Journal of Modern Physics, 2024, 15, 1502-1522
https://www.scirp.org/journal/jmp
ISSN Online: 2153-120X
ISSN Print: 2153-1196

The Correct Reissner-Nordstrøm, Kerr and Kerr-Newman Metrics

Carlo Maria Pace

ICRANet, Pescara, Italy
Email: pace@icra.it

How to cite this paper: Pace, C.M. (2024) The Correct Reissner-Nordstrøm, Kerr and Kerr-Newman Metrics. *Journal of Modern Physics*, **15**, 1502-1522.
https://doi.org/10.4236/jmp.2024.1510062

Received: July 16, 2024
Accepted: September 15, 2024
Published: September 18, 2024

Abstract

In a very recent article of mine I have corrected the traditional derivation of the Schwarzschild metric thus arriving to formulate a correct Schwarzschild metric different from the traditional Schwarzschild metric. In this article, starting from this correct Schwarzschild metric, I also propose corrections to the other traditional Reissner-Nordstrøm, Kerr and Kerr-Newman metrics on the basis of the fact that these metrics should be equal to the correct Schwarzschild metric in the borderline case in which they reduce to the case described by this metric. In this way, we see that, like the correct Schwarzschild metric, also the correct Reissner-Nordstrøm, Kerr and Kerr-Newman metrics do not present any event horizon (and therefore do not present any black hole) unlike the traditional Reissner-Nordstrøm, Kerr and Kerr-Newman metrics.

Keywords

General Theory of Relativity, Schwarzschild, Reissner-Nordstrøm, Kerr, Kerr-Newman, Metric, Event Horizon, Black Hole

1. The Correct Schwarzschild Solution

In this article we will use the formulas with the velocity of light $c \equiv 1$.

We have shown in [1] that the correct Schwarzschild solution expressed as the formally flat metric in the commonly used coordinates ($\mathrm{d}s^2$), which metric is expressed as a function of the coordinates curved for expressing the gravitational field as the curvature of the space-time, is:

$$\mathrm{d}s^2 = \left(1 + \frac{2GM}{r_g}\right)\mathrm{d}t_g^2 - \frac{1}{1 + \frac{2GM}{r_g}}\mathrm{d}r_g^2 - r_g^2\mathrm{d}\theta_g^2 - r_g^2\sin^2\theta_g\mathrm{d}\varphi_g^2 \qquad (1)$$

where M is (a constant, which is equal to) the total mass of the system, and t_g,

r_g, θ_g, φ_g are the space-time coordinates measured relatively to a reference frame that is integral with a space-time curved for expressing the gravitational field as the curvature of the space-time. In other words, this equation (1) is expressed in curved coordinates.

We can note that in the (1) the coefficient of $\mathrm{d}t_g^2$ is always greater than one (except in the case where there is no gravitational field, in which case this coefficient is equal to one), and the more intense the gravitational field is, the greater this coefficient is. We have already shown in [1] that this is a sign that the coordinates are curved and is closely related to the fact that the clocks in a gravitational field run more slowly.

On the other hand, we have also shown in [1] that the correct Schwarzschild solution expressed as the formally flat metric in the curved coordinates, which metric is expressed as a function of the commonly used coordinates, is:

$$\mathrm{d}s_g^2 = \frac{1}{1+\frac{2GM}{r_g}}\mathrm{d}t^2 - \left(1+\frac{2GM}{r_g}\right)\mathrm{d}r^2 - r^2\mathrm{d}\theta^2 - r^2\sin^2\theta\mathrm{d}\varphi^2 \tag{2}$$

where $\mathrm{d}s_g^2$ is a metric formally flat in the curved coordinates.

As for the relation between r_g and r, we have:

$$\mathrm{d}r^2 = \frac{1}{1+\frac{2GM}{r_g}}\mathrm{d}r_g^2 \tag{3}$$

From which, we have:

$$\int_0^{r^2}\mathrm{d}r^2 = \int_0^{r_g^2}\frac{1}{1+\frac{2GM}{r_g}}\mathrm{d}r_g^2 \tag{4}$$

From which, we have:

$$r^2 = \int_0^{r_g}\frac{2r_g^2\mathrm{d}r_g}{r_g+2GM} \tag{5}$$

From which, we have:

$$r^2 = \left[r_g^2 - 4GMr_g + 8G^2M^2\ln\left(2GM+r_g\right)\right]_0^{r_g} \tag{6}$$

From which, we have:

$$r^2 = r_g^2 - 4GMr_g + 8G^2M^2\ln\left(1+\frac{r_g}{2GM}\right) \tag{7}$$

According to the (7) for $r_g \to 0$ also $r \to 0$ and for $r_g \to +\infty$ also $r \to +\infty$. Moreover, as r_g increases, r also increases as can be seen by differentiating the right side of the (7) with respect to r_g or directly from the (5). On the other side, for any value of $r_g > 0$ we have that $r < r_g$, as can be seen directly from the (4).

Furthermore, for $r_g \gg 2GM$ we have that $r \cong r_g\left(1-\frac{2GM}{r_g}\right)$ and also

$r_g \cong r\left(1+\frac{2GM}{r}\right)$. This implies that for $\frac{2GM}{r} \ll 1$ the presence of r_g instead of r in the (2) implies only corrections to the second order in $\frac{2GM}{r}$.

On the other hand, for $r_g \ll 2GM$ we have $r^2 \cong \frac{r_g^3}{3GM}$.

In particular for $r_g = 2GM$, $r^2 = 4G^2M^2(2\ln 2 - 1)$, and so in this case we have $r = 2GM\sqrt{2\ln 2 - 1} \cong 1.24GM$.

Moreover, for $r_g = 4GM$, $r^2 = 8G^2M^2 \ln 3$, and so in this case we have $r = 2GM\sqrt{2\ln 3} \cong 2.96GM$.

Instead for $r_g = 8GM$, $r^2 = 8G^2M^2(4+\ln 5)$, and so in this case we have $r = 2GM\sqrt{2(4+\ln 5)} \cong 6.70GM$.

Instead, the common erroneous expression for the Schwarzschild solution is [2]:

$$\mathrm{d}s^2 = \left(1-\frac{2GM}{r}\right)\mathrm{d}t^2 - \frac{1}{1-\frac{2GM}{r}}\mathrm{d}r^2 - r^2\mathrm{d}\theta^2 - r^2\sin^2\theta\mathrm{d}\varphi^2 \tag{8}$$

We can note that we have not any singularity in the correct expressions (1) and (2) for any value of $r > 0$ and of $r_g > 0$. Therefore we can say that there is not any event horizon and therefore that there is not any black hole [2] [3].

In particular, the coefficients of $\mathrm{d}t^2$ in (2) and of $\mathrm{d}t_g^2$ in (1) are always >0, while the coefficients of $\mathrm{d}r^2$ in (2) and of $\mathrm{d}r_g^2$ in (1) are always <0. Therefore since the coefficients of $\mathrm{d}t^2$ in (2) and of $\mathrm{d}t_g^2$ in (1) are always not negative the time (that is, the temporal coordinate) does not become in any case as a spatial coordinate, contrary to the common treatment of the space-time inside the event horizon [2] [3]. Moreover, since the coefficients of $\mathrm{d}r^2$ in (2) and of $\mathrm{d}r_g^2$ in (1) are always not positive, also here the spatial coordinate r (or r_g) does not become in any case as a temporal coordinate, contrary to the common treatment of the space-time inside the event horizon [2] [3].

Therefore, the light cones are always orientated in the usual way, in particular there is not any horizontal inclination of the light cones, contrary to the common treatment of the space-time inside the event horizon [2] [3].

As we have already shown in [1], the correct formula of the ratio between the times when they are measured in two different positions in this case is:

$$\frac{\mathrm{d}t_{g2}}{\mathrm{d}t_{g1}} = \sqrt{\frac{1+\frac{2GM}{r_{g1}}}{1+\frac{2GM}{r_{g2}}}} \tag{9}$$

Therefore in this case we have that in the presence of a gravitational field the clocks go more slowly (that is, that the measurements of time relatively to a reference frame that is integral with a space-time curved for expressing the presence of a gravitational field flow more slowly). And the more intense is the gravitational field the more slowly the clocks go (that is, the measurements of time relatively to a reference frame that is integral with a space-time curved for expressing the presence of a more intense gravitational field flow more slowly than the measurements of time relatively to a reference frame that is integral with a space-time curved for expressing the presence of a less intense gravitational field).

Analogously, as we have already shown in [1], the correct ratio of the relative frequencies $\nu_1 = 1/\mathrm{d}t_{g1}$ and $\nu_2 = 1/\mathrm{d}t_{g2}$ is:

$$\frac{\nu_1}{\nu_2} = \sqrt{\frac{1+\dfrac{2GM}{r_{g1}}}{1+\dfrac{2GM}{r_{g2}}}} \tag{10}$$

This is the correct formula for the gravitational redshift of light in the correct Schwarzschild metric. Therefore, the gravitational redshift is always not infinite for any value of $r > 0$ and of $r_g > 0$.

We can note that the two formulas (9) and (10) are different from those obtained usually from the incorrect expression of the Schwarzschild solution by means of an incorrect procedure [1] [2], but are equal at the first order in $\frac{2GM}{r}$ (to the incorrect formulas). In fact, the formulas commonly used, instead of the two correct formulas (9) and (10), are respectively [1] [2]:

$$\frac{\mathrm{d}t_2}{\mathrm{d}t_1} = \sqrt{\frac{1-\dfrac{2GM}{r_2}}{1-\dfrac{2GM}{r_1}}} \tag{11}$$

$$\frac{\nu_1}{\nu_2} = \sqrt{\frac{1-\dfrac{2GM}{r_2}}{1-\dfrac{2GM}{r_1}}} \tag{12}$$

As we have already noted in [1], the light formally moves in a straight line relative to the reference system curved for expressing the presence of the gravitational field. Therefore we can impose the condition $\mathrm{d}s_g^2 = 0$ for the propagation of light. Therefore from the (2) if we take a radial motion of the light in the commonly used coordinates ($\mathrm{d}\theta = 0$ and $\mathrm{d}\varphi = 0$) we have:

$$\frac{1}{1+\dfrac{2GM}{r_g}}\mathrm{d}t^2 - \left(1+\frac{2GM}{r_g}\right)\mathrm{d}r^2 = 0 \tag{13}$$

From which we have that the radial velocity of light in the commonly used coordinates is equal to [1] [2]:

$$v_l = \frac{\mathrm{d}r}{\mathrm{d}t} = \frac{1}{1+\dfrac{2GM}{r_g}} \tag{14}$$

We can note that the radial velocity of light in the commonly used coordinates is always ≤1, and is equal to 1 only when there is not a gravitational field. Moreover this formula is in agreement with the available experimental data [2].

For further information on the correct Schwarzschild solution, in particular how it is obtained, please refer to [1].

2. The Correct Reissner-Nordstrøm Solution

As for the Reissner-Nordstrøm solution [2] [3], that is the solution that represents the curved space-time geometry surrounding an electrically charged mass, we have that the commonly used expressions for the space-time interval and the electric field are respectively [2]:

$$\mathrm{d}s^2 = \left(1-\frac{2GM}{r}+\frac{GQ^2}{r^2}\right)\mathrm{d}t^2 - \frac{1}{1-\frac{2GM}{r}+\frac{GQ^2}{r^2}}\mathrm{d}r^2 - r^2\mathrm{d}\theta^2 - r^2\sin^2\theta\mathrm{d}\varphi^2 \quad (15)$$

and

$$E(r) = \frac{Q}{r^2} \quad (16)$$

where M and Q are two constants: M is the total mass of the system and Q is the total electric charge of the system.

In the (15) there are singularities when

$$1-\frac{2GM}{r}+\frac{GQ^2}{r^2} = 0 \quad (17)$$

that is, when

$$r^2 - 2GMr + GQ^2 = 0 \quad (18)$$

or, better yet, when

$$r = GM \pm \sqrt{G^2M^2 - GQ^2} \quad (19)$$

Obviously there are real singularities only when $G^2M^2 - GQ^2 \geq 0$.

But the expression (15) is erroneous: in fact, by means of the fact that the correct Reissner-Nordstrøm solution must be equal to the correct Schwarzschild solution for $Q = 0$, we can say that the correct Reissner-Nordstrøm solution expressed as the formally flat metric in the commonly used coordinates ($\mathrm{d}s^2$), which metric is expressed as a function of the coordinates curved for expressing the gravitational field as the curvature of the space-time, is:

$$\mathrm{d}s^2 = \left(1+\frac{2GM}{r_g}+\frac{GQ^2}{r_g^2}\right)\mathrm{d}t_g^2 - \frac{1}{1+\frac{2GM}{r_g}+\frac{GQ^2}{r_g^2}}\mathrm{d}r_g^2 - r_g^2\mathrm{d}\theta_g^2 - r_g^2\sin^2\theta_g\mathrm{d}\varphi_g^2 \quad (20)$$

where M and Q are two constants: M is the total mass of the system and Q is the total electric charge of the system. Moreover t_g, r_g, θ_g, φ_g are the space-time coordinates measured relatively to a reference frame that is integral with a space-time curved for expressing the gravitational field as the curvature of the space-time. In other words, this equation (20) is expressed in curved coordinates.

We can note that in the (20) the coefficient of $\mathrm{d}t_g^2$ is always greater than one (except in the case where there is no gravitational field, in which case this coefficient is equal to one), and the more intense the gravitational field is, the greater this coefficient is. We have already shown in [1] that this is a sign that the coordinates are curved and is closely related to the fact that the clocks in a gravitational field run more slowly.

Analogously to the case of the Schwarzschild metric, we can write also in this case the formally flat metric in the curved coordinates, which metric is expressed as a function of the commonly used coordinates. In this case we have:

$$\mathrm{d}s_g^2 = \frac{1}{1+\frac{2GM}{r_g}+\frac{GQ^2}{r_g^2}}\mathrm{d}t^2 - \left(1+\frac{2GM}{r_g}+\frac{GQ^2}{r_g^2}\right)\mathrm{d}r^2 - r^2\mathrm{d}\theta^2 - r^2\sin^2\theta\mathrm{d}\varphi^2 \quad (21)$$

where $\mathrm{d}s_g^2$ is a metric formally flat in the curved coordinates.

As for the relation between r_g and r, we have:

$$\mathrm{d}r^2 = \frac{1}{1+\frac{2GM}{r_g}+\frac{GQ^2}{r_g^2}}\mathrm{d}r_g^2 \quad (22)$$

From which, we have:

$$\int_0^{r^2}\mathrm{d}r^2 = \int_0^{r_g^2}\frac{1}{1+\frac{2GM}{r_g}+\frac{GQ^2}{r_g^2}}\mathrm{d}r_g^2 \quad (23)$$

From which, we have:

$$r^2 = \int_0^{r_g}\frac{2r_g^3\mathrm{d}r_g}{r_g^2+2GMr_g+GQ^2} \quad (24)$$

From which, we have:

$$r^2 = \Bigg[r_g^2 - 4GMr_g + G\left(4GM^2-Q^2\right)\ln\left(r_g^2+2GMr_g+GQ^2\right) + \frac{G^2M\left(3Q^2-4GM^2\right)}{\sqrt{G^2M^2-GQ^2}}\ln\left(\frac{GM+r_g-\sqrt{G^2M^2-GQ^2}}{GM+r_g+\sqrt{G^2M^2-GQ^2}}\right)\Bigg]_0^{r_g} \quad (25)$$

From which, we have:

$$r^2 = r_g^2 - 4GMr_g + G\left(4GM^2-Q^2\right)\ln\left(1+\frac{r_g^2+2GMr_g}{GQ^2}\right) + \frac{G^2M\left(3Q^2-4GM^2\right)}{\sqrt{G^2M^2-GQ^2}}\cdot\ln\left(\frac{GM+r_g-\sqrt{G^2M^2-GQ^2}}{GM+r_g+\sqrt{G^2M^2-GQ^2}}\cdot\frac{GM+\sqrt{G^2M^2-GQ^2}}{GM-\sqrt{G^2M^2-GQ^2}}\right) \quad (26)$$

According to the (26) for $r_g \to 0$ also $r \to 0$ and for $r_g \to +\infty$ also $r \to +\infty$. Moreover, as r_g increases, r also increases, as we can see directly from the (24). On the other side, for any value of $r_g > 0$ we have that $r < r_g$, as we can see directly from the (23).

Furthermore, for $r_g \to +\infty$ we have that $r \cong r_g\left(1 - \frac{2GM}{r_g}\right)$ and also $r_g \cong r\left(1 + \frac{2GM}{r}\right)$. This implies that, in this case, the presence of r_g instead of r in the (21) implies only corrections to the second order in $\frac{2GM}{r}$.

On the other hand, for $r_g \to 0$ we have $r \cong \frac{r_g^2}{\sqrt{2GQ^2}}$, as we can see easily from the (24).

Also in this case as in that of Schwarzschild, we have not any singularity in the correct expressions (20) and (21) for any value of $r > 0$ and of $r_g > 0$. Therefore we can say that there is not any event horizon and therefore that there is not any black hole [2] [3].

In particular, also here the coefficients of $\mathrm{d}t^2$ in (21) and of $\mathrm{d}t_g^2$ in (20) are always >0, while the coefficients of $\mathrm{d}r^2$ in (21) and of $\mathrm{d}r_g^2$ in (20) are always <0. Therefore, since the coefficients of $\mathrm{d}t^2$ in (21) and of $\mathrm{d}t_g^2$ in (20) are always not negative, the time (that is, the temporal coordinate) does not become in any case as a spatial coordinate, contrary to the common treatment of the space-time inside the event horizon [2] [3]. Moreover, since the coefficients of $\mathrm{d}r^2$ in (21) and of $\mathrm{d}r_g^2$ in (20) are always not positive, also here the spatial coordinate r (or r_g) does not become in any case as a temporal coordinate, contrary to the common treatment of the space-time inside the event horizon [2] [3].

Therefore, also here the light cones are always orientated in the usual way, in particular there is not any horizontal inclination of the light cones, contrary to the common treatment of the space-time inside the event horizon [2] [3].

In this case the correct formulas (9) and (10) become respectively:

$$\frac{\mathrm{d}t_{g2}}{\mathrm{d}t_{g1}} = \sqrt{\frac{1 + \frac{2GM}{r_{g1}} + \frac{GQ^2}{r_{g1}^2}}{1 + \frac{2GM}{r_{g2}} + \frac{GQ^2}{r_{g2}^2}}} \tag{27}$$

$$\frac{\nu_1}{\nu_2} = \sqrt{\frac{1 + \frac{2GM}{r_{g1}} + \frac{GQ^2}{r_{g1}^2}}{1 + \frac{2GM}{r_{g2}} + \frac{GQ^2}{r_{g2}^2}}} \tag{28}$$

Therefore also in this case we have that in the presence of a gravitational field the clocks go more slowly (that is, that the measurements of time relatively to a reference frame that is integral with a space-time curved for expressing the presence of a gravitational field flow more slowly). And the more intense is the gravitational field the more slowly the clocks go (that is, the measurements of time relatively to a reference frame that is integral with a space-time curved for expressing the presence of a more intense gravitational field flow more slowly than the measurements of time relatively to a reference frame that is integral with a space-time curved for expressing the presence of a less intense gravitational field).

Furthermore, the gravitational redshift, that is expressed by the formula (28), is always not infinite for any value of $r > 0$ and of $r_g > 0$, as in the correct Schwarzschild solution [1].

We can note that the two correct formulas (27) and (28) are different from those obtained usually from the incorrect expression of the Reissner-Nordstrøm solution by means of an incorrect procedure [1] [2]. In fact, the formulas commonly used, instead of the two correct formulas (27) and (28), are respectively [1] [2]:

$$\frac{\mathrm{d}t_2}{\mathrm{d}t_1} = \sqrt{\frac{1 - \frac{2GM}{r_2} + \frac{GQ^2}{r_2^2}}{1 - \frac{2GM}{r_1} + \frac{GQ^2}{r_1^2}}} \tag{29}$$

$$\frac{\nu_1}{\nu_2} = \sqrt{\frac{1 - \frac{2GM}{r_2} + \frac{GQ^2}{r_2^2}}{1 - \frac{2GM}{r_1} + \frac{GQ^2}{r_1^2}}} \tag{30}$$

In this case the formula (14) of the radial velocity of light in the commonly used coordinates [1] [2] becomes:

$$v_l = \frac{\mathrm{d}r}{\mathrm{d}t} = \frac{1}{1 + \frac{2GM}{r_g} + \frac{GQ^2}{r_g^2}} \tag{31}$$

We can note that, also here, the radial velocity of light in the commonly used coordinates is always ≤1, and is equal to 1 only when there is not a gravitational field.

3. The Correct Kerr Solution

As for the Kerr solution, that is the solution that represents the curved space-time geometry surrounding a rotating mass, we have that the commonly used expression is [2]:

$$\mathrm{d}s^2 = \mathrm{d}t^2 - \frac{\rho^2}{\Delta}\mathrm{d}r^2 - \rho^2\mathrm{d}\theta^2 - \left(r^2 + a^2\right)\sin^2\theta\mathrm{d}\varphi^2 - \frac{2GMr}{\rho^2}\left(\mathrm{d}t - a\sin^2\theta\mathrm{d}\varphi\right)^2 \tag{32}$$

where ρ^2 and Δ are functions of r and θ:

$$\rho^2 \equiv r^2 + a^2\cos^2\theta \tag{33}$$

$$\Delta \equiv r^2 - 2GMr + a^2 \tag{34}$$

and M and a are constants: M is the total mass of the system and a is the spin angular momentum of the system per unit mass.

In the (32) there are singularities (event horizons) when

$$r^2 - 2GMr + a^2 = 0 \tag{35}$$

that is, when

$$r = GM \pm \sqrt{G^2M^2 - a^2} \tag{36}$$

Obviously there are real singularities (event horizons) only when $G^2M^2 - a^2 \geq 0$.

Moreover we have that the coefficient g_{00} is equal to zero when

$$r^2 - 2GMr + a^2\cos^2\theta = 0 \tag{37}$$

that is, when

$$r = GM \pm \sqrt{G^2M^2 - a^2\cos^2\theta} \tag{38}$$

Therefore there are two distinct surfaces where g_{00} is equal to zero. These surfaces are infinite-redshift surfaces. Obviously such surfaces really exist only where $G^2M^2 - a^2\cos^2\theta \geq 0$.

But the expression (32) is erroneous: in fact, by means of the fact that the correct Kerr solution must be equal to the correct Schwarzschild solution for $a = 0$, we can say that the correct Kerr solution expressed as the formally flat metric in the commonly used coordinates ($\mathrm{d}s^2$), which metric is expressed as a function of the coordinates curved for expressing the gravitational field as the curvature of the space-time, is:

$$\begin{aligned} \mathrm{d}s^2 = \mathrm{d}t_g^2 - \frac{\rho^2}{\Delta}\mathrm{d}r_g^2 - \rho^2\mathrm{d}\theta_g^2 - \left(r_g{}^2 + a^2\right)\sin^2\theta_g\mathrm{d}\varphi_g^2 \\ + \frac{2GMr_g}{\rho^2}\left(\mathrm{d}t_g - a\sin^2\theta_g\mathrm{d}\varphi_g\right)^2 \end{aligned} \tag{39}$$

where ρ^2 and Δ are functions of r_g and θ_g :

$$\rho^2 \equiv r_g^2 + a^2\cos^2\theta_g \tag{40}$$

$$\Delta \equiv r_g^2 + 2GMr_g + a^2 \tag{41}$$

and M and a are constants: M is the total mass of the system and a is the spin angular momentum of the system per unit mass. Moreover t_g , r_g , θ_g , φ_g are the space-time coordinates measured relatively to a reference frame that is integral with a space-time curved for expressing the gravitational field as the curvature of the space-time. In other words, this equation (39) is expressed in curved coordinates.

We can note that in the (39) the coefficient of $\mathrm{d}t_g^2$ is always greater than one (except in the case where there is no gravitational field, in which case this coefficient is equal to one), and the more intense the gravitational field is, the greater this coefficient is. As mentioned before, we have already shown in [1] that this is a sign that the coordinates are curved and is closely related to the fact that the clocks in a gravitational field run more slowly.

Also in this case as in that of Schwarzschild, we have not any singularity in the correct expression (39) for any value of $r_g > 0$. Therefore we can say that there is not any event horizon and therefore that there is not any black hole [2] [3].

Furthermore, since the coefficient of $\mathrm{d}t_g^2$ in the (39) is always ≥1, there is not any infinite-redshift surface and the time (that is, the temporal coordinate) does not become in any case as a spatial coordinate, contrary to the common treatment of the space-time inside the event horizon [2] [3]. Moreover, since the coefficient of $\mathrm{d}r_g^2$ in the (39) is always not positive, also here the spatial coordinate r_g does not become in any case as a temporal coordinate, contrary to the common treatment of the space-time inside the event horizon [2] [3].

Therefore also here the light cones are always orientated in the usual way, in particular there is not any horizontal inclination of the light cones, contrary to the common treatment of the space-time inside the event horizon [2] [3].

Now, it is very complicated to express this metric as the formally flat metric in the curved coordinates, which metric is expressed as a function of the commonly used coordinates, but however we can obtain easily a such expression for $\mathrm{d}\theta_g = 0$ and $\mathrm{d}\varphi_g = 0$. In fact the (39) for $\mathrm{d}\theta_g = 0$ and $\mathrm{d}\varphi_g = 0$ becomes:

$$\mathrm{d}s^2 = \left(1 + \frac{2GMr_g}{\rho^2}\right)\mathrm{d}t_g^2 - \frac{\rho^2}{\Delta}\mathrm{d}r_g^2 \tag{42}$$

where ρ^2 and Δ are functions of r_g:

$$\rho^2 \equiv r_g^2 + a^2 \cos^2\theta_g \tag{43}$$

$$\Delta \equiv r_g^2 + 2GMr_g + a^2 \tag{44}$$

Therefore the (42) can be written as:

$$\mathrm{d}s^2 = \left(1 + \frac{2GMr_g}{r_g^2 + a^2\cos^2\theta_g}\right)\mathrm{d}t_g^2 - \frac{r_g^2 + a^2\cos^2\theta_g}{r_g^2 + 2GMr_g + a^2}\mathrm{d}r_g^2 \tag{45}$$

or also as:

$$\mathrm{d}s^2 = \left(1 + \frac{2GMr_g}{r_g^2 + a^2\cos^2\theta_g}\right)\mathrm{d}t_g^2 - \frac{1}{1 + \dfrac{2GMr_g + a^2\sin^2\theta_g}{r_g^2 + a^2\cos^2\theta_g}}\mathrm{d}r_g^2 \tag{46}$$

Now by analogy with the previous cases we can write in this case the formally flat metric in the curved coordinates, which metric is expressed as a function of the commonly used coordinates, as:

$$\mathrm{d}s_g^2 = \frac{1}{1 + \dfrac{2GMr_g}{r_g^2 + a^2\cos^2\theta_g}}\mathrm{d}t^2 - \left(1 + \frac{2GMr_g + a^2\sin^2\theta_g}{r_g^2 + a^2\cos^2\theta_g}\right)\mathrm{d}r^2 \tag{47}$$

where $\mathrm{d}s_g^2$ is a metric formally flat in the curved coordinates and θ_g is a constant.

As for the relation between r_g and r, we have:

$$\mathrm{d}r^2 = \frac{1}{1 + \dfrac{2GMr_g + a^2\sin^2\theta_g}{r_g^2 + a^2\cos^2\theta_g}}\mathrm{d}r_g^2 \tag{48}$$

From which, we have:

$$\int_0^{r^2} \mathrm{d}r^2 = \int_0^{r_g^2} \frac{1}{1+\dfrac{2GMr_g + a^2\sin^2\theta_g}{r_g^2 + a^2\cos^2\theta_g}} \mathrm{d}r_g^2 \tag{49}$$

From which, we have:

$$r^2 = \int_0^{r_g} \frac{2r_g\left(r_g^2 + a^2\cos^2\theta_g\right)\mathrm{d}r_g}{r_g^2 + 2GMr_g + a^2} \tag{50}$$

From which, we have:

$$\begin{aligned} r^2 = \Bigg[& r_g^2 - 4GMr_g + \left(-a^2\sin^2\theta_g + 4G^2M^2\right)\ln\left(r_g^2 + 2GMr_g + a^2\right) \\ & + \frac{GM\left(2a^2 + a^2\sin^2\theta_g - 4G^2M^2\right)}{\sqrt{G^2M^2 - a^2}} \cdot \ln\left(\frac{GM + r_g - \sqrt{G^2M^2 - a^2}}{GM + r_g + \sqrt{G^2M^2 - a^2}}\right)\Bigg]_0^{r_g} \end{aligned} \tag{51}$$

From which, we have:

$$\begin{aligned} r^2 = {} & r_g^2 - 4GMr_g + \left(-a^2\sin^2\theta_g + 4G^2M^2\right)\ln\left(1 + \frac{r_g^2 + 2GMr_g}{a^2}\right) \\ & + \frac{GM\left(2a^2 + a^2\sin^2\theta_g - 4G^2M^2\right)}{\sqrt{G^2M^2 - a^2}} \\ & \cdot \ln\left(\frac{GM + r_g - \sqrt{G^2M^2 - a^2}}{GM + r_g + \sqrt{G^2M^2 - a^2}} \cdot \frac{GM + \sqrt{G^2M^2 - a^2}}{GM - \sqrt{G^2M^2 - a^2}}\right) \end{aligned} \tag{52}$$

According to the (52) for $r_g \to 0$ also $r \to 0$ and for $r_g \to +\infty$ also $r \to +\infty$. Moreover, as r_g increases, r also increases, as we can see directly from the (50). On the other side, for any value of $r_g > 0$ we have that $r < r_g$, as we can see directly from the (49).

Furthermore, for $r_g \to +\infty$ we have that $r \cong r_g\left(1 - \frac{2GM}{r_g}\right)$ and also $r_g \cong r\left(1 + \frac{2GM}{r}\right)$. This implies that, in this case, the presence of r_g instead of r in the (47) implies only corrections to the second order in $\frac{2GM}{r}$.

On the other hand, for $r_g \to 0$ in the case of $\cos^2\theta_g \neq 0$ we have $r \cong r_g\left|\cos\theta_g\right|$, while in the case of $\cos^2\theta_g = 0$ we have $r \cong \frac{r_g^2}{\sqrt{2a^2}}$, as we can see easily from the (50).

In this case the correct formulas (9) and (10) become respectively:

$$\frac{\mathrm{d}t_{g2}}{\mathrm{d}t_{g1}} = \sqrt{\frac{1 + \dfrac{2GMr_{g1}}{r_{g1}^2 + a^2\cos^2\theta_g}}{1 + \dfrac{2GMr_{g2}}{r_{g2}^2 + a^2\cos^2\theta_g}}} \tag{53}$$

$$\frac{\nu_1}{\nu_2} = \sqrt{\frac{1+\dfrac{2GMr_{g1}}{r_{g1}^{\ 2}+a^2\cos^2\theta_g}}{1+\dfrac{2GMr_{g2}}{r_{g2}^{\ 2}+a^2\cos^2\theta_g}}} \tag{54}$$

Therefore also in this case we have that in the presence of a gravitational field the clocks go more slowly (that is, that the measurements of time relatively to a reference frame that is integral with a space-time curved for expressing the presence of a gravitational field flow more slowly). And the more intense is the gravitational field the more slowly the clocks go (that is, the measurements of time relatively to a reference frame that is integral with a space-time curved for expressing the presence of a more intense gravitational field flow more slowly than the measurements of time relatively to a reference frame that is integral with a space-time curved for expressing the presence of a less intense gravitational field).

Furthermore, the gravitational redshift, that is expressed by the formula (54), is always not infinite for any value of $r>0$ and of $r_g>0$, as in the correct Schwarzschild solution.

We can note that the two correct formulas (53) and (54) are different from those obtained usually from the incorrect expression of the Kerr solution by means of an incorrect procedure [1] [2]. In fact, the formulas commonly used, instead of the two correct formulas (53) and (54), are respectively [1] [2]:

$$\frac{\mathrm{d}t_2}{\mathrm{d}t_1} = \sqrt{\frac{1-\dfrac{2GMr_2}{r_2^2+a^2\cos^2\theta}}{1-\dfrac{2GMr_1}{r_1^2+a^2\cos^2\theta}}} \tag{55}$$

$$\frac{\nu_1}{\nu_2} = \sqrt{\frac{1-\dfrac{2GMr_2}{r_2^2+a^2\cos^2\theta}}{1-\dfrac{2GMr_1}{r_1^2+a^2\cos^2\theta}}} \tag{56}$$

In this case the formula (14) of the radial velocity of light in the commonly used coordinates [1] [2] becomes:

$$v_l = \frac{\mathrm{d}r}{\mathrm{d}t} = \sqrt{\frac{1}{\left(1+\dfrac{2GMr_g}{r_g^2+a^2\cos^2\theta_g}\right)\left(1+\dfrac{2GMr_g+a^2\sin^2\theta_g}{r_g^2+a^2\cos^2\theta_g}\right)}} \tag{57}$$

We can note that, also here, the radial velocity of light in the commonly used coordinates is always ≤1, and is equal to 1 only when there is not a gravitational field.

4. The Correct Kerr-Newman Solution

As for the Kerr-Newman solution [2] [3], that is the solution that represents the curved space-time geometry surrounding an electrically charged rotating mass, we have that the commonly used expression is [3]:

$$\mathrm{d}s^2 = \frac{\Delta}{\rho^2}\left(\mathrm{d}t - a\sin^2\theta\mathrm{d}\varphi\right)^2 - \frac{\sin^2\theta}{\rho^2}\left[\left(r^2 + a^2\right)\mathrm{d}\varphi - a\mathrm{d}t\right]^2 - \frac{\rho^2}{\Delta}\mathrm{d}r^2 - \rho^2\mathrm{d}\theta^2 \quad (58)$$

where ρ^2 and Δ are functions of r and θ:

$$\Delta \equiv r^2 - 2GMr + a^2 + GQ^2 \quad (59)$$

$$\rho^2 \equiv r^2 + a^2\cos^2\theta \quad (60)$$

and M, Q and a are constants: M is the total mass of the system, Q is the total electric charge of the system, and a is the spin angular momentum of the system per unit mass.

In the (58) there are singularities (event horizons) when

$$r^2 - 2GMr + a^2 + GQ^2 = 0 \quad (61)$$

that is, when

$$r = GM \pm \sqrt{G^2M^2 - a^2 - GQ^2} \quad (62)$$

Obviously there are real singularities (event horizons) only when $G^2M^2 - a^2 - GQ^2 \geq 0$.

Moreover we have that the coefficient g_{00} is equal to zero when

$$r^2 - 2GMr + a^2\cos^2\theta + GQ^2 = 0 \quad (63)$$

that is, when

$$r = GM \pm \sqrt{G^2M^2 - a^2\cos^2\theta - GQ^2} \quad (64)$$

Therefore there are two distinct surfaces where g_{00} is equal to zero. These surfaces are infinite-redshift surfaces. Obviously such surfaces really exist only where $G^2M^2 - a^2\cos^2\theta - GQ^2 \geq 0$.

But also here the expression (58) is erroneous: in fact, by means of the fact that the correct Kerr-Newman solution must be equal to the correct Kerr solution for $Q = 0$, and must be equal to the correct Reissner-Nordstrøm solution for $a = 0$, and must be equal to the correct Schwarzschild solution for $Q = 0$ and $a = 0$, we can say that the correct Kerr-Newman solution expressed as the formally flat metric in the commonly used coordinates ($\mathrm{d}s^2$), which metric is expressed as a function of the coordinates curved for expressing the gravitational field as the curvature of the space-time, is:

$$\begin{aligned}\mathrm{d}s^2 = {} & \frac{\Delta}{\rho^2}\left(\mathrm{d}t_g - a\sin^2\theta_g\mathrm{d}\varphi_g\right)^2 - \frac{\sin^2\theta_g}{\rho^2}\left[\left(r_g^2 + a^2\right)\mathrm{d}\varphi_g - a\mathrm{d}t_g\right]^2 \\ & - \frac{\rho^2}{\Delta}\mathrm{d}r_g^2 - \rho^2\mathrm{d}\theta_g^2\end{aligned} \quad (65)$$

where ρ^2 and Δ are functions of r_g and θ_g:

$$\Delta \equiv r_g^2 + 2GMr_g + a^2 + GQ^2 \quad (66)$$

$$\rho^2 \equiv r_g^2 + a^2\cos^2\theta_g \quad (67)$$

and M, Q and a are constants: M is the total mass of the system, Q is the total electric charge of the system, and a is the spin angular momentum of the system per unit mass. Moreover t_g, r_g, θ_g, φ_g are the space-time coordinates measured relatively to a reference frame that is integral with a space-time curved for expressing the gravitational field as the curvature of the space-time. In other words, this equation (65) is expressed in curved coordinates.

As we can see, the difference between the correct formula and the incorrect formula is only in the definition of Δ, in which we have respectively $+2GMr_g$ instead of $-2GMr_g$.

Moreover, we can note that in the (65) the coefficient of $\mathrm{d}t_g^2$ is always greater than one (except in the case where there is no gravitational field, in which case this coefficient is equal to one), and the more intense the gravitational field is, the greater this coefficient is. As mentioned before, we have already shown in [1] that this is a sign that the coordinates are curved and is closely related to the fact that the clocks in a gravitational field run more slowly.

Also in this case as in that of Schwarzschild, we have not any singularity in the correct expression (65) for any value of $r_g > 0$. Therefore we can say that there is not any event horizon and therefore that there is not any black hole [2] [3].

Furthermore, since the coefficient of $\mathrm{d}t_g^2$ in the (65) is always ≥1, there is not any infinite-redshift surface and the time (that is, the temporal coordinate) does not become in any case as a spatial coordinate, contrary to the common treatment of the space-time inside the event horizon [2] [3]. Moreover, since the coefficient of $\mathrm{d}r_g^2$ in the (65) is always not positive, also here the spatial coordinate r_g does not become in any case as a temporal coordinate, contrary to the common treatment of the space-time inside the event horizon [2] [3].

Therefore, also here the light cones are always orientated in the usual way, in particular there is not any horizontal inclination of the light cones, contrary to the common treatment of the space-time inside the event horizon [2] [3].

Now, also in this case, it is very complicated to express this metric as the formally flat metric in the curved coordinates, which metric is expressed as a function of the commonly used coordinates, but however we can obtain easily a such expression for $\mathrm{d}\theta_g = 0$ and $\mathrm{d}\varphi_g = 0$. In fact the (65) for $\mathrm{d}\theta_g = 0$ and $\mathrm{d}\varphi_g = 0$ becomes:

$$\mathrm{d}s^2 = \frac{\Delta - a^2 \sin^2\theta_g}{\rho^2}\mathrm{d}t_g^2 - \frac{\rho^2}{\Delta}\mathrm{d}r_g^2 \tag{68}$$

where ρ^2 and Δ are functions of r_g:

$$\Delta \equiv r_g^2 + 2GMr_g + a^2 + GQ^2 \tag{69}$$

$$\rho^2 \equiv r_g^2 + a^2\cos^2\theta_g \tag{70}$$

Therefore the (68) can be written as:

$$\mathrm{d}s^2 = \left(1 + \frac{2GMr_g + GQ^2}{r_g^2 + a^2\cos^2\theta_g}\right)\mathrm{d}t_g^2 - \frac{1}{1 + \dfrac{2GMr_g + GQ^2 + a^2\sin^2\theta_g}{r_g^2 + a^2\cos^2\theta_g}}\mathrm{d}r_g^2 \tag{71}$$

Now by analogy with the previous cases we can write in this case the formally flat metric in the curved coordinates, which metric is expressed as a function of the commonly used coordinates, as:

$$\mathrm{d}s_g^2 = \frac{1}{1+\frac{2GMr_g + GQ^2}{r_g^2 + a^2\cos^2\theta_g}}\mathrm{d}t^2 - \left(1+\frac{2GMr_g + GQ^2 + a^2\sin^2\theta_g}{r_g^2 + a^2\cos^2\theta_g}\right)\mathrm{d}r^2 \tag{72}$$

where $\mathrm{d}s_g^2$ is a metric formally flat in the curved coordinates and θ_g is a constant.

As for the relation between r_g and *r*, we have:

$$\mathrm{d}r^2 = \frac{1}{1+\frac{2GMr_g + GQ^2 + a^2\sin^2\theta_g}{r_g^2 + a^2\cos^2\theta_g}}\mathrm{d}r_g^2 \tag{73}$$

From which, we have:

$$\int_0^{r^2}\mathrm{d}r^2 = \int_0^{r_g^2}\frac{1}{1+\frac{2GMr_g + GQ^2 + a^2\sin^2\theta_g}{r_g^2 + a^2\cos^2\theta_g}}\mathrm{d}r_g^2 \tag{74}$$

From which, we have:

$$r^2 = \int_0^{r_g}\frac{2r_g\left(r_g^2 + a^2\cos^2\theta_g\right)\mathrm{d}r_g}{r_g^2 + 2GMr_g + GQ^2 + a^2} \tag{75}$$

From which, we have:

$$\begin{aligned} r^2 = \Bigg[& r_g^2 - 4GMr_g + \left(4G^2M^2 - a^2\sin^2\theta_g - GQ^2\right) \\ & \cdot\ln\left(r_g^2 + 2GMr_g + GQ^2 + a^2\right) \\ & + \frac{GM\left(2a^2 + a^2\sin^2\theta_g + 3GQ^2 - 4G^2M^2\right)}{\sqrt{G^2M^2 - GQ^2 - a^2}} \\ & \cdot\ln\left(\frac{GM + r_g - \sqrt{G^2M^2 - GQ^2 - a^2}}{GM + r_g + \sqrt{G^2M^2 - GQ^2 - a^2}}\right)\Bigg]_0^{r_g} \end{aligned} \tag{76}$$

From which, we have:

$$\begin{aligned} r^2 = {} & r_g^2 - 4GMr_g + \left(4G^2M^2 - a^2\sin^2\theta_g - GQ^2\right) \\ & \cdot\ln\left(1+\frac{r_g^2 + 2GMr_g}{GQ^2 + a^2}\right) + \frac{GM\left(2a^2 + a^2\sin^2\theta_g + 3GQ^2 - 4G^2M^2\right)}{\sqrt{G^2M^2 - GQ^2 - a^2}} \\ & \cdot\ln\left(\frac{GM + r_g - \sqrt{G^2M^2 - GQ^2 - a^2}}{GM + r_g + \sqrt{G^2M^2 - GQ^2 - a^2}}\cdot\frac{GM + \sqrt{G^2M^2 - GQ^2 - a^2}}{GM - \sqrt{G^2M^2 - GQ^2 - a^2}}\right) \end{aligned} \tag{77}$$

According to the (77) for $r_g \to 0$ also $r \to 0$ and for $r_g \to +\infty$ also $r \to +\infty$. Moreover, as r_g increases, *r* also increases, as we can see directly from the (75). On the other side, for any value of $r_g > 0$ we have that $r < r_g$, as we can see directly from the (74).

Furthermore, for $r_g \to +\infty$ we have that $r \cong r_g\left(1-\frac{2GM}{r_g}\right)$ and also $r_g \cong r\left(1+\frac{2GM}{r}\right)$. This implies that, in this case, the presence of r_g instead of r in the (72) implies only corrections to the second order in $\frac{2GM}{r}$.

On the other hand for $r_g \to 0$ in the case of $\cos^2\theta_g \neq 0$ we have $r \cong r_g\sqrt{\frac{a^2\cos^2\theta_g}{GQ^2+a^2}}$, while in the case of $\cos^2\theta_g = 0$ we have $r \cong \frac{r_g^2}{\sqrt{2\left(GQ^2+a^2\right)}}$, as we can see easily from the (75).

In this case the correct formulas (9) and (10) become respectively:

$$\frac{\mathrm{d}t_{g2}}{\mathrm{d}t_{g1}} = \sqrt{\frac{1+\frac{2GMr_{g1}+GQ^2}{r_{g1}^2+a^2\cos^2\theta_g}}{1+\frac{2GMr_{g2}+GQ^2}{r_{g2}^2+a^2\cos^2\theta_g}}} \tag{78}$$

$$\frac{\nu_1}{\nu_2} = \sqrt{\frac{1+\frac{2GMr_{g1}+GQ^2}{r_{g1}^2+a^2\cos^2\theta_g}}{1+\frac{2GMr_{g2}+GQ^2}{r_{g2}^2+a^2\cos^2\theta_g}}} \tag{79}$$

Therefore also in this case we have that in the presence of a gravitational field the clocks go more slowly (that is, that the measurements of time relatively to a reference frame that is integral with a space-time curved for expressing the presence of a gravitational field flow more slowly). And the more intense is the gravitational field the more slowly the clocks go (that is, the measurements of time relatively to a reference frame that is integral with a space-time curved for expressing the presence of a more intense gravitational field flow more slowly than the measurements of time relatively to a reference frame that is integral with a space-time curved for expressing the presence of a less intense gravitational field).

Furthermore, the gravitational redshift, that is expressed by the formula (79), is always not infinite for any value of $r_g > 0$ or of $r > 0$, as in the correct Schwarzschild solution.

We can note that the two correct formulas (78) and (79) are different from those obtained usually from the incorrect expression of the Kerr-Newman solution by means of an incorrect procedure [1] [2]. In fact, the formulas commonly used, instead of the two correct formulas (78) and (79), are respectively [1] [2]:

$$\frac{\mathrm{d}t_2}{\mathrm{d}t_1} = \sqrt{\frac{1+\frac{-2GMr_2+GQ^2}{r_2^2+a^2\cos^2\theta}}{1+\frac{-2GMr_1+GQ^2}{r_1^2+a^2\cos^2\theta}}} \tag{80}$$

$$\frac{v_1}{v_2} = \sqrt{\frac{1 + \frac{-2GMr_2 + GQ^2}{r_2^2 + a^2 \cos^2 \theta}}{1 + \frac{-2GMr_1 + GQ^2}{r_1^2 + a^2 \cos^2 \theta}}} \quad (81)$$

In this case the formula (14) of the radial velocity of light in the commonly used coordinates [1] [2] becomes:

$$v_l = \frac{\mathrm{d}r}{\mathrm{d}t} = \sqrt{\frac{1}{\left(1 + \frac{2GMr_g + GQ^2}{r_g^2 + a^2 \cos^2 \theta_g}\right)\left(1 + \frac{2GMr_g + GQ^2 + a^2 \sin^2 \theta_g}{r_g^2 + a^2 \cos^2 \theta_g}\right)}} \quad (82)$$

We can note that, also here, the radial velocity of light in the commonly used coordinates is always ≤1, and is equal to 1 only when there is not a gravitational field.

5. The Consequences of the Correct Metrics

We have seen that these correct metrics of Schwarzschild, Reissner-Nordstrøm, Kerr and Kerr-Newman do not imply any event horizon and, consequently, these metrics do not imply any black hole.

In fact, in these metrics there is not any singularity in general at any value of $r > 0$ or of $r_g > 0$.

Moreover, according to these metrics, for any value of $r > 0$ or of $r_g > 0$ the coefficient of $\mathrm{d}t^2$ and the coefficient of $\mathrm{d}t_g^2$ always remain positive and the coefficient of $\mathrm{d}r^2$ and the coefficient of $\mathrm{d}r_g^2$ always remain negative. Therefore, since the coefficient of $\mathrm{d}t^2$ and the coefficient of $\mathrm{d}t_g^2$ are always not negative the time (that is, the temporal coordinate) does not become in any case as a spatial coordinate, contrary to the common treatment of the space-time inside the event horizon [2] [3]. On the other hand, since the coefficient of $\mathrm{d}r^2$ and the coefficient of $\mathrm{d}r_g^2$ are always not positive the spatial coordinate r or r_g does not become in any case as a temporal coordinate, contrary to the common treatment of the space-time inside the event horizon [2] [3].

Consequently, the light cones are always orientated in the usual way, in particular there is not any horizontal inclination of the light cones, contrary to the common treatment of the space-time inside the event horizon [2] [3].

6. Experimental Prospects

6.1. The Available Experimental Data

As we have already noted in [1], as for the experimental data obtained with the help of x-ray astronomy the proof that we have found black holes, and therefore event horizons, is based only on the fact that we have found invisible objects which have masses that are too great, according to the commonly accepted theory, for not being black holes [2] [4] [5]. But according to the correct theory of this article, whatever the masses and the dimensions of these invisible objects are, we never have black holes, and therefore we never have event horizons. Therefore such experimental data cannot discriminate between the commonly accepted theory and the same theory corrected according to this article.

On the other hand, as we have already noted in [1], with regard to the experimental data of the so-called gravitational waves (obtained by the LIGO collaboration) of a collision between two black holes, such gravitational waves were detected only below measurement errors, i.e. the signals detected were lower than the background noise (cf. chapter 6 of [4]). Furthermore the models expected from the theory were used for selecting the signals from the background noise (cf. chapter 6 of [4]) with the help of supercomputers: obviously, this is an incorrect practice which cannot produce any significant data. The awareness of the non-significance of the LIGO collaboration data is now widespread [6]-[9]. Obviously, also such data cannot discriminate between the commonly accepted theory and the same theory corrected according to this article.

As for the alleged photos of black holes, as we have already noted in [1], they were formed with the help of special algorithms from something compatible with the white noise. In other words, these photos were extracted from something compatible with the white noise only on the basis of the images that were expected by the researchers, with the help of appropriate algorithms loaded onto supercomputers (cf. the Section "Imaging a Black Hole" of [10]. See also [11]). Therefore, also in this case the researchers wanted to measure something that is below measurement errors, and so these photos are completely unreliable. On the other hand, serious doubts have now spread about the reliability of these photos [12] [13]. Consequently such photos cannot prove anything and in particular cannot discriminate in any way between the commonly accepted theory and the same theory corrected according to this article.

Moreover, the corrections, that we have proposed in this article, to the commonly accepted theory are very small in the normal experimental situations (for example in the solar system), so the fact that, in these situations, so far no difference has been noted between the commonly accepted theory and the experimental results is not strange. In fact, in the usual case of $\frac{2GM}{r} \ll 1$, $\frac{GQ^2}{r^2}$ negligible compared to $\frac{2GM}{r}$ and a^2 negligible compared to r^2, we have that the difference between the previsions of the commonly accepted theory and the previsions of the same theory corrected according to this article is only at the second order in $\frac{2GM}{r}$ [1]. And all the experiments conducted so far in the solar system have not had errors so small as to test differences at the second order in $\frac{2GM}{r}$ [2].

Therefore, in conclusion, there is no available experimental data that can discriminate between the commonly accepted theory and the same theory corrected according to this article.

6.2. A Proposal for a Crucial Experiment

On the other hand, a crucial experiment could be done, which discriminates between the commonly accepted theory and the same theory corrected according to this article, by taking advantage of the high precision and sensitivity of the latest atomic clocks.

In fact, as we have shown in [1], the ratio of the passage of time in the gravitational field according to the correct Schwarzschild metric to that according to the commonly accepted Schwarzschild metric, in the case of $\frac{2GM}{r} \ll 1$, is approximately equal to $1+\frac{1}{2}\left(\frac{2GM}{r}\right)^2$.

Now throughout the solar system we have effectively $\frac{2GM}{r} \ll 1$.

This, as we have shown in [1], allows us, with the use of the latest atomic clocks [14] [15], to be able to perform in the solar system a crucial experiment between the commonly accepted Schwarzschild metric and the same metric corrected according to this article.

Now, since the corrections of this article to the Reissner-Nordstrøm, Kerr and Kerr-Newman metrics strictly depend on the corrections of this article to the Schwarzschild metric, we can say that this crucial experiment would also discriminate between the commonly accepted Reissner-Nordstrøm, Kerr and Kerr-Newman metrics and the same metrics corrected according to this article.

7. General Conclusions

As we have seen, the corrections of this article imply that the correct solutions of these metrics do not entail any event horizon and, consequently, any black hole, since there is not any black hole without an event horizon [1]. Therefore, this article confutes all the physics that on the basis of these metrics foresees the possibility of the existence of event horizons and black holes [2] [3] [16] [17].

On the other hand, we have seen that the alleged proofs in favour of the existence of black holes and event horizons based respectively on x-ray astronomy, on alleged gravitational waves and on alleged photos of black holes are not conclusive and therefore are not sufficient to discriminate between the commonly accepted theory and the same theory corrected according to this article [1].

Moreover, we have observed that the corrections, that we have proposed here, to the commonly accepted theory are very small in the normal experimental situations, so the fact that so far no difference has been noted between the commonly accepted theory and the experimental results is not strange. In fact, as we have seen, in the usual case of $\frac{2GM}{r} \ll 1$, $\frac{GQ^2}{r^2}$ negligible compared to $\frac{2GM}{r}$ and a^2 negligible compared to r^2, we have that the difference between the previsions of these erroneous metrics and the previsions of these correct metrics is practically only in the second order in $\frac{2GM}{r}$ [1]. And, as we have already noted, all the experiments conducted so far have not had errors so small as to test differences at the second order in $\frac{2GM}{r}$ [2].

However, as we have already noted, recently atomic clocks have been constructed with a sensitivity such as to test these small differences in experiments that are feasible in the solar system [1]. Therefore, it would be appropriate to try to make a crucial experiment that discriminates between the commonly accepted theory and the same theory corrected according to this article [1].

Finally, according to this article, all the physics that is based on these incorrect metrics should be modified on the basis of the correct formulas that we have calculated [1].

Conflicts of Interest

The author declares no conflicts of interest regarding the publication of this paper.

References

[1] Pace, C.M. (2024) The Solution of the Einstein's Equations in the Vacuum Region Surrounding a Spherically Symmetric Mass Distribution. *Journal of Modern Physics*, **15**, 1353-1374. https://doi.org/10.4236/jmp.2024.159055

[2] Ohanian, H.C. and Ruffini, R. (2013) Gravitation and Spacetime. 3rd Edition, Cambridge University Press. https://doi.org/10.1017/cbo9781139003391

[3] Misner, C.W., Thorne, K.S. and Wheeler, J.A. (1973) Gravitation. W. H. Freeman and Company.

[4] Gubser, S.S. and Pretorius, F. (2017) The Little Book of Black Holes. Princeton University Press. https://doi.org/10.2307/j.ctvc774j3

[5] López-Cruz, O., Añorve, C., Birkinshaw, M., Worrall, D.M., Ibarra-Medel, H.J., Barkhouse, W.A., *et al.* (2014) The Brightest Cluster Galaxy in A85: The Largest Core Known So Far. *The Astrophysical Journal Letters*, **795**, L31. https://doi.org/10.1088/2041-8205/795/2/l31

[6] Brooks, M. (2018) Exclusive: Grave Doubts over LIGO's Discovery of Gravitational Waves. https://www.newscientist.com/article/mg24032022-600-exclusive-grave-doubts-over-ligos-discovery-of-gravitational-waves/

[7] Unzicker, A. (2019) Fake News from the Universe? https://www.telepolis.de/features/Fake-News-from-the-Universe-4464599.html

[8] Jackson, A.D., Liu, H. and Naselsky, P. (2019) Noise Residuals for GW150914 Using Maximum Likelihood and Numerical Relativity Templates. *Journal of Cosmology and Astroparticle Physics*, **2019**, No.5, Article 14. https://doi.org/10.1088/1475-7516/2019/05/014

[9] Liu, H., Creswell, J., von Hausegger, S., Jackson, A.D. and Naselsky, P. (2018) A Blind Search for a Common Signal in Gravitational Wave Detectors. *Journal of Cosmology and Astroparticle Physics*, **2018**, No. 2, Article 13. https://doi.org/10.1088/1475-7516/2018/02/013

[10] van Langevelde, H.J., *et al.* (2024) Event Horizon Telescope: Science. https://eventhorizontelescope.org/science

[11] Sofri, L., *et al.* (2019) Perché la prima immagine del buco nero non è una "foto". https://www.ilpost.it/2019/04/10/immagine-buco-nero-foto/

[12] Miyoshi, M., Kato, Y. and Makino, J. (2022) The Jet and Resolved Features of the Central Supermassive Black Hole of M87 Observed with the Event Horizon Telescope

(EHT). *The Astrophysical Journal*, **933**, Article No. 36. https://doi.org/10.3847/1538-4357/ac6ddb

[13] Miyoshi, M., Kato, Y., Makino, J. and Tsuboi, M. (2024) The Jet and Resolved Features of the Central Supermassive Black Hole of M87 Observed with EHT in 2017—Comparison with the GMVA 86 GHz Results. *The Astrophysical Journal Letters*, **963**, L18. https://doi.org/10.3847/2041-8213/ad250e

[14] Bothwell, T., Kennedy, C.J., Aeppli, A., Kedar, D., Robinson, J.M., Oelker, E., *et al*. (2022) Resolving the Gravitational Redshift across a Millimetre-Scale Atomic Sample. *Nature*, **602**, 420-424. https://doi.org/10.1038/s41586-021-04349-7

[15] Conover, E. (2021) An Atomic Clock Measured How General Relativity Warps Time across a Millimeter. https://www.sciencenews.org/article/atomic-clock-general-relativity-time-warp-millimeter-physics

[16] Hawking, S.W. and Penrose, R. (1996) The Nature of Space and Time. Princeton University Press.

[17] Hawking, S. (1988) A Brief History of Time. Bantam Dell Publishing Group.