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## Thermal productions of axion in DFSZ-type axion models

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Axion is a strong candidate for dark matter and has several types of production mechanisms. While the misalignment mechanism has been well-known since long ago and is usually assumed, thermal productions are another attractive possibility. In this talk, we will discuss thermal productions of the axion in DFSZ-type axion models, which involve heavy additional Higgs bosons. Interestingly, in this setup, axion is predominantly produced from the heavy Higgs boson decays, assuming that the reheating temperature of the Universe is larger than the mass of the heavy Higgs bosons. This is a characteristic feature of the DFSZ-type models in the sense that this does not happen in KSVZ-type axion models. Focusing on the axion with a mass of keV to sub-GeV scale, we will discuss how cosmological observations such as X-ray and CMB constrain the model parameter space.

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