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Cosmological Constraints on MeV-scale New Mediators

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Recently, many people have researched extensively dark matter models having dark sectors. Especially, MeV-scale dark matter can evade severe constraints from direct detections and is worth
considering its phenomenology. Those dark sector models often contain new light mediators. The mediators are produced in the early universe by the portal interactions and inject energy into the SM sector when decaying. Precise cosmological observations, therefore, can be sensitive to them. In this talk, we discuss cosmological constraints on the MeV-scale mediators, among which we pay particular attention to the dark photon and dark scalar. The dark photon and dark scalar are produced
from the thermal bath by the renormalizable couplings induced by kinetic and mass mixing, respectively. We estimate the energy injection into the SM plasma and provide the constraints
from the CMB Neff by solving the Boltzmann equations of the dark photon/scalar and SM sector. The out of equilibrium decay has a significant impact on the cosmological constraints, and therefore we treat the momentum dependence of the Boltzmann equations for the dark sector mediators. In addition, we find the production of the dark photon and dark scalar has quite different nature. The dark photon couples to the SM fermions universally, and its production is the conventional freeze-in type. Therefore we can put robust constraints from the CMB Neff and other observations. The dark scalar interacts with the SM fermions via the Yukawa couplings. Hence the contribution from heavy particles is significant and makes the thermal evolution very complicated. In particular, the resultant constraints depend strongly on the reheating temperature, even if the underlying
Lagrangian is renormalizable. We obtain the most conservative cosmological constraints on the dark photon/scalar, complementary to accelerator experiments and astrophysical observations.

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