10th International Conference on Gravitation and Cosmology: New Horizons and Singularities in Gravity (ICGC 2023)

Contribution ID: **15** Type: **Poster**

Testing f(R) Scalaron gravity near the Galactic Center black hole

The presence of compact stellar orbits near the Galactic Center (GC) black hole presents a magnificent opportunity for testing modified theories of gravity as the gravitational potential (GM/c^2r) is equal to or more than 100 times the one encountered in the solar system. In this work, we study the effect of f(R) gravity near the GC black hole using both model dependent and independent approaches. In the model dependent approach, we choose a cosmologically motivated model, $f(R) \propto R^2$ and study the deviation in orbital pericentre shift from GR for both zero and non-zero spin of the black hole and with semi-major axis equal to or below a=1000 au (S0-2 like orbits). It is seen that f(R) gravity effects become prominent near compact orbits. In the model independent approach to f(R) gravity, the bounds on generic scalaron fields ($\psi = f'(R)$) and coupling constant (α) are extracted from the current bounds on Parametrised Post Newtonian (PPN) parameters (γ, β) near the GC black hole . Using the same bounds, the screening of f(R) gravity is further investigated. It has been observed that the lighter mass scalarons ($10^{-22}\ eV$) and intermediate mass scalarons ($10^{-19}\ eV$) remain unscreened near S0-2 like orbits (a \sim 1000 au) as well as near the orbit of newly detected short period star S4716 (a \approx 407 au). But the heavier mass scalarons ($10^{-16}\ eV$) tend to remain completely screened near these orbits. Testability of the f (R) gravity effects using astrometric capabilities of current and upcoming Extremely Large Telescopes (ELTs) is also highlighted. A new rotating metric with scalaron is obtained using Newman Janis Algorithm from a previously proposed Schwarzschild metric with scalarons (Kalita 2018). The effective potential is developed for this scalaron Kerr metric. Prospects for testing gravity through pericentre shift in this model will also be highlighted.

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Session Classification: Classical & Quantum Gravity

Track Classification: Classical & Quantum Gravity