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## Ultraviolet Freeze-in and Non-Standard Cosmologies

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A notable feature of UV freeze-in is that the relic density is strongly dependent on the highest temperatures of the thermal bath, and a common assumption is that the relevant ‘highest temperature’ should be the reheating temperature after inflation  $T_{RH}$ . However, the temperature of the thermal bath can be significantly higher in certain scenarios, reaching a value denoted  $T_{max}$ , a fact which is only apparent away from the instantaneous decay approximation. Interestingly, it has been shown that if the operators are of sufficiently high mass dimension then the dark matter abundance can be enhanced by a ‘boost factor’ depending on  $(m_{max}/T_{RH})$  relative to naive estimates assuming instantaneous reheating. We highlight here that in non-standard cosmological histories the critical mass dimension of the operator above at which the instantaneous decay approximation breaks down, and the exponent of the boost factor, depend on the equation of state  $w$  prior to reheating. We highlight four examples in which the dark matter abundance receives a significant enhancement in the context of gravitino dark matter, the moduli portal, the Higgs portal, and the spin-2 portal (as might arise in bimetric gravity models). We comment on the transition from kination domination to radiation domination as a motivated example of non-standard cosmologies.

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