Contribution ID: **43** Type: **not specified**

Antinuclei as a Signature for Dark Matter

Sunday 5 January 2020 21:10 (20 minutes)

Antideuteron and antihelium nuclei have been proposed as a detection channel for dark matter annihilations and decays in the Milky Way, due to a low expected astrophysical background. To estimate both the signal for various dark matter models and the astrophysical background, one employs usually the coalescence model in a Monte Carlo framework. However, this approach lacks an underlying microscopic picture, and the numerical value of the coalescence parameter obtained from fits to different reactions varies considerably. We therefore develop a new coalescence model for deuteron, helium-3, tritium and their antinuclei based on the Wigner function representations of the produced nuclei states. This approach includes both the size of the formation region, which is process dependent, and momentum correlations in a semi-classical picture. The model includes a single universal free parameter that we tune to experimental data on antideuteron production in electron-positron, proton-proton and proton-nucleus collisions. The obtained value $a_0 \sim 1$ fm agrees well with its physical interpretation as the size of the formation region. We use this model to estimate the expected antinuclei signal on Earth from dark matter annihilations and the secondary production in the Galaxy, and comment on the expected signals in AMS-02 and the upcoming GAPS experiments.

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Session Classification: submitted talks