Einstein and Møller Energies of a Particular Asymptotically Reissner-Nordström Non-Singular Black Hole Solution

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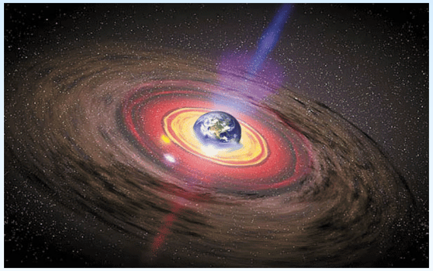

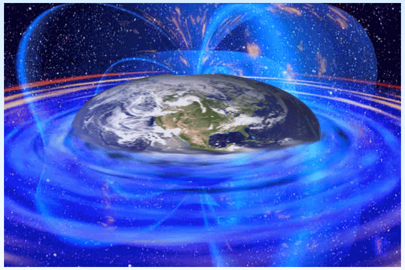

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Abstract

The localization of energy-momentum for a four-dimensional charged, static and spherically symmetric, non-singular black hole solution that asymptotically behaves as a Reissner-Nordström solution, is studied. The energy and momentum distributions are computed by applying the Einstein and Møller energy-momentum complexes. It is found that all the momenta vanish, while the energies depend on the electric charge, the mass, and the radial coordinate. Finally, the behavior of the energies near the origin, near infinity, as well as in the case of a vanishing electric charge is examined.

Einstein and Møller Prescriptions – Calculations and Results

The metric function under study is

$$f(r) = 1 - \frac{2M}{r}\left(\frac{1}{1+\left(\frac{q^2}{Mr}\right)^4}\right)^{3/4}\left(\frac{q^2/(Mr)}{\exp\left(\frac{q^2}{Mr}\right)-1}\right)$$

Einstein energy

$$E_E = \left(\left(1+\frac{q^8}{M^4r^4}\right)^{-1}\right)^{3/4} q^2 r^{-1}\left(e^{\frac{q^2}{Mr}}-1\right)^{-1}$$

Møller energy

$$E_M = 1/2\left(-6\,q^{10}\frac{1}{\sqrt[4]{\left(1+\frac{q^8}{M^4r^4}\right)^{-1}}}r^{-7}\left(e^{\frac{q^2}{Mr}}-1\right)^{-1}\left(1+\frac{q^8}{M^4r^4}\right)^{-2}M^{-4} + \right.$$

$$\left. + 4\left(\left(1+\frac{q^8}{M^4r^4}\right)^{-1}\right)^{3/4} q^2 r^{-3}\left(e^{\frac{q^2}{Mr}}-1\right)^{-1} - 2\left(\left(1+\frac{q^8}{M^4r^4}\right)^{-1}\right)^{3/4} q^4 e^{\frac{q^2}{Mr}} r^{-4}\left(e^{\frac{q^2}{Mr}}-1\right)^{-2}M^{-1}\right)r^2$$

Results and Discussion - Comparison between Einstein and Møller Prescriptions

√ All the momenta vanish in both prescriptions.

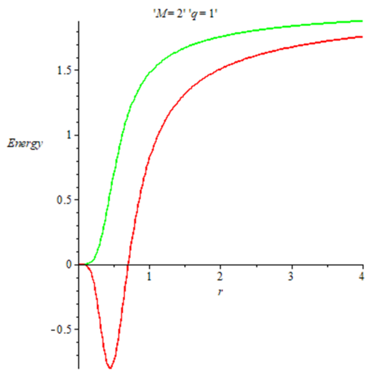
√ The energy distributions obtained have well-defined expressions showing a dependence on the mass *M*, the charge *q* and on the radial coordinate *r*.

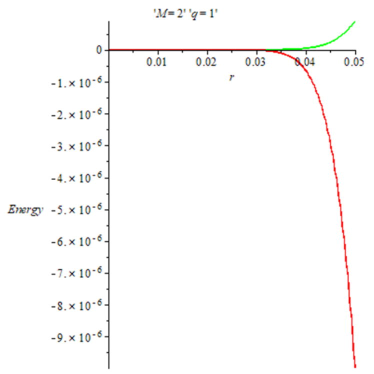
√ Both energies acquire the same value *M* (ADM mass) for $r \to \infty$ or for $q = 0$.

√ We conclude that the Einstein energy E_E is everywhere greater than the Møller energy E_M.

√ In fact, one can advocate that the positive energy region can be used for the effect of a convergent gravitational lens.

√ The negativity of the energy distribution in the case of the Møller prescription, for a range of values of *r*, *M* and *q* pinpoints the difficulty of a physically meaningful interpretation of the energy in certain regions.





Case	$r \to 0$	$r \to \infty$	$r \to -\infty$	$q \to 0$
E_E	0	M	M	M
E_M	0	M	M	M