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Extended Abstract

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Sunyaev-Zeldovich effect as tool to probe fundamental physics and modified gravity

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We used the data on the Cosmic Microwave Background (CMB) temperature anisotropies measured by the Planck satellite and a sample of X-ray selected clusters with spectroscopically measured redshifts to probe the standard cosmological model and the underlying theory of gravity. To avoid antenna beam effects, we brought all the maps to the same resolution. We used a CMB template to subtract the cosmological signal while preserving the Thermal Sunyaev-Zeldovich (TSZ) anisotropies; next, we removed galactic foreground emissions around each cluster and we masked out all known point sources. Once the cleaning procedure is completed, we measured the TSZ effect on discs of aperture 500 and centered at the position of each galaxy cluster in our sample. Then, we extracted the value of the CMB temperature at galaxy cluster location. With these data we constrained the deviation of adiabatic evolution of the Universe and the spatial variation of the fine structure constant. Next, we measured the TSZ profile of COMA cluster and used it to constrain modified gravity models that, in their weak field limit, modify the Newtonian potential.

Feedback from supermassive black holes has a substantial but only partially understood impact on structure formation in the universe. The Sunyaev-Zeldovich signal from the hot gas that is present in black hole environments serves, as a potential probe of this feedback mechanism. Using a simple one-dimensional Sedov-Taylor model of energy outflow we calculate the angular power spectrum of the Sunyaev-Zeldovich distortion. The amplitude of temperature fluctuation is of the order of a micro-Kelvin in the cosmic microwave background at arcminute scales. This signal is at or below the noise level of current microwave experiments including the Atacama Cosmology Telescope and the South Pole Telescope. To further investigate this effect we have constructed microwave maps of the resulting distortion around individual black holes from a cosmological hydrodynamic simulation. The simulation employs a self-consistent treatment of star formation, supernova feedback and accretion and feedback from supermassive black holes. We show that the temperature distortion scales approximately with the black hole mass and accretion rate, with a typical amplitude up to a few micro-Kelvin on angular scales around 10 arcseconds. We also discuss the possible techniques for detection of this signal which includes pointed observations from high resolution millimeter wave telescopes and cross-correlation of optical quasar catalogs with microwave maps. We perform a cross-correlation analysis of the signal, by stacking microwave maps of quasars identified in the Sloan Digital Sky Survey. We use the microwave data from the Wilkinson Microwave Anisotropy Probe experiment to do this analysis. We perform a twocomponent (SZ+Dust) fit to the cross-correlation spectrum. Our results yield a best fit y parameter of $(5.8 \pm 1.8) \times 10^{-7}$. This signal is likely to be originating from the SunyaevZeldovich distortions from intervening large scale structures. We show that the Atacama Cosmology Telescope will be able to constrain this signal with a much higher statistical significance. In this work we have shown that a traditional tool of cosmology, namely the microwave background, can be used as a potential probe of feedback from supermassive black holes, which is an interesting problem in theories of galaxy evolution. Wilkinson Microwave Anisotropy Probe experiment to do this analysis. We perform a twocomponent (SZ+Dust) fit to the cross-correlation spectrum. Our results yield a best fit y parameter of $(5.8 \pm 1.8) \times 10^{-7}$. This signal is likely to be originating from the SunyaevZeldovich distortions from intervening large scale structures. We show that the Atacama Cosmology Telescope will be able to constrain this signal with a much higher statistical significance. In this work we have shown that a traditional tool of cosmology, namely the microwave background, can be used as a potential probe of feedback from supermassive black holes, which is an interesting problem in theories of galaxy evolution.

We study the effects of two popular modified gravity theories, which incorporate very different screening mechanisms, on the angular power spectra of the thermal (tSZ) and kinematic (kSZ) components of the Sunyaev-Zel'dovich effect. Using the first cosmological simulations that simultaneously incorporate both screened modified gravity and a complete galaxy formation model, we find that the tSZ and kSZ power spectra are significantly enhanced by the strengthened gravitational forces in Hu-Sawicki f(R) gravity and the normal-branch Dvali-Gabadadze-Porrati model. Employing a combination of non-radiative and full-physics simulations, we find that the extra baryonic physics present in the latter acts to suppress the tSZ power on angular scales $l \gtrsim 3000$ and the kSZ power on all tested scales, and this is found to have a substantial effect on the model differences. Our results indicate that the tSZ and kSZ power can be used as powerful probes of gravity on large scales, using data from current and upcoming surveys, provided sufficient work is conducted to understand the sensitivity of the constraints to baryonic processes that are currently not fully understood.

Bottom Note: *This work is partly presented at International Conference on Planetary Science and Particle Physics*, August 27-28, 2018, Boston, USA