Bringmann and Pfrommer Reply: In a recent Letter [1], we have proposed a general scenario where a *new light vector boson V*

(1) mediates a velocity-dependent self-interaction between dark matter (DM) particles χ, and
(2) induces a late kinetic decoupling of DM as the result of efficient scattering with some late-time relativistic species in the universe.

The role of the relativistic late-time scattering partners of the DM could, e.g., be taken by standard neutrinos (which requires an explicitly broken $SU(2)_L$ to avoid V-e couplings of the same strength as the necessary V-ν couplings) or by sterile neutrinos with mass $m_{\nu_s} \ll$ keV (which indeed turns out to be a very promising avenue for model building [2]). To the best of our knowledge, this scenario results in the only existing DM-based *simultaneous* solution to the most pressing small-scale problems of standard Λ cold DM cosmology (though a plethora of individual explanations have been discussed as well, both astrophysical and in terms of DM).

We fully agree with the authors of the Comment [3] to our proposal [1] that big bang nucleosynthesis (BBN) provides a very efficient way of constraining additional relativistic degrees of freedom at temperatures $T \lesssim 1$ MeV. However, we would like to stress that the allowed number of (effective) additional neutrino species ΔN_ν during BBN is still a matter of debate [4]. Moreover, the resulting constraint on m_V strongly depends on the exact numerical value of the assumed limit on ΔN_ν and thus the details of the underlying analysis (as is seen very clearly in Fig. 1 [3]). In fact, in the relativistic limit, the contribution from V to ΔN_ν is 1.71 (or only 1.14 if the longitudinal component is not thermalized, e.g., because it is inert), so V is left completely unconstrained for *any* mass if such a value is found compatible with BBN. While additional sterile neutrinos would certainly increase ΔN_ν, they would do so only marginally if they are not fully thermalized [i.e., $T_{\nu_s} < T_\nu = (4/11)^{1/3} T_\gamma$ at kinetic decoupling of DM], thus not necessarily changing these general conclusions.

Furthermore, as also acknowledged by the authors, standard BBN limits only apply for relativistic species, with ΔN_ν being constant during BBN. In other words, these limits do not actually originate from $T = 1$ MeV (as assumed in [3]) but rather from the whole range in temperature that determines the abundance of primordial helium and deuterium, 1 MeV $\gtrsim T \gtrsim 0.1$ MeV. As a result, the upper limits on m_V shown in Fig. 1 [3] become overly restrictive for $m_V \sim 1$ MeV.

To summarize, BBN limits on the existence of additional light species in the early universe are very useful in constraining particular realizations of our general scenario [1]. At the present stage, however, the significant inherent model dependence of those limits makes it difficult to derive model-independent implications. Last, but not least, it is worth stressing that in particular "heavy" V bosons with $m_V \gtrsim 1$ MeV—implying neutrino couplings of order unity [1], which is phenomenologically particularly appealing in the case of sterile neutrinos [2]—remain unconstrained.

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