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The Realistic Scattering of Puffy Dark Matter

If dark matter has a finite size, the intrinsic interaction responsible for the structure formation is inevitable from the perspective of dark matter self-scattering. To describe the circumstance in which the binding force realizes the finite size dark protons, we first use the Eikonal approximation to simplify the convoluted scattering between dark protons into the case at the $t = 0$ limit. The Chou-Yang model is then introduced to reduce the number of input parameters to one based on the simplicity and analyticity principle.
A new definition of velocity dependence and the corresponding implications on the small cosmological structures from Chou-Yang dark protons are shown clearly. Even though the parameter space is not fully covered, the numerical findings show that the amplitude coefficient can alter the self-scattering cross-section, allowing us to recover the excluded parameter space without using binding force. Finally, we demonstrate that the correct relic density from thermal freeze-out production prefers super heavy dark protons.
When the dark strong interaction is ignored, we present a comprehensive study on the self-interaction cross-section of puffy dark matter (DM) particles, which have a significant intrinsic size compared to their Compton wavelength.
For such puffy DM self-interaction cross-section in the resonant and classical regimes, our study demonstrates the significance of the Yukawa potential and the necessity of partial wave analysis:
(i) Due to the finite-size effect of puffy DM particles, the new Yukawa potential of puffy DM is found to enlarge the Born-effective regime for the self-interaction cross-section, compared with the point-like DM;
(ii) Our partial wave analysis shows that depending on the value of the ratio between R_χ (radius of a puffy DM particle) and $1/m_\phi$ (force range), the three regimes (Born-effective, resonant and classical) for puffy DM self-interaction cross-section can be very different from the point-like DM;
(iii) We find that to solve the small-scale anomalies via self-interacting puffy DM, the Born-effective and the resonant regimes exist for dwarf galaxies, while for the cluster and Milky Way galaxy the non-Born regime is necessary.

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