Title: Dark Matter in Pop III stars: The effect of a hypothetical object over another

Abstract:

Intro: Population III stars are the first supplier of light and metal of the universe. As formed in dense halos, their formation and evolution can be strongly affected by the capture and annihilation of Weakly Interactive Massive Particles (WIMPs) a Dark Matter (DM) candidate.

Method: Using the GENeva stellar Evolution Code (GENEC) we computed 20 M_{sun} Pop III models from ZAMS to the end of He burning, surrounded by DM of density from 10^8 to 3×10^{10} GeV/cm^3, with 3 different spins 0, 0.2, and 0.4 of their critical velocity, v_{crit} (Pauchet & Nandal 2025).

Results: WIMPs are captured and annihilate in the star center producing a new source of energy throttling nuclear burning. This leads to an extended Main Sequence (MS) duration. A 20 M_{sun} star in a 3×10^{10} GeV/cm^3 halo can reach up to 10^3 times longer MS than an DM-free star. Physically, the additional energy injection from WIMPs annihilation in the stellar core inflates the star, increasing internal radiative pressure and yielding a larger radius (cooler Teff) at the ZAMS. Rotation in addition to DM allows for more mixing of elements which leads to He quasi homogeneity. For a star with 10^{10} Gev/cm^3 WIMPs density and rotating at 0.2 v_{crit}, Hydrogen surface abundance is lowered to ~0.53 while Helium increases to Y~0.47 in comparison to X~0.75 and X~0.25 for a DM-free star, values generally reached for DM-free stars at much larger spin > 0.5 v_{crit}. The same model also leads to extreme CNO yields, i.e. 50 times higher surface abundances.

Conclusion: PopIII stars powered by DM energy, also called Dark Stars (DSs), could be the progenitors of the massive black holes in the center of galaxies, they could accrete a larger amount of matter due to their extended lifetime and be more stable against Gravitational Relativistic (GR) instabilities (Nandal et al. subm). Their detection could be possible due to their peculiar spectral signature, producing SuperNovae remnants (SNrs) rich in He, CNO and poor in H.