

QUANTUM EFFECTS ON THE BLACK HOLE SHADOW IN A PRESENCE OF PLASMA

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<https://doi.org/10.5281/zenodo.7544304>

The Einstein's theory of general relativity (GR) is an effective gravitational theory which is applicable for physical scales much greater than the Planck scale but smaller than the Hubble scale. However near the Planck scale, the GR gets necessary amendments in the action by certain averaging effects such as due to renormalization group [1]. The astrophysical black holes (BHs) are surrounded by plasma and magnetic field. This has been recently confirmed by the astronomical observations of M87 galactic center observed by the Event Horizon Telescope (EHT) collaboration using the polarized synchrotron radiation probes [2]. The observations showed the presence of hot plasma having temperature of the order 10 billion Kelvin along with magnetic field with strength of order 30 Gauss.

The spacetime metric describing a static and spherically symmetric The renormalization group improved (RGI) BH is given by [3]:

$$ds^2 = -f(r)dt^2 + \frac{dr^2}{f(r)} + r^2(d\theta^2 + \sin^2\theta d\varphi^2)$$

with

$$f(r) = 1 - \frac{2M}{r} \left(1 + \frac{\Omega M^2}{r^2} + \frac{\Omega\gamma M^3}{r^3}\right)^{-1}$$

If the observer is located at a sufficiently large distance from the BH then one can approximate radius of BH shadow as [4]

$$R_{sh} = r_p \sqrt{\frac{1}{f(r_p)} - \frac{\omega_p^2(r_p)}{\omega_0^2}},$$

where r_p is the radius of photon orbits, ω_p^2 and ω_0^2 are the plasma frequency and photon frequency, respectively.

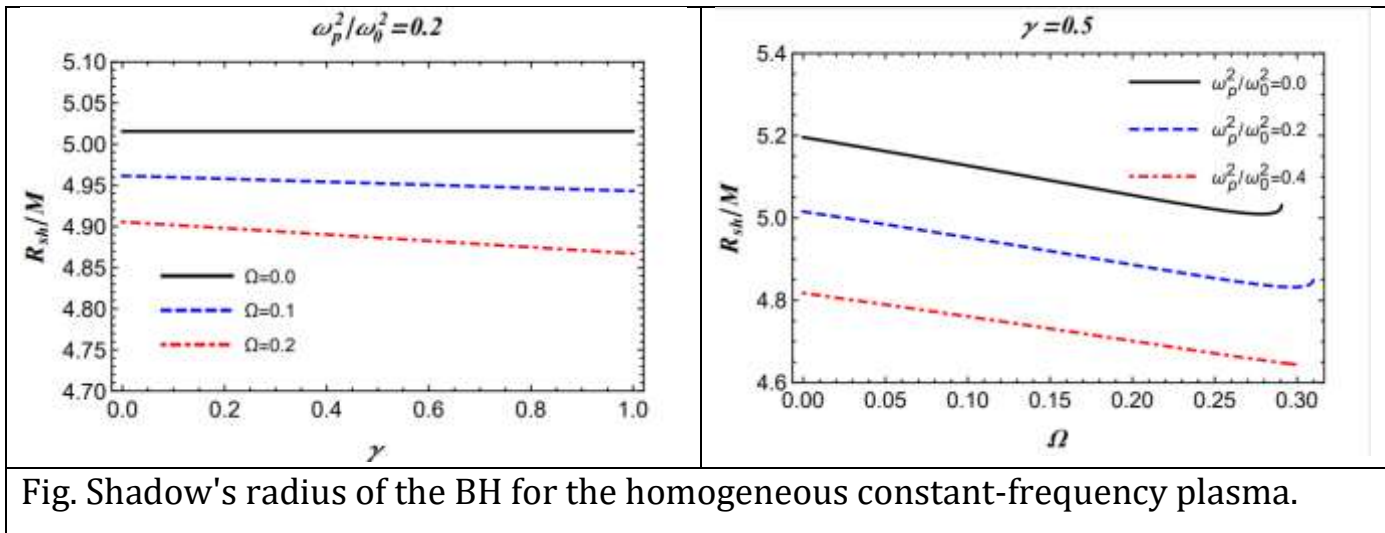


Fig. Shadow's radius of the BH for the homogeneous constant-frequency plasma.

The radius of BH shadow is depicted for different parameters in Figure for a homogeneous plasma with fixed plasma frequency. We have discussed the shadow cast by the BH in RGI gravity and have noticed the role of the model parameters γ and Ω on the BH shadow. It can be shown that with the increasing values of parameters γ and Ω the radius of the shadow of BH decreases and it can be visually confirmed from Figure.

References:

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