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Axion as a cold dark matter candidate

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We show that the axion as a coherently oscillating scalar field acts as a cold dark matter (CDM) to the second-order perturbations in all cosmological scales including the super-horizon scale. The proof is made in the axion-comoving gauge. For a canonical mass, the axion pressure term causes deviation from the CDM only on scales smaller than the Solar System size. Beyond such a small scale the equations of the axion fluid are the same as the ones of the CDM based on the CDM-comoving gauge which are exactly identical to the Newtonian equations to the second order. Our analysis includes the cosmological constant, and can be easily applicable for the realistic situation including other fluids and fields.

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