Elliptical galaxies shed new light on dark matter

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In the 1930s, it was first noticed that the dynamics of astrophysical objects (galaxies, galaxy clusters and the universe itself) required an invisible and unknown form of mass, known now as dark matter. Strong mass discrepancies in spiral galaxies measured in the 1970s gave new weight to the concept of dark matter and motivated physicists to propose a number of dark matter particle candidates.

Over the 50 years since, intense worldwide campaigns to detect, directly or indirectly, dark matter particles have not been successful. As the dark matter problem is currently "lost in the dark," other schools of thought have arisen which suggest that instead of looking for missing "phantom" matter, we should instead modify our understanding of dynamics or gravity. These are the so-called modified Newtonian dynamics (MOND) or modified gravity (MOG) approaches.

Kepler's empirical laws of how planets orbit the sun, discovered about 400 years ago, led to the development of Newton's theory of dynamics and gravity shortly thereafter. With this historical lesson in mind, some astronomers have asked if Kepler-like laws of the stellar motions in galaxies may hold a crucial clue to solving the dark matter conundrum. Previous work has studied stars in spiral galaxies, where the gravitational acceleration is typically 100 billion to 1 trillion times smaller than on Earth.

Astrophysicists Kyu-Hyun Chae from Sejong University, South Korea, and Mariangela Bernardi and Ravi K. Sheth from the University of Pennsylvania, USA, showed that various dark matter, MOND or MOG scenarios, actually make divergent predictions at 10 to 100 times higher accelerations, and pointed out that massive elliptical galaxies were excellent laboratories for this test.

The Korea-US collaboration carefully selected nearly spherical galaxies from the Sloan Digital Sky Survey and the ATLAS3D survey and showed that they were indeed able to derive an acceleration relation (a possibly Kepler-like law) between baryons (normal matter) and dark or phantom matter. Although the MOND framework itself that M. Milgrom suggested more than 30 years ago is not ruled out by their new acceleration relation, a number of more recent theories are. Thus, their relation significantly constrains the space of possible modifications of dynamics or gravity and illuminates the directions for future research that are more likely to shed new light on dark matter and how it is related to baryons.

More information: Radial Acceleration Relation between Baryons and Dark or Phantom Matter in the Super-critical Acceleration Regime of Nearly Spherical Galaxies. arXiv:1707.08280 [astro-ph.GA] arxiv.org/abs/1707.08280

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