordinates or can be explained by the variability of radio sources by analogy with variable NVSS-Planck sources. The appearance of the obtained spectrum indicates that most of the spots have an extra galactic nature and associated with the nearest radio sources. We believe that the contribution of unaccounted radio sources to the foreground may affect the resulting map of the cosmological microwave background.

3. The spectrum of averaged temperatures of hot spots detected near the RCR sources

The spectrum of averaged temperatures of hot spots detected near the RCR sources was obtained (Fig. 4), which showed a quantitative excess of the averaged temperatures of spots detected on Planck maps over those obtained by modeling of [3, 4]. The shape of the obtained spectrum indicates that most of the spots have an extragalactic nature: synchrotron at frequencies below 353 GHz and dust at frequencies greater than or equal to 353 GHz. This may be another argument in favor of the connection of spots with the nearest RCR sources, which are mostly extragalactic objects.

References

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[3] G. De Zotti, C. Burigana, M. Negrello, et al., *Surveys of extragalactic sources with Planck,* Proceedings JENAM 2004 meeting *"The many scales in the Universe", 13-17 Sept. 2004, Granada, Spain.* [astro-ph:00411182].

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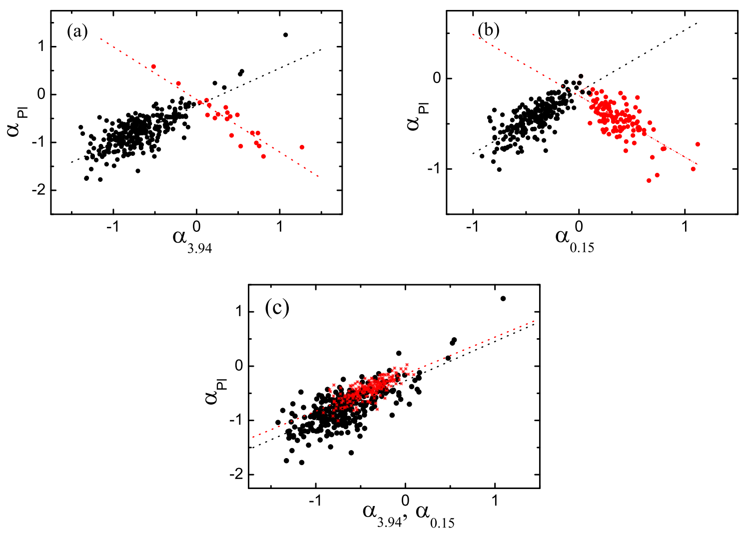

Figure 1: The dependencies $\alpha_{Pl} = f(\alpha_{3.94})$ - (a) and $\alpha_{Pl} = f(\alpha_{0.15})$ - (b) obtained for RCR sources and nearest spots on Planck maps and for NVSS sources and the nearest objects of the Planck catalogue respectively. Approximating lines are also shown: the black dotted line is the ascending branch, the red dotted line is the descending one. (c) - ascending branches of dependencies $\alpha_{Pl} = f(\alpha_{3.94})$ (black circles), with approximating lines (black dotted lines) and $\alpha_{Pl} = f(\alpha_{0.15})$ (red crosses), with approximating lines (red dotted lines). Flux densities of the spots were estimated using calibration curves in [1].

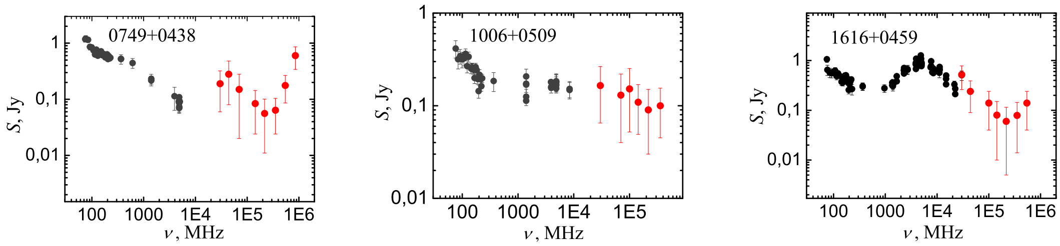

Figure 2: The combined spectra of RCR sources and the positive spots closest to them on Planck maps. The filled black circles denote the flux densities of RCR objects from the available catalogs, red filled circles indicate the estimated flux densities of the spots.

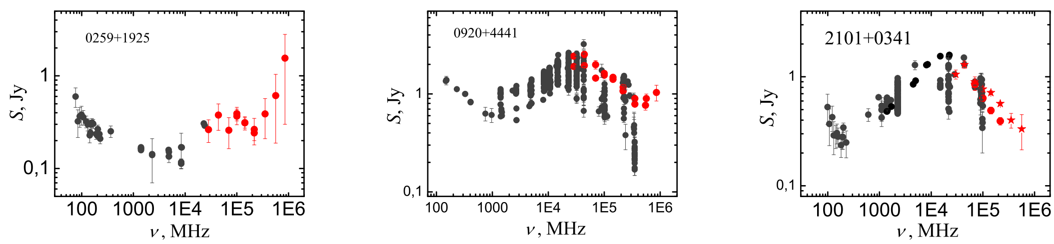

Figure 3: Examples of the spectra of NVSS-Planck sources. The sources 0920+4441 and 2101+0341 have a high degree of variability, in which the emission of compact jets predominates. The flux densities of sources from the Planck catalogue are indicated by red filled circles, black filled circles – flux densities of NVSS sources.

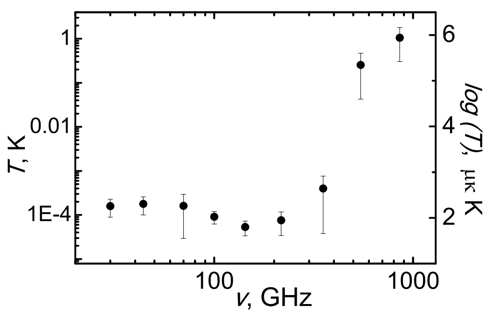

Figure 4: Spectrum of the averaged thermodynamic temperature T of spots located near RCR sources on a logarithmic scale.