DRACO and FORNAX to help examine Self-Interacting Dark Matter and Cold Dark Matter

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Original research: https://ui.adsabs.harvard.edu/abs/2020PhRvL.124n1102S/abstract

Credits: [1] M. Kaplinghat, M. Valli, and H.-B. Yu, (2019), arXiv:1904.04939 [astro-ph.GA]. T. K. Fritz, G. Battaglia, M. S. Pawlowski, N. Kallivayalil, R. van der Marel, S. T. Sohn, C. Brook, and G. Besla, Astronomy & Astrophysics 619, A103 (2018), arXiv:1805.00908 [astro-ph.GA].Gaia Collaboration, Astronomy and Astrophysics 616, A12 (2018), arXiv:1804.09381 [astro-ph.GA].S. P. Fillingham, M. C. Cooper, T. Kelley, M. K. R. Wimberly, M. Boylan-Kolchin, J. S. Bullock, S. Garrison-Kimmel, M. S. Pawlowski, and C. Wheeler, (2019), arXiv:1906.04180 [astro-ph.GA].

Source: University of California – Riverside

Summary:

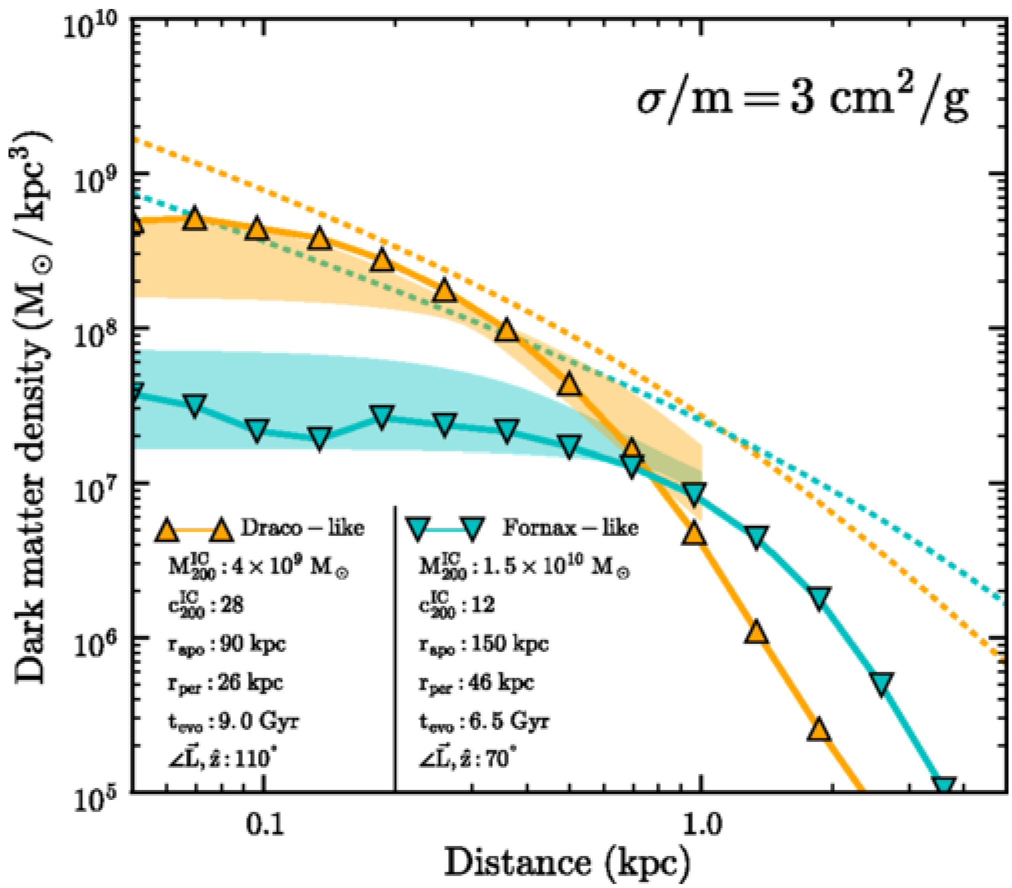
Introduction to SIDM and CDM. First of all, let us first recognize what dark matter is. Dark matter composes 27% of our Universe (which is more than ordinary matter). Unlike ordinary matter, dark matter does not absorb, reflect or emit light, which is why its properties, behavior and nature is still a mystery to humanity. Dark matter is usually studied through one type of its particles: Cold Dark Matter (CDM). CDM doesn't relate to temperature (but does refer to behavior of particles under temperature), it actually means particles moving with slow velocities and low energy in the universe. CDM can be thought of as collisionless dark matter particles. In CDM, dark matter subhalos contain and hold the satellite galaxies through gravitational scaffolding. CDM is great in explaining the formation and structure of galaxies but fails to explain the range of dark matter subhalo densities in the universe. Due to this problem, astrophysicists prefer Self Interacting Dark Matter (SIDM). This SIDM could help them in simulating and calculating dark matter densities in satellite galaxies. In SIDM, it is believed that in the inner halo of galaxies the dark matter strongly collides with each other, which is known as 'dark matter self-interaction'. This also lowers the halo concentration.

Why DRACO and FORNAX. Let's start with something like 'universal address' to give a vague idea of where DRACO and FORNAX are and what they experience in their locations. Our Milky Way galaxy spreads out its spiral arms to a limited space, after that comes a stellar halo. Between this halo and spiral arms is a 'tidal field' which has a gravitational force in it that feels like tides. Now these tidal fields contain satellite galaxies in them. These satellite galaxies are held together by the gravitational pull of dark matter subhalos. Two of these 50 discovered satellite galaxies are DRACO and FORNAX. DRACO has a high dark matter density whereas FORNAX which has a low dark matter density. The halos of these satellite galaxies have SIDM which is responsible for diverse dark matter distribution. Also in SIDM, the subhalos interact with Milky Way tides to produce diverse dark matter distributions in inner regions of subhalos. DRACO and FORNAX stand to be the best candidates to help test dark matter theory because physicists believe that both of these represent opposite ends of the spectrum for how central the DM subhalos are. Also their extremes can be covered with SIDM simulations.

Simulation. In SIDM, the dark matter self-interaction and tidal interaction combine to produce interesting signs. 'Exotic dynamics' are being simulated by physicists when a SIDM subhalo alters in tidal fields. They further noted that SIDM subhalo can produce a high dark matter density, which can also explain the case of DRACO. SIDM predicts a core collapse. The core collapse of the satellite galaxy happens under the influence of gravitational force. Usually when the core is normal, its density is normal but when the core collapses under gravity it increases its density. (i) In the case of DRACO, high initial concentration leads to high dark matter density; for which increased dark matter mass needs to be distributed in the inner halo. For SIDM, core collapse only happens when the halo concentration is high (because timescale < 13.8 billion years). (ii) In the case of FORNAX, there must be low concentration subhalo, which leads to low density. So we may say that

(i) DRACO - dark matter density and halo concentration is high.

(ii)FORNAX - dark matter density and halo concentration is low.



[1]Fig 3. The figure above matches with the results of the simulation. We can see a graph where the dark matter density (vertical/Y-axis) is given against distance (horizontal/X-axis). The units to measure the output from the graph for dark matter density is {Mo/ (kpc) ^3} and distance is {kpc}. The orange triangle, area and dashed curves represent profiles for DRACO, and the blue for FORNAX. The dashed curve shows initial

dark matter density and the normal curve shows final dark matter density. We can basically interpret from the graph (in both cases) that; the higher the density the closer is the object towards the core of the satellite galaxy. We also observe that DRACO has higher dark matter density than FORNAX when they are closest to the core and vice-versa when the farthest (for both initial and final). The shaded area represents cored isothermal density.

Results. After doing numerical simulations to properly take account of tidal interactions between dark matter self-interactions and tidal interactions, we get the result of simulation; SIDM subhalos central dark matter is increasing, therefore increasing mass and density of dark matter in subhalos. These simulations identify conditions for this (increase of central dark matter) phenomenon to occur in SIDM and help explain DRACO's observations.

Conclusion. We have proved that the SIDM subhalos and the tidal fields interact to give out diverse dark matter density. Scientists may further look forward to investigating other satellite galaxies of our Milky Way to obtain dark matter data. A hydrodynamical simulation on a Milky Way like galaxy would be a great approach.

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