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Stellar evolution constrains primordial black holes as dark matter candidates

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Dark matter could be captured by stars at any stage of their evolution.
By considering adiabatic contraction of the dark matter (DM) during star formation, we estimate the amount of DM trapped in stars at their birth.
We simulate the adiabatic contraction of a DM distribution during the process of the star formation, paying particular attention to the phase space distribution of the DM particles after the contraction. Assuming the initial uniform density and Maxwellian distribution of DM velocities, we find that the majority of particles contributing at any given moment into the density $\rho(r)$ at small r have very elongated orbits and spend most of their time at distances larger than r. That greatly increases amount of DM that could be captured during star lifetime
As a concrete example we consider the case of primordial black holes (PBHs). If the DM consists partly of PBHs, they will be trapped together with the rest of the DM and will be finally inherited by a star compact remnant—a white dwarf (WD) or a neutron star (NS), which they will destroy in a short time. Observations of WDs and NSs thus impose constraints on the abundance of PBH.

We show that the best constraints come from WDs and NSs in dwarf spheroidals which could exclude the DM consisting entirely of PBH in the mass range $10^{16} - 10^{24}$ g, with the strongest constraint on the fraction $\Omega_{PBH}/\Omega_{DM} \leq 10^{-2}$ being in the range of PBH masses $10^{20} - 10^{21}$ g. If the primordial origin of some old globular clusters would be confirmed these constraints would be considerably strengthened and total mass range $10^{16} - 10^{26}$ g would be excluded.

Collaboration

– not specified –

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