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Editorial

Debate on the Physics of Galactic Rotation and the Existence of Dark Matter

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This Special Issue was motivated by the disparate explanations of galactic dynamics promulgated by different philosophical camps. The most populous camp advocates Newtonian orbital models where stars revolve in a galactic disk; these models require huge amounts of dark matter to reconcile the observed rotation curves (RCs) of stars that are smoothly distributed in spiral galaxies with the behavior exhibited by the few planets independently orbiting in the Solar system. A competing view called MOND offers "modified Newtonian dynamics" to explain galactic rotation without dark matter; these models require modification of the classical law of gravitation, but not in a way that is consistent with general relativity. These ideas are irreconcilable and consensus does not exist. Consequently, a few individuals and small research groups have pursued alternate means to explain galactic rotation without requiring either dark matter or non-Newtonian physics.

The overarching purpose of this Special Issue is to stimulate discussion and provide alternative ideas as a step towards an improved understanding of galactic dynamics. As originally conceived, a main goal was to assemble brief reviews by advocates of diverse viewpoints that summarize their preferred models while providing quantitative comparisons and cogent criticisms of other models. Our hope was to foster constructive criticism and communication between the various proponents. The second goal was to solicit novel explanations for galactic rotation, comprehensive analyses of RC, or new evidence for the existence of dark matter, which would shed light on various possibilities. A broad solicitation for contributions was issued, and numerous advocates of prevailing and novel models were specifically invited.

Most of the manuscripts we received did not adhere to the requested format. However, all papers met the second goal of offering comprehensive analyses, new evidence, or novel approaches. One paper reviews the literature on MOND and applies this type of analysis to a new database [1]. Surface brightness vs. radius (r) extracted from a new database is flat and distance, which shows ordinary matter, is more abundant than assumed in many models [2]. Three quite different Newtonian inverse models are presented, which extract density (ρ) from RC. Results for $\rho(r)$, obtained for a thick disk numerically [3] and for the equatorial plane via matrix inversion [4], bracket those obtained analytically for a spinning oblate shape [5]. None of these three inverse models require dark matter, and neither does a forward Newtonian model which considers a log normal distribution of mass [6].

Despite our broad solicitation and many invitations, only one paper argues for non-baryonic halos [7]. This author also models dark matter near the Earth [8]. Thus, the desired debate was limited. Two explanations for this come to mind.

One possibility is a recent development in particle physics, where multiple heavy hadron collider experiments in 2019 failed to yield evidence for non-baryonic matter. This non-result, which followed the discounting of neutrinos as halo constituents from 2015 observational collaborations, eliminated the other contender for non-baryonic matter, as no other means for its direct detection currently exist.

The lack of debate may also reflect some troubling trends of our times. Research in the physical sciences has become highly compartmentalized, impeding effective communication outside one's group. Over-specialization is driven by ongoing realities. One is that obtaining funding now requires researchers to strongly advocate their own work, rather than fairly assess their work in the context of current knowledge. In addition, the long-standing master–apprentice relationship in graduate school preferentially populates the research factions that are most successful in obtaining funding, favoring those with consensus views over those that innovate. Statistics of the reviewer pool and its anticipated feedback are among the obvious reasons for this outcome.

Because the desired debate did not materialize, we reviewed the mathematical underpinnings of all RC models and also closely examined the methods by which Doppler measurements are converted to RCs [9]. We present evidence that "warps" represent a perpendicular axis of rotation, in accordance with Jacobi's formulation for triaxial ellipsoids and SB morphology.

We hope that the reader will examine the various alternatives presented in this issue with a look to the future. What needs to be done next to better understand the dynamics of spiral galaxies? Our opinion is that the Doppler data need reprocessing to address the facts that spiral galaxies are not optically thin in the z-direction and that density grades outwards in z, while also accounting for the possibility of a second spin axis. Improvements in data processing, and refinements in existing inverse and forward models of RC, are needed before we can effectively address the evolutionary behavior of the amazing giants in our universe.

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