Possible Evidence for Planck-scale Resonant Particle Production during Inflation from the CMB Power Spectrum

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The *Planck* Satellite has provided the highest resolution yet available in the determination of the power spectrum of the cosmic microwave background (CMB) [1]. Analysis of this power spectrum provides powerful constraints on the physics of the very early universe [1].

The primordial power spectrum is believed to derive from quantum fluctuations generated during the inflationary epoch. In this paper [2] we analyzed a peculiar feature visible in the observed power spectrum near multipoles ℓ = 10–30. This is an interesting region in the CMB power spectrum because it corresponds to angular scales that are not yet in causal contact, so that the observed power spectrum is close to the true primordial power spectrum.

An illustration of the *Planck* observed power spectrum in this region is shown in Figure 1. Although the error bars are large, there is a noticeable systematic deviation in the range ℓ = 10–30 below the best fit based upon the standard ΛCDM cosmology with a power-law primordial power spectrum. This same features is visible in the CMB power spectrum from the Wilkinson Microwave Anisotropy Probe (*WMAP*) [3], and hence, are likely a true feature in the CMB power spectrum.

The line drawn on Figure 1 shows a fit to the the ℓ = 10–30 dip in the *Planck* CMB power spectrum based upon a model for the creation of N nearly degenerate trans-Planckian massive fermions during inflation. The best fit to the CMB power spectrum implies an optimum feature at $k_* = 0.0011 \pm 0.0004\, h\,\mathrm{Mpc}^{-1}$ (wave number at the resonant frequency) and an amplitude of $A \approx 1.7 \pm 1.5$. For monomial inflation potentials consistent with the *Planck* tensor-to-scalar ratio, this feature corresponds to the resonant creation of nearly degenerate particles with $m \sim 8$–$11\, m_{\rm pl}/\lambda^{3/2}$ and a Yukawa coupling constant λ between the fermion species and the inflaton field of $\lambda \approx (1.0 \pm 0.5)N^{-2/5}$ for N degenerate fermion species.

If the present analysis is correct, this may be one of the first hints at observational evidence of new particle physics at the Planck scale. Indeed, one expects a plethora of particles at the Planck scale, particularly in the context of string theory. Perhaps, the presently observed CMB power spectrum contains the first suggestion that a subset of such particles may have coupled to the inflaton field leaving a relic signature of their existence in the CMB primordial power spectrum.

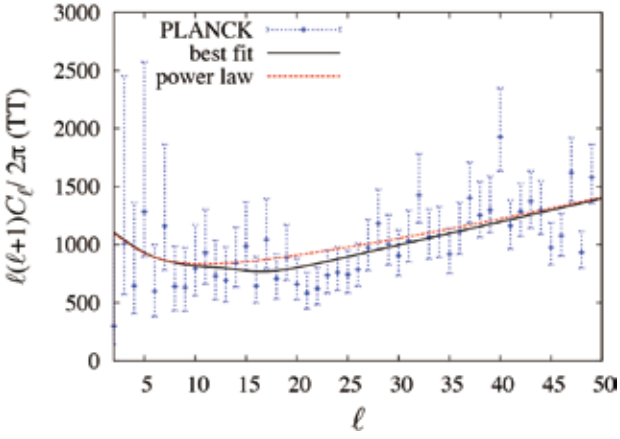

Figure 1: (Color online) CMB power spectrum in the range of ℓ = 3–50 Points with error bars are from the *Planck* Data Release [1]. The dashed line shows the best standard ΛCDM fit to the *Planck* CMB power spectrum based upon a power-law primordial power spectrum. The solid line shows the best fit for a model with resonant particle creation during inflation.

References

[1] Planck Collaboration, Planck XX: 2016, *A&A*, **594**, A20.
[2] Mathews, G. J., et al.: 2015, *Phys. Rev. D*, **92**, 123519.
[3] Hinshaw, G., et al. (WMAP Collaboration): 2013. *ApJS*, **208**, 19.