Extension of the laws of gravitation

30/07/2024

Black holes. Gravitational spectral shift

Pascal DUBOIS

This note answers the following questions:

1. How can the laws of gravitation be extended beyond the weak field conditions in which they were established?
2. What are the implications for black holes?
3. What are the consequences for the spectral shift of a gravitational source?

1. Generalisation of the laws of gravitation

1.1. Reminder of the principles adopted

In the note entitled *"Another approach to relativity"* we proposed new laws of gravitation in a weak field (i.e. when the ratio $Gm/\mathbf{c}^2r$ is sufficiently small compared with 1). [1]

These laws are based on the principles set out below:

First principle: gravitational field and potential energy

The gravitation created by a gravitational source of mass m can be characterised by a gravitational field that imparts potential energy to the particles present in it.

The variation in the potential energy of a particle, of zero or non-zero mass, is proportional to its total energy E, calculated in the reference frame linked to the source; it is given by the relation :

$$dE_g = 2\,(Gm/\,\mathbf{c}^2r^2)\,E\,dr$$

Second principle: conservation of energy

The variation in total energy of a particle is equal to the inverse of the variation in potential energy plus the work of external forces, if any:

$$dE = dE_x - dE_g$$

[1] These laws make it possible to predict the results of experiments considered as tests of the theory of general relativity. In conclusion, the note explains the similarities and differences with this theory.

Third principle: the influence of gravitation on the energy and momentum of a particle

The rest energy of a non-zero mass particle varies with its distance from the source.

In the absence of external forces, the variation in energy associated with rest energy and the variation in energy associated with momentum are each equal to and opposite half the variation in potential energy.

Fourth principle: equivalence between gravitation and acceleration

The fundamental law of dynamics can be applied to determine the relationship between the change in momentum of the particle and the change in energy associated with that momentum under the effect of the gravitational field. [2]

1.2. Reminder of the characteristics of the gravitational field

In the note entitled *"Gravitational field, Fundamental Principle of Dynamics and Quantum Mechanics"* we presented a gravitational field model consistent with the laws described in the previous paragraph.

The field associated with a mass m can be considered as an energy distribution beyond the Schwarzschild sphere of radius: $\mathrm{R_g} = 2\ \mathrm{Gm}/\mathbf{c}^2$. The energy contained in a shell of radius r decreases in inverse proportion to the square of this radius.[3]

A mechanism for refreshing the field constantly adapts it to variations in the energy of its source; this mechanism uses gravitational waves to form a system that can be considered equivalent to the mass of the source.

The gravitational interaction consists of an exchange of energy between gravitational sources and the global field created by these sources.

We show that we can deduce the fundamental principle of dynamics from the properties attributed to the gravitational field.

<u>*Note*</u>: It **is important to note that the reasoning that leads to this result justifies the third principle in paragraph 1.1.** [4]

We also show that the characteristics of the gravitational wave that accompanies a moving particle allow it to act as a pilot wave (in reference to the concept introduced by Louis de Broglie's theory) and thus explain the wave behaviour of the particle.

Finally, the motion of a particle appears to be entirely controlled by the gravitational field associated with it.

---

[2] Given the third principle, equivalence cannot be considered complete.

[3] The energy density of the field therefore varies as $1/\mathrm{r}^4$.

[4] Cf. *"Gravitational field, Fundamental Principle of Dynamics and Quantum Mechanics"* § 2.3.

1.3. Extension of the laws of gravitation outside weak field conditions

Since the gravitational field model we have just presented is expressed in the same way whatever the distance from the source, we are inclined to consider that the formulation of the laws of gravitation is also independent of this distance.

In our model, what could be more particularly discussed is the equal sharing of the potential energy between the variation of the energy linked to the rest energy and the variation of the energy linked to the momentum. Why should this sharing be independent of the distance from the source?

The comment made in the previous paragraph provides the answer: the 50/50 split is a consequence of the model chosen for the field.

We will therefore assume that the laws of gravitation in their incremental form are valid throughout the gravitational field:

Change in potential energy: $dE_g = 2\,(Gm/\,\mathbf{c}^2r^2)\,E\,dr$

Energy variation at rest: $dE_0 = -\,(Gm/\,\mathbf{c}^2r^2)\,E_0\,dr$

Total energy change: $dE = dE_x - 2\,(Gm/\,\mathbf{c}^2r^2)\,E\,dr$

Speed variation $(\gamma = (1 - v^2/\mathbf{c}^2)^{-1/2})$: $d\gamma = -\,(Gm/\,\mathbf{c}^2r^2)\,\gamma\,dr$ [5]

This leads to the following expressions for the energy of the particle subjected to the action of the field:

$$E_0 = E_{0\infty}\exp\,(GM/\,\mathbf{c}^2r) \tag{1.1}$$

And, in the absence of external forces :

$$E = E_{\infty}\exp\,(2\,GM/\,\mathbf{c}^2r) \tag{1.2}$$

$$\gamma = \gamma_{\infty}\exp\,(GM/\,\mathbf{c}^2r) \tag{1.3}$$

To be validated, this choice of extension of the laws of gravitation would require experimental confrontations. The following are the consequences for the notion of a black hole and the spectral shift of gravitational sources, which appear to be preliminaries to any experimental verification.

[5] We have : $E = \gamma\,E_0$. Equal sharing of potential energy results in : $\gamma\,dE_0 = E_0\,d\gamma$.

2. Black holes

In astrophysics, a black hole is a celestial object so compact that the intensity of its gravitational field prevents any form of matter or radiation from escaping.

In the theory of general relativity, black holes with no angular momentum or charge are characterised by their Schwarzschild radius R_g , which defines the event horizon below which no particle, of zero or non-zero mass, can escape from the black hole.

Equations (1.1), (1.2) and (1.3) give the following results for $r = R_g$:

$$E_0 = E_{0\infty} \exp(1/2)$$

$$E = E_\infty \exp(1)$$

$$\Upsilon = \Upsilon_\infty \exp(1/2)$$

Unlike general relativity, no singularity appears.

This is not incompatible with the existence of black holes if we correct their definition as follows: no energy can escape from a black hole except that carried by the gravitational waves that refresh the field. [6]

We have seen that, in a weak field for a photon, we can assume that the product $\mathbf{c}_g\, \nu_g$ (velocity x frequency) is conserved.[7] If this postulate is extended to the entire gravitational field, to the Schwarzschild radius, then the speed of the photon is :

$$\mathbf{c}_{Rg} = c/\exp(1)$$

3. Gravitational spectral shift

Let's move away from black holes and look at the gravitational spectral shift of a source of mass m emitting radiation of frequency ν_0 .

If equation (1.2) relating to total energy remains valid at the surface of a source of radius R, at infinity the received frequency tends towards :

$$\nu_\infty = \nu_0 \exp(-\,2GM/\,\mathbf{c}^2R) \qquad (3.1)$$

Recall the result given by general relativity :

$$\nu_\infty = \nu_0\,(1-\,2GM/\,\mathbf{c}^2\,R)^{1/2} \qquad (3.2)$$

[6] These waves cannot be equated with the gravitational waves of general relativity.

[7] In the case of isolated photons, however, the question arises as to whether the rule postulated for an electromagnetic wave is still valid.