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OBSERVATIONAL TESTS OF GENERAL RELATIVITY AND ALTERNATIVE THEORIES OF GRAVITY WITH GALACTIC CENTER OBSERVATIONS USING CURRENT AND FUTURE LARGE OBSERVATIONAL FACILITIES

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Now there are two basic observational techniques to investigate a gravitational potential at the Galactic Center to prove a presence of a supermassive black hole, namely, (a) monitoring the orbits of bright stars near the Galactic Center with the largest telescopes; (b) measuring the size and shape of shadows around black hole giving an alternative possibility to evaluate black hole parameters with the Event Horizon Telescope. We discuss opportunities to test gravity theories with observations of bright stars at the Galactic Center. Recently, the joint LIGO - Virgo team not only discovered gravitational waves and binary black holes but also found an upper limit on graviton mass $m_g < 1.2 \times 10^{-22}$ eV (Abbott et al. 2016). We show that an analysis of bright star trajectories could constrain graviton mass with a comparable accuracy. We discuss opportunities to improve current estimates of graviton mass significantly with subsequent observations of Keck, VLT, GRAVITY, E-ELT and TMT and to reach a graviton mass estimate as low as $m_g < 5 \times 10^{-23}$ eV (Zakharov et al. 2018). We discuss recent GRAVITY results about gravitational redshift for S2 star near the pericenter passage. These results confirmed GR predictions for the Galactic Center. Therefore, such an analysis gives an opportunity to treat observations of bright stars near the Galactic Center as a useful tool to obtain constraints on the fundamental gravity law. We showed that in the future graviton mass estimates obtained with analysis of trajectories of bright stars would be better than current LIGO bounds on the value, therefore, based on a potential reconstruction at the Galactic Center we obtain bounds on a graviton mass and these bounds are comparable with LIGO constraints. Similarly, we could constrain a tidal charge for the black hole (Zakharov, 2018). Analyzing size of shadows around the supermassive black hole at the Galactic Center (or/and in the center of M87) observing with the Event Horizon Telescope one could constrain parameters of different alternative theories of gravity as well (Zakharov, 2019).

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