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Orbital evolution of solar system bodies due to dark matter haloes and giant molecular clouds

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We have investigated the effect of gravitational perturbations from dark matter haloes on Oort cloud comets, which are the most loosely bounded bodies among the solar system bodies. Oort cloud comets receive perturbation form external bodies: the galactic disk, nearby stars, and giant molecular clouds. The effects of these external perturbations have been studied by previous authors. Recent N-body simulations have revealed that dark matter particles form spherical-shape substructure called “dark matter halo”. Giant molecular clouds are also supposed to perturb solar system bodies. It is predicted that the dark matter haloes have a broad size distribution ranging from galactic size down to solar system size and each size equally contribution to the total mass of the galactic dark matter, in contrast to molecular clouds that are dominated by the largest bodies and nearby stars that are essentially point-like bodies. Here, we develop a formulation to evaluate the effect from external bodies with arbitrary sizes, which can be applicable for all of nearby stars, molecular clouds, and dark matter haloes. We evaluated the strength of the perturbations by dark matter haloes and giant molecular clouds by the increase rate of velocity dispersion of the solar system bodies. We found that the effect of nearby stars is generally largest, since the size distribution of dark matter haloes bay include large uncertainty, we also study the parameter range in which the effect of dark matter haloes is dominated.

Keywords: Comet, Oort cloud, Trans-Neptunian objects, Giant molecular cloud, Dark matter halo