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Wiener-filter inspired cross-correlation angular power spectrum of the unresolved gamma ray background and galaxies in a multitracer framework

Although one of the two namesakes of the ΛCDM cosmological model, the hypothesis of cold dark matter existence still chiefly relies on its gravitational effects, whilst both direct and indirect detection via non-gravitational signatures have not yet been achieved.
Weakly interacting massive particles (WIMP) are a candidate cold relic with a mass from 0.1 GeV to several TeV: they might thus annihilate or decay in γ photons. We know as well that the universe is permeated by an unresolved gamma-ray background (UGRB) detected by experiments such as Fermi – LAT. The UGRB seems to be chiefly sourced by highly energetic astrophysical sources: AGNs are the most likely sources, but exotic processess as dark matter contributions are not excluded; at low redshifts, the astrophysical contribution should even be subdominant compared to WIMP annihilation or decay signatures, as shown in previous works. More generally, the addition of dark matter to the UGRB sources was shown to improve, rather significantly at the lowest redshift, the fit compared to an astrophysics-only case.

For both astrophysical and dark matter research goals, it is interesting to relate the UGRB to the large scale structure (LSS) of the universe: if it is indeed sourced by objects clustered in the cosmic web, or by Dark Matter, whose clustering should be the ultimate responsible of the observed structure, it has to display parte of the anisotropy shown by the LSS. Indeed, although dominated by an isotropic shot-noise component, a degree of anisotropy was detected in the UGRB autocorrelation angular power spectrum in the past; the subsequently measured power spectrum of the cross-correlation with reliable LSS tracers like galaxies shows more clearly such anisotropy, suggesting a link between the UGRB and the Large Scale Structure of the Universe, at the same time allowing a better understanding of its composition.

Typical signal shapes and contribution can be analysed in terms of multipoles, redshift, gamma ray energy bin and mass range of the probed halos, to be gauged to sensitivity and resolution of present and future instruments, tuning the forecast according to observate capabilities and different research aims: hoping to extract larger and more significant information on the UGRB, we discuss the application of a multitracer technique to the galaxy-gamma ray cross-correlation signal, that is, a simultaneous fit of the galaxy autocorrelation, gamma autocorrelation and gamma-galaxy cross-correlation power spectra, taking into account the covariance between them and exploiting the increased amount of information and the possibility of overcoming part of the cosmic variance limits that the shot-noise imposes in independent fit configurations. The strategy is combined with a weighting scheme of the galaxy tracer distribution, which proved effective in enhancing the anisotropic contribution of other shot-noise-dominated LSS tracers, such as cosmic rays and gravitational waves. Its efficiency is assessed in terms of signal-to-noise ratio, comparing low and intermediate redshift galaxy surveys, and we discuss the cases of the UGRB signal being sourced either exclusively by astrophysical objects, exclusively dark matter, or both components together.

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