Internship in ESA's Advanced Concepts Team
On
Constraining Modified Newtonian Dynamics (MOND) with current or future ESA missions

European Space Research and Technology Centre
ESA ESTEC

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Topic Description

Several independent observations point to the fact that the visible mass in galaxies and galaxy clusters is insufficient to account for their dynamics, when analysed using Newton's laws. This is known as the "missing mass problem" [1, 2, 3]. This observation necessitates at least one of the following:

There exists in galaxies large quantities of unseen matter which boosts the stars' velocities beyond what would be expected on the basis of the visible mass alone, or Newton's Laws do not apply to galaxies.

Option 1 leads to the dark matter (DM) hypothesis; option 2 leads to MOND.

While the majority of astronomers, astrophysicists and cosmologists embrace the dark matter hypothesis, MOND remains a contestant in this question to this date. Proponents of MOND in particular stress the successes of the theory on galactic scales, such as that MOND provides a theoretic explanation for the empirical (baryonic) Tully-Fisher relation between the intrinsic luminosity of a spiral galaxy and its asymptotic rotation [4, 5], or that MOND predicts a far stronger correlation between features in the baryonic mass distribution and features in the rotation curve than does the dark matter hypothesis [6]. Proponents of DM in particular criticise the difficulties MOND has on the scales larger than that of galaxies. For example, on the scales of galaxy clusters MOND does not yet appear to solve the missing mass problem without the need of some additional, non-visible, matter – though a considerably smaller amount than without MOND [7]. Furthermore, MOND has a harder time than DM to adequately explain features on cosmological scales, such as structure formation or the spectrum of the cosmic microwave background radiation [7, 8].

Past proposals for space-based tests of MOND include the observation of the imprints of the theory in the planetary shifts of the perihelia (a slow change in the orientation of their orbits) [9], the detection of anomalous tidal stresses at the Earth-Sun saddle point by ESA's LISA Pathfinder probe [10] and the capturing of MOND effects in the orbits of test masses which build an "artificial solar system" in a purpose-built spacecraft, again located at the Earth-Sun saddle point [11].

Objectives

1) The main objective of this internship is to revisit the above mentioned and potentially other space-based tests of MOND and to reassess their feasibility in the light of current and potential future ESA missions and emergent technologies.

2) An optional additional objective is to design and conceptually proof a new such space-based test.

Joining the ACT

Creativity and out-of-the-box thinking are essential in the ACT. Therefore, the team is constantly striving to be a diverse, inclusive and equitable workplace bringing together people from various backgrounds. We strongly encourage people from under-represented groups to apply to be part of our team as diversity is central to our mission and core values.

In order to make our hiring as fair as possible, we also ask applicants to not include photos in their CVs.

References

https://en.wikipedia.org/wiki/Modified_Newtonian_dynamics

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[11] Sahni, Varun; Shtanov, Yuri (2008). "Apsis: An Artificial Planetary System in Space to Probe Extra-Dimensional Gravity and Mond". International Journal of Modern Physics D. 17 (3n04): 453–466.