Blue Tensor Spectrum from Particle Production during Inflation

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Primordial gravitational waves (GWs) are inevitably generated as quantum fluctuations during inflation. In most inflationary models with a single scalar field, these GW signals are detectable only if the inflaton field range is trans-Planckian; such detectably large signals would, combined with the measured value of the curvature perturbations, set the inflationary energy scale to be around the GUT scale. However, it is a natural expectation that interactions between different particle species be present during inflation. We consider a hidden (non-inflaton) pseudo-scalar field, which is ubiquitous in high-energy theories such as string theory, to be present during inflation. By symmetry, the pseudo-scalar field naturally couples to a (hidden) U(1) gauge field. This coupling can lead to a copious production of the gauge quanta, inducing the quadrupole moment. The produced quanta then source the GWs, adding the contribution uncorrelated to the standard vacuum fluctuations. It has been found that the sourcing effect can dominate the GW signals, still respecting the bounds on the curvature perturbations. In this case, the GW spectrum can evade the restriction from the inflationary energy scale, and detectable GW signals can be produced even for a small range of inflaton field values. Moreover, this effect can accommodate a blue spectrum of the GWs and thus relax the apparent tension between the Planck upper bound and the BICEP2 detection. Within this model, the GW spectrum contains information of the pseudo-scalar field. For a given GW spectrum, we show that the pseudo-scalar potential can be reconstructed, as long as the signal is dominated by the sourcing effect. This mechanism also predicts a maximally chiral GW signals due to the parity-breaking nature of the pseudo scalar-gauge coupling and therefore potentially induces non-zero TB and EB correlations of the CMB anisotropy.