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How could we probe the angular dependence of dark matter self-interactions?

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Self-interacting dark matter (SIDM) is promising to solve or at least mitigate small-scale problems of cold collisionless dark matter. N-body simulations have proven to be a powerful tool to study SIDM within the astrophysical context. However, it turned out to be difficult to simulate dark matter models that typically scatter about a small angle, for example, light mediator models. We developed a novel numerical scheme for this regime of frequent self-interactions that allows for N-body simulations of systems like galaxy cluster mergers or even cosmological simulations. We have studied various systems and found significant differences between the phenomenology of frequent self-interactions and the commonly studied large-angle scattering (rare self-interactions). For example, in mergers of galaxy clusters, frequent self-interactions can produce larger offsets between galaxies and DM than rare self-interactions. In addition, we find the abundance of satellites to be stronger suppressed for small-angle scattering in galaxy clusters. Generally speaking, we find the most significant differences in the phenomenology of systems far from equilibrium. Consequently, these are the best-suited systems to probe the angular dependence of SIDM.

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