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Contributory: Nature of the dark matter distribution near the Galactic Center black hole: Insights from stellar orbital precession

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Abstract:

The stellar orbits near the Galactic Center black hole provide a unique probe for understanding the nature of mass distribution as well as carrying out tests of gravity. Inferring the nature of mass distribution in the region is crucial for understanding the formation history of the black hole and how it interacts with its environment. In this work we consider several viable dark matter models and constrain the parameters of the models which are consistent with the latest bound on dark mass near the Galactic Center. The pericenter shift of stellar orbits in presence of such mass distributions are worked out. We compare the dark matter precession with general relativistic precession and identify regions where dark matter induced effects might be dominant. We consider 13 S-stars that have passed or expected to pass their pericenter within the next decade. The prospect of detection of the dark matter effects in these stellar orbits through existing and upcoming large telescopes have been explored. In the orbit of S2, the effect of the different dark matter profiles along with some modified gravity models is investigated. It is seen that the orbit of S2 is insensitive to dark matter distribution but provides a good probe for testing modified gravity theories. Additionally, other stellar orbits with low eccentricity and large semi-major axis are found to be prominent probes for distinguishing different dark matter distributions. We identify five S-star orbits that can be used to distinguish between these mass profiles using observational facilities like Keck, Very Large Telescope and upcoming Thirty Meter Telescope.

References:

1. Paul D., Kalita S., 2026, MNRAS, 547, 2
2. GRAVITY Collaboration et al., 2024, A&A, 692, A242

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