How an induced Kerr–Newman black hole releases gravitational waves without a mini black hole explosion

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Abstract. Our task is to create circumstances in which the no-hair theorem of black holes no longer applies. First, we must determine if the mini black hole bomb would spontaneously occur. In all, the main end result is to try to avoid the so called black hole bomb effect, where a mini black hole explodes in a laboratory setting within say 10^{-16} s or so. That is, the idea would be to have a reasonably stable configuration with input laser energy, but a small mass, and to do it over hopefully 10^{-15}, or more, times longer than the 10^{-16} s preevaporation life of the mini black hole. That is, a duration of say up to 10^{-1} s which would provide a baseline as to astrophysical modeling of a Kerr–Newman black hole.

Keywords: Kerr–Newman black hole, high-frequency gravitational waves (HGW), causal discontinuity, PACS: 98.80.-k.

1. Introduction

To begin, a Kerr–Newman black-hole event horizon, with a charge Q and a constant angular momentum J as an induced state of affairs, is fed by laser-induced energy to generate gravitational waves and gravitons. Therefore, we use the formation of an event horizon [1] at the outer boundary of a matter-energy *bubble* of space–time in a laboratory setting and also using criteria for spatial resolution of a graviton [2] within a confined metric geometry. In addition, we generalize the entropy, [2] depending upon graviton production, due to infinite quantum statistics, [2] where we assume that graviton count, equivalent to a particle count, N, is equivalent to an entropy count, for reasons we go into in our manuscript. Furthermore, we use background as to the Kerr and Kerr–Newman metrics, [3, 4] which is important for our write up, and, in addition, we use Appell's 1887 nonstandard treatment of electrodynamics, [5] which is part and parcel of what is implied elsewhere. [6, 7] Note that the treatment of the ergosphere, and the question of a nonzero angular momentum associated with a black hole, [8] means that we have far more detail as to black hole physics than usual. [4] We do *not* call the angular momentum a constant in time. That is, we have torque in our model. Park's description [9] of how a rod rotating at a given high frequency, ω, gives a distinct GW and would be a graviton creator if the ends of the spinning rod were tapped by a laser. In a different way, we can use the idea of an artificial Kerr black hole generating GW as also another cosmological window into relic conditions of cosmology. Finally, our laboratory test, if initiated properly, may falsify or give credence to the 7.7×10^{-23} eV/c^2 upper bound to a massive graviton [10, p. 320], which may clarify if there is, say a difference between relic gravitons and later versions of what gravitons are, well after the onset of inflation.

2. A brief recap of Kerr–Newman black hole physics

A complete derivation of Lens and Thirring's study of how a spinning sphere of uniform density creates a gravitational field, [11, p. 257] leads to a metric of

$$\mathrm{d}S^2 = \left(1 - \frac{2m}{r}\right) c^2\,\mathrm{d}t^2 - \left(1 - \frac{2m}{r}\right)\mathrm{d}\sigma^2 + \frac{4\kappa J}{c^2 r}(\sin^2\theta) c\,\mathrm{d}\varphi\,\mathrm{d}t, \tag{1}$$

where J is the angular momentum of the sources, $\mathrm{d}\sigma^2$ is the three-dimensional Lens–Thirring flat-space line element, iff $J = -c^3 m \frac{a}{\kappa}$, and $r = \rho$. This gives us a rotating Kerr black hole.

In our consideration, we set J to a constant for ease of calculation and—with the caveat that, if a is a measure of the angular momentum per mass and if m in (1) is mass, we can say that m is the "geometric mass"—this simplification leads to a Coriolis-like force: [8, 11]

$$\rho\ddot{\varphi} + \frac{-2ma}{\rho^3}\dot{\rho} = 0. \tag{2}$$

If we replace ρ with the angular velocity ω, the above is the Coriolis force. [11, p. 130] If we add a charge, Q, into this business, we get, in part, [12]

$$\mathrm{d}S^2 = \frac{\widetilde{\rho}^2}{c^2}\left(\frac{-\,\mathrm{d}r^2}{\Delta} + \mathrm{d}\theta^2\right) = \frac{\Delta(c\,\mathrm{d}t - \widetilde{a}(\sin^2\theta)\,\mathrm{d}\varphi^2)}{\widetilde{\rho}^2} - \frac{(\sin^2\theta)(c\,\mathrm{d}t - \widetilde{a}(\sin^2\theta)\,\mathrm{d}\varphi^2)}{\widetilde{\rho}^2}$$

where $\widetilde{a} = \frac{J}{mc}$, $\Delta = r^2 - r_S r + \widetilde{a}^2 + r_Q^2$, $\widetilde{\rho}^2 = r^2 + \widetilde{a}^2(\cos^2\theta)$, $r_S = \frac{2Gm}{c^2}$, and $r_Q^2 = \frac{Q^2 G}{4\pi\varepsilon_0 c^4}$. We will, for the sake of simplicity, approximate J as a constant when we do our calculations.

3. What a charge, Q, in a rotating-black-hole solution gives

With an extremal condition on the mass of a Kerr–Newman black hole bounded below by angular momentum J, and charge, Q, [8] and if we have a mass m redefined as the Christodoulou–Ruffini mass, [6, p. 12] which we could set as M, [13] then we have $M = m$, $S = S_{\text{ext}}$, $J = J_{\text{ext}}$,

$$S = \pi\sqrt{Q_{\text{ext}}^4 + 4J_{\text{ext}}^2} = \pi\sqrt{Q^4 + 4J^2} \text{ and } M^2 = m^2 = \frac{1}{2}(Q^2 + \sqrt{Q^4 + 4J^2}). \tag{3}$$

The last two parts of (3) can be interpreted using the ideas of infinite quantum statistics, as a way of making a linkage between entropy and counting numbers of emitted particles, using $S = S_{\text{ext}} \approx n(\text{particle count})$. [3] We can then, using (3), make the following statement as to number of particles stimulated by a laser hitting an artificial black hole, which we will in this first reading equate with Gravitons (massive) and the matter–energy input into the artificial black hole is

$$E_{\text{ext}} = \frac{k_B}{2} T_{\text{applied}} \approx Mc^2 \Leftrightarrow \left(\frac{k_B}{2c^2} T_{\text{applied}}\right)^2 = \frac{1}{2}\left(q^2 + \frac{c_1 n}{\pi}\right)$$
$$\Rightarrow Q^2 = 2\left(\frac{k_B}{2c^2} T_{\text{applied}}\right)^2 + \frac{c_1 n}{\pi}. \tag{4}$$

The particle count—in this case, stimulated graviton emission from the black hole—and the temperature, T_{applied}, from a laser smashing into a target will influence an effective charge, Q.

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4. Specifying conditions for the production of gravitons, from the artificial Kerr–Newman black hole

We can consider working with the induced Kerr-Newman black hole assuming that there is a stimulated emission of particles from the artificial black hole and assuming that there is a method of input from lasers, or possibly thermonuclear fusion:

$$Q = \sqrt{2\left(\frac{k_B}{2c^2}T_{\text{applied}}\right)^2 + \frac{c_1 n}{\pi}} \text{ and } E_{\text{ext}} = \frac{k_B}{2}T_{\text{applied}}. \tag{5}$$

We will be examining what would be possible input energy into this *induced Kerr–Newman* black hole.

We go back to optimizing [8]

$$Q = \sqrt{2\left(\frac{k_B}{2c^2}T_{\text{applied}}\right)^2 + \frac{c_1 n}{\pi}} \tag{6}$$

$$E_{\text{ext}} = \frac{k_B}{2}T_{\text{applied}} \approx Mc^2 \tag{7}$$

$$2M^2 \geq Q^2 + \sqrt{Q^4 + 4J^2} \tag{8}$$

and

$$2M^2 \geq 2\left(\frac{k_B}{2c^2}T_{\text{applied}}\right)^2 + \frac{c_1 n}{\pi} + \sqrt{\left[2\left(\frac{k_B}{2c^2}T_{\text{applied}}\right)^2 + \frac{c_1 n}{\pi}\right]^2 + 4J^2} \tag{9}$$

and

$$B = \frac{+2Q}{\left(\frac{rJ}{mc}\right)} \tag{10}$$

Note that the expression for B, magnetic field, is commensurate with a specific value of r, such that we have E effectively disappear.

5. What conditions permit $T_E(\omega) \equiv \frac{1}{4\pi(2\widetilde{M}-\omega)} \cong T_{\text{applied}}$?

We submit that this is not a trivial question, and answering it would lead to perhaps successful implementation of our idea for forming a Kerr–Newman artificial black hole. Answering it will require well-posed modeling and experimental constraint conditions, which we will try to bring up in this section, First, to do this identification of $T_E(\omega) \equiv \frac{1}{4\pi(2\widetilde{M}-\omega)} \cong T_{\text{applied}}$, we have to have the fix put in. This is basic. That is, a mathematical investigation may, indeed, yield conditions in which one can establish $T_E(\omega) \cong T_{\text{applied}}$. Furthermore, we must also investigate the strength of gravitational waves from the formula for GW *strain.* [6, p. 505] Namely, in the case of laser light implosion, we have $h \sim$ the strain strength of GW, which may be measured from an induced black hole, [6] which were initially for a laser interferometer system, in LIGO, with the following comparisons. [8]

$$T_E(\omega) \equiv \frac{1}{4\pi(2\widetilde{M} - \omega)} \cong T_{\text{applied}}, \tag{11}$$

where $\omega = \omega_{\text{GW}}$, $\widetilde{M}$ is the mass of the induced black hole, ω_{laser} is the frequency of the laser, and W_{laser} is the laser light power. Then

$$h \sim GW - strength = \left(\frac{h\omega_{\text{GW}}}{4\pi\omega_{\text{laser}}W_{\text{laser}}}\right)^{\frac{1}{2}}. \tag{12}$$

6. Conclusion: what (11) portends for emitted GW (graviton?) radiation from the artificial black hole

Equation (11) is for laser-induced implosions on a black hole, Kerr–Newman style, which would, in the case of the national ignition facility, have an enormous power behind it. This assumes a signal-to-noise ratio of about one. Note that the original form of (11) [6] was for laser interferometry in a LIGO-style system. To get what we are seeking, we are likely assuming that the laser light would be very high frequency, and that both ω_{laser} and ω_{GW} would be very high, likely in the 10^8 to 10^{12} Hz range. Furthermore, we would be looking at an induced ring singularity of at least an angstrom in *width,* likely much larger. Our working assumption would be then that the emitted GW from the induced black hole would scale roughly as [8]

$$\omega_{\text{GW}} \approx 2\widetilde{M} = \frac{1}{4\pi T_{\text{applied}}}, \tag{13}$$

if $\omega = \omega_{\text{GW}}$ and $\widetilde{M}$ is the mass of the induced black hole.

This should be seen against the usual dimensional analysis, assuming that $k_B = h = c \to 1$ in dimensional analysis which would be seen as akin to the more usual [8]

$$E_{\text{ext}} = \frac{k_B}{2} T_{\text{applied}} \approx Mc^2 \xrightarrow[k_B=h=c\to 1]{} \omega_{\text{GW}}. \tag{14}$$

That is, as the applied temperature grows, the system approaches that required for GW production. In addition, if we are referring to a ring singularity [8] in an induced Kerr–Newman black hole, we would have [8]

$$\lambda_{\text{GW}}\nu_{\text{GW}} \equiv 2\pi\lambda_{\text{GW}}\omega_{\text{GW}} \approx c \equiv 1 \Rightarrow \lambda_{\text{GW}} \approx \frac{1}{2\pi\omega_{\text{GW}}}, \tag{15}$$

if $\lambda_{\text{GW}} \geq$ the radius of the ring singularity $\approx \frac{1}{2\pi\omega_{\text{GW}}}$.

If the radius of the black hole singularity ring is not on an angstrom scale, it is easy to postulate that one is having at least a 10^{10} Hz frequency in emitted radiation, and the strength of the GW, can be easily made, with adjustment in input parameters, so $h \approx 10^{23}$ is probable. That is, this should be seen in light of having a suitable temperature, T_{applied}, applied to the artificial Kerr–Newman black hole provided that we are looking at, say [8]

$$h \sim GW - strength = \left(\frac{h\omega_{\text{GW}}}{4\pi\omega_{\text{laser}}W_{\text{laser}}}\right)^{\frac{1}{2}} \propto 10^{-23}. \tag{16}$$

Leading to, in terms of laboratory conditions,

$$\begin{aligned} T_{\text{applied}} \xrightarrow[\text{derived}]{} (T_{\text{applied}})_{\text{derived}} \Leftrightarrow (\Delta E)_{\text{derived}} &= \frac{k_B}{2}(T_{\text{applied}})_{\text{derived}} \\ &\approx \frac{h}{(\Delta t_{\text{applied}})_{\text{derived}}} \approx \hbar(\omega_{\text{applied}})_{\text{derived}}. \end{aligned} \tag{17}$$

If this is done and we then wind up with $(\omega_{\text{applied}})_{\text{derived}}$ on the order of 10^{10} Hz, we are then in terms of experimental input well on our way toward setting parameterization of a quantum theory of gravity, which so far has eluded experimentalists. [8, 14, 15, 16, 17, 18, 19, 20, 21]

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