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Production of magnetic fields in axion inflation and their post-inflationary evolution

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There has recently been a growing evidence for the existence of magnetic fields in the extra-galactic regions, while the attempt to associate it only with the inflationary epoch has been found extremely challenging. We thus take into account the post-inflationary evolution of the magnetic fields originated from vacuum fluctuations during inflation. We consider the model in which the inflaton is a pseudo scalar and is coupled to the electromagnetic (EM) field through the term allowed by the symmetries. This interaction dynamically breaks parity and induces the continuous production of a helical EM field through tachyonic instability. The dominant contribution to the observed magnetic fields in this model comes from the modes that leave the horizon near the end of inflation, further enhanced right after the end of inflation. The EM field is subsequently amplified by parametric resonance during the period of inflaton oscillation. Once reheating occurs, the produced helical magnetic fields undergo a turbulent process called inverse cascade, which shifts their peak correlation from smaller to larger scales. We take all these effects into account in a self-consistent manner and obtain the magnetic fields with the effective strength of order 10−19 G. While this effect is present in any models with a pseudo-scalar inflaton, our result indicates the necessity of additional mechanisms to accommodate the observations.

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