Contribution ID: **20** Type: **Contributed talk**

Dark Matter Heating vs. Rotochemical Heating in Old Neutron Stars

Tuesday, 12 November 2019 17:20 (20 minutes)

WIMP DMs in the Universe accumulate in neutron stars (NSs) through their interactions with nucleons. It has been known that their annihilation inside the NS core causes late-time heating, with which the surface temperature becomes $T_s \simeq (2-3) \times 10^3$ K for the NS age $t > 10^{6-7}$ years. Thus the measurement of NS surface temperature can be used as a new probe of WIMP DMs. Because of the strong gravity of NSs, DM heating has several advantages compared to the direct detection experiments on the earth.

Despite such advantages, the background on the DM heating is rarely discussed in the particle physics community. In particular, the rotochemical heating, internal heating caused by the out-of-equilibrium beta reactions in a NS, should be considered because it does not assume any exotic physics. In fact, if the rotochemical heating operates in a NS, it may conceal the DM heating effects.

In this work, we reevaluate the significance of the DM heating in NSs, including the effect of the rotochemical heating. We show that the signature of DM heating can still be detected in old ordinary pulsars, and discuss what is necessary to confirm the evidence for the DM heating.

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Session Classification: Young Scientists session

Track Classification: DM Astrophysics