10th International Workshop on Astronomy and Relativistic Astrophysics
September 5 – 9, 2022



Scattering properties of charged black holes in nonlinear and Maxwell's electrodynamics

Marco A. A. de Paula[1,a], Luiz C. S. Leite[1,2,b], Luís C. B. Crispino[1,c]

[1]Programa de Pós-Graduação em Física, Universidade Federal do Pará, Brazil

[2]Instituto Federal do Pará, Campus Altamira, Brazil

[a]marco.paula@icen.ufpa.br, [b]luiz.leite@ifpa.edu.br, [c]crispino@ufpa.br

Abstract

We investigate the scattering properties of a massless scalar field in the background of a charged Ayón-Beato-García regular black hole solution. Using a numerical approach, we compute the differential scattering cross section for arbitrary values of the scattering angle and of the incident wave frequency. We compare our results with those obtained via the classical geodesic scattering of massless particles, as well as with the semiclassical glory approximation, and show that they present an excellent agreement in the corresponding limits. We also show that Ayón-Beato-García and Reissner-Nordström black hole solutions present similar scattering properties, for low-to-moderate values of the black hole electric charge, for any value of the scattering angle.

Main problem

- The study of regular black hole (RBH) solutions has attracted much attention in the last years;
- Investigate how RBH solutions scatter matter fields is a fundamental issue in BH physics;
- However, few works devoted to this topic, in the background RBH geometries, were performed;
- We analyze the scattering cross section (SCS) of massless test scalar fields in the background of the static and spherically symmetric Ayón-Beato and García (ABG) RBH spacetime (Ayón-Beato and García, 1998):

$$ds^2 = f(r)dt^2 - f(r)^{-1}dr^2 - r^2 d\theta^2 - r^2 \sin^2\theta d\varphi^2 \qquad f(r)_{\mathrm{ABG}} = 1 - \frac{2Mr^2}{(r^2+Q^2)^{3/2}} + \frac{Q^2 r^2}{(r^2+Q^2)^2}$$

- To do this, we numerically solve the differential SCS for a static and spherically symmetric spacetime given by (Futterman *et al.*, 1988):

$$\frac{d\sigma}{d\Omega} = \left| \frac{1}{2i\omega} \sum_{l=0}^{\infty} (2l+1) \left[e^{2i\delta_l(\omega)-1} \right] P_l(\cos\theta) \right|^2$$

- For further details, we recommend Ref. Eur. Phys. J. Plus **137**, 785 (2022).

Results and Conclusions

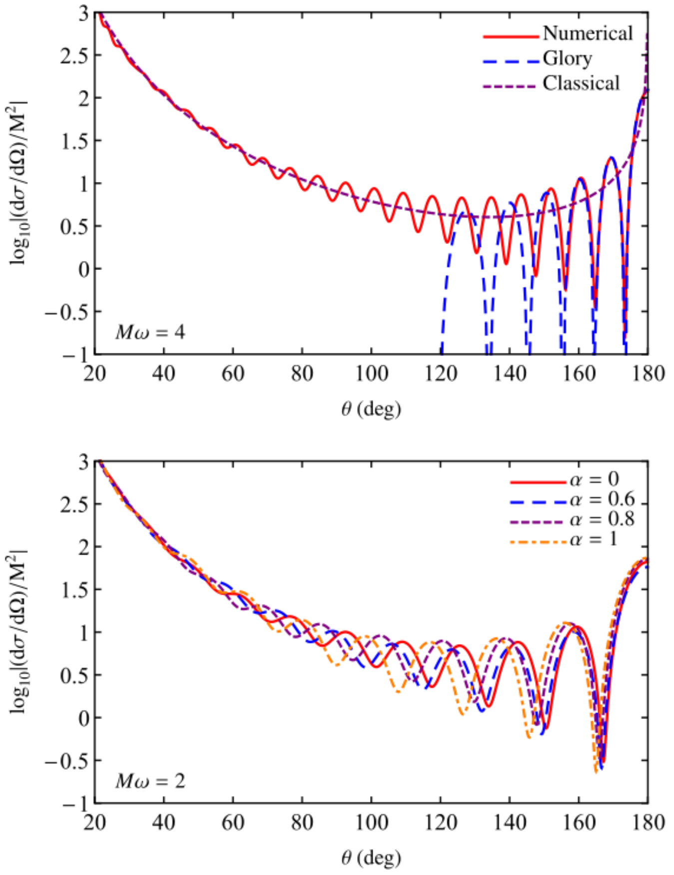

Fig. 1: Differential SCS of the ABG RBH, considering: (i) $\alpha = Q/Q_{ext} = 0.5$ and $M\omega = 4$, and the corresponding classical and semiclassical (glory) approximations (top panel); and (ii) for distinct values of α with $M\omega = 2$ (bottom panel).

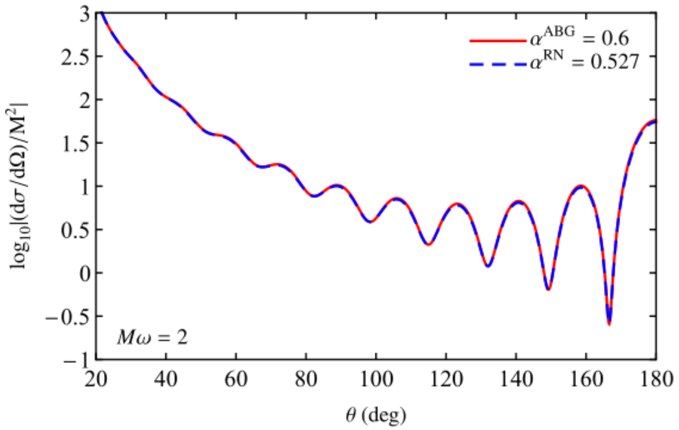

Fig. 2: Differential SCSs of ABG and Reissner–Nordström BHs for $\alpha^{ABG} = 0.6$, $\alpha^{RN} = 0.527$, an $M\omega = 2$.

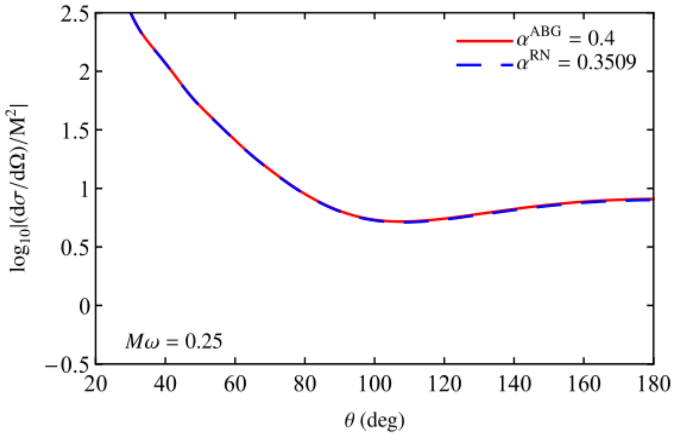

Fig. 3: Differential SCSs of ABG and Reissner–Nordström BHs for $\alpha^{ABG} = 0.4$, $\alpha^{RN} = 0.3509$, and $M\omega = 0.25$.

- We have investigated the scattering properties of a massless and chargeless test scalar field in the background of ABG RBHs;
- We computed the SCS numerically and compared our results with classical scattering and semiclassical glory approximation, showing that the results agree very well in the corresponding limits;
- We have shown that the contributions of the charge to the SCS of ABG RBHs is more important as we consider higher values of the scattering angle;
- We obtained that for small-to-moderate values of α, the results for the SCSs of ABG and Reissner–Nordström BHs can be very similar in the whole scattering angle range, even for small frequency values.