INDIAN INSTITUTE OF TECHNOLOGY GUWAHATI
PhD-17 SHORT ABSTRACT OF THESIS

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SHORT ABSTRACT

The origin of large-scale cosmic magnetic fields and the physics of the post-inflationary reheating era remain two of the major open questions in modern cosmology. This thesis investigates their interplay and explores the resulting observational signatures, with particular emphasis on gravitational waves (GWs). We first study inflationary magnetogenesis in non-instantaneous reheating scenarios and show that the post-inflationary evolution of electromagnetic fields can substantially alleviate the strong-coupling and backreaction problems. Efficient conversion of electric into magnetic energy during reheating enhances the present-day magnetic field strength while generating secondary GWs that can exceed the primordial inflationary background. The resulting GW spectrum exhibits characteristic spectral breaks determined by the reheating dynamics. We then investigate post-inflationary magnetogenesis with a time-dependent gauge-field coupling active during reheating. We demonstrate that this mechanism can generate the observed large-scale magnetic fields without encountering strong-coupling or backreaction issues, while producing a broken power-law stochastic GW background whose amplitude and spectral shape are governed by the reheating equation of state and reheating temperature. We further explore magnetogenesis from axion-like particles after recombination, showing that ultra-light axions can generate helical magnetic fields and chiral GWs, providing potential observational targets for future CMB polarization and GW experiments. Finally, we propose a new mechanism for primordial black hole (PBH) formation, in which magnetic-field-induced density perturbations generated during reheating collapse into PBHs that can account for the observed dark matter abundance. These scenarios also predict correlated secondary GW signals. Overall, this thesis establishes a unified framework connecting reheating dynamics, primordial magnetogenesis, gravitational waves, and primordial black holes, providing new observational probes of the physics of the early Universe.