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Constraining inflationary magnetogenesis and reheating via GWs in light of PTA data

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Recent advancements in our observation of the cosmos have led to significant progress. However, we still lack a complete understanding of the dynamics involved in the reheating process after cosmic inflation. Gaining a deep understanding of reheating dynamics is crucial for deciphering the unfolding story of our universe. It is essential for reheating to conclude before the Big Bang Nucleosynthesis (BBN) temperature, denoted as $T_{\rm re} > T_{\rm BBN} \simeq 10^{-2}$ GeV.

Detecting reheating dynamics through observations of the Cosmic Microwave Background (CMB) faces challenges due to their shorter wavelengths. Fortunately, the recent detection of Gravitational Waves (GWs) by collaborations like LIGO-Virgo and Pulsar Timing Arrays (PTAs) has opened up a new avenue in observational cosmology. Our research, detailed in the paper (arXiv:2401.01864v1 [astro-ph.CO]), utilizes constraints on the epoch of reheating and inflationary magnetogenesis, employing limits on primordial magnetic fields (PMFs) and their contributions to secondary GWs.

Our analysis reveals that the combined spectral density of primary and secondary GWs from PMFs can generally be described as a broken power law with five distinct indices. We demonstrate that PMFs with blue tilt spectra, while adhering to other observational constraints, can generate significant GWs detectable by PTAs and upcoming observatories such as LISA, DECIGO, and BBO.

Importantly, our study identifies a specific spectral type whose slope depends on both the magnetic spectra index and the equation of state of the universe during the reheating period. Additionally, we determine that for $w_{\rm re} > 1/3$, the high frequency of GWs may impact the extra relativistic degree of freedom known as $\Delta N_{\rm eff}$.

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