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We consider an alternative to WIMP cold dark matter (CDM), ultralight bosonic dark matter (m ≥ 10ˆ(-22) eV) described by a complex scalar field (SFDM) with global U(1) symmetry, for which the comoving particle number density is conserved after particle production during standard reheating. We allow for a repulsive self-interaction. For complex SFDM, structure formation is CDM-like on large scales but suppressed on small-scales by quantum effects, just as in the case of a real scalar field. However, in the ΛSFDM universe, the background evolution of the complex field differs from that of the real field; complex SFDM starts relativistic, evolving from stiff (w=1) to radiationlike (w=1/3), before becoming nonrelativistic at late times (w=0). Thus, before the familiar radiation-dominated era, there is an earlier era of stiff-SFDM-domination, during which the expansion rate is higher than in ΛCDM. SFDM particle mass m and coupling strength λ, of a quartic self-interaction, are therefore constrained by cosmological observables, particularly N_eff, the effective number of neutrino species during BBN, and z_eq, the redshift of matter-radiation equality. Furthermore, since the stochastic gravitational-wave background (SGWB) from inflation is amplified during the stiff era, it can contribute a radiationlike component large enough to affect these observables by further boosting the expansion rate. Remarkably, this same amplification makes detection of the SGWB possible at high frequencies by current laser interferometer experiments, e.g., aLIGO/Virgo and LISA. For SFDM particle parameters that satisfy these cosmological constraints, the amplified SGWB is detectable by LIGO for a broad range of reheat temperatures T_reheat, for values of tensor-to-scalar ratio r currently allowed by CMB polarization measurements. The SGWB is maximally detectable if modes that reentered the horizon when reheating ended have frequencies today in the LIGO sensitive band. For r=0.01, if SFDM parameters are chosen which marginally satisfy the above constraints, the maximally detectable model for (λ/(mcˆ2)ˆ2, m)=(10ˆ(-18)eVˆ(-1)cmˆ3, 8×10ˆ(-20)eV) corresponds to T_reheat≈10ˆ4 GeV, for which we predict an aLIGO O1 run detection with SNR ˜ 10. Upper limits on the SGWB reported by aLIGO O1 already place a new kind of cosmological constraint on SFDM. A wider range of SFDM parameters and T_reheat should be accessible to aLIGO/Virgo O5. For r=0.01 and λ/(mcˆ2)ˆ2=10ˆ(-18)eVˆ(-1)cmˆ3, 3σ detection is predicted for 600 ≤ T_reheat(GeV) ≤ 10ˆ7 by O5.

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