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How to Measure the Spin of a Black Hole

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Black holes and fast spinning stars attract the surrounding objects in a different way than Newtonian gravity. As shown by my work on Gravitomagnetism [1], the spin of fast spinning stars and black holes is far the most important factor in the behavior of nearby objects. This paper shows that the accretion disc of any black hole is orbiting in prograde way. Moreover, it is explained that the accretion disc's turbulence, curvature and quantity of the vortexes are predominant factors for the gravitational strength of a black hole. The measurement of the spin of a black hole depends mainly on this factor, and to a lesser extent, to a few other factors.

Keywords: Black hole, gravitomagnetism, angular momentum, accretion disc, gravitational constant.

1. Foundations of Gravitomagnetism

The Newtonian gravity is incomplete. The first attempt to cope with that was made by Oliver Heaviside at the end of the nineteenth century. He transposed electromagnetism to gravity by replacing charge by mass and the magnetic field $\mathbf{B}$ to what I call gyrotation $\mathbf{\Omega}$, the equivalent magnetic field for gravity. It has the dimension of [Hz], and represents the transmission through space of a field that is caused by the motion of masses.

The Maxwell equations and the Lorentz force can be transposed into the Heaviside-Maxwell equations for gravity [1]:

$$\nabla\cdot\mathbf{g} = 4\pi G\rho \tag{1}$$

$$c^2\,\nabla\times\mathbf{\Omega} = 4\pi G\,\mathbf{j} + \partial\,\mathbf{g}/\partial t \tag{2}$$

$$\nabla\cdot\mathbf{\Omega} = 0 \tag{3}$$

$$\nabla\times\mathbf{g} = -\partial\,\mathbf{\Omega}/\partial t \tag{4}$$

$$\mathbf{F} = m\left(\mathbf{g} + \mathbf{v}\times\mathbf{\Omega}\right) \tag{5}$$

Wherein G is the gravitational constant, c the speed of light, ρ is the mass density, $\mathbf{j}$ the mass density flow, and $\mathbf{v}$ the velocity of a second mass m.

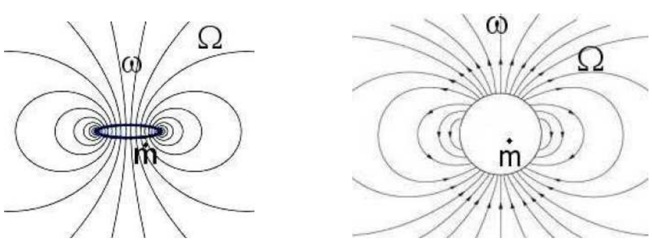

Fig. 1 : Side view. Gyrotation field of a ring and of a sphere with mass m and angular velocity $\boldsymbol{\omega}$.

The equation (2) expresses the creation of a gyrotation field out of a mass density flow $\mathbf{j}$, which can be integrated for spinning spheres, rings and toroids.

$$\mathbf{\Omega} = -\frac{G\,I}{2\,r^3c^2}\left(\boldsymbol{\omega} - \frac{3\mathbf{r}\left(\boldsymbol{\omega}\cdot\mathbf{r}\right)}{r^2}\right) \tag{6}$$

Herein, I is the angular inertia momentum of the spinning object along its spin axis, with an angular velocity $\boldsymbol{\omega}$.

Eq. (6) expresses the value of the gyrotation field outside the object at any place *r*. Inside the object, there also exists a gyrotation field.

2. Gyrotation field of a spinning black hole

It is clear that all stars spin like the Sun does. Before nebulae retracted, for sure there was some motion in it. When they eventually retract to a white dwarf, their spin dramatically increase. The chance to find a retracted star without a spin is inexistent. Also black holes spin, and generally, they spin fast.

Eq. (6) gives the gyrotation field $\mathbf{\Omega}$ of a black hole at any place in space (outside the object itself) and eq. (5) gives the total gravity force upon a moving mass *m* in its neighborhood.

The name 'black hole' is a bit confusing because most of the time, the Newtonian gravity alone will be insufficient to create an event horizon. Only due to a high spin, a sufficient bending of light could be obtained near the equator, but the spin alone will never suffice to avoid light to escape at the poles [1].

Another important aspect of black holes is that their shape is expected to be a torus, because gyrotation makes fast spinning stars incapable of exploding between the latitudes of nearly 35° north and south, whatever its spin rate is [1]. Elsewhere however, matter cannot be hold together by gyrotation.

3. Black holes with an accretion disc

What is clearly not enough understood is that the condition for an accretion disc is to get a spinning central star or black hole.

In fact, the gyrotation field of spinning stars flattens the surrounding orbits to a disc, like with disc galaxies and with the solar system [1]. The faster the star or black hole spins, the stronger the disc is flattened. Only the gasses of an accretion disc will form a counter-pressure and will widen the disc a bit.

The motion inside the accretion disc is explained below. It is in strong contradiction with nowadays' belief.

If the angular velocity of the black hole is spinning in the same sense as the Earth, the direction of the gyrotation field is shown in fig. 2.

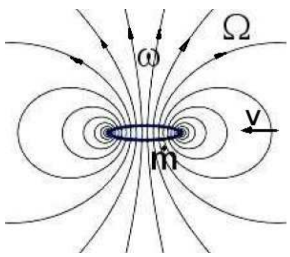

Fig. 2 : Side view. The gyrotation field of a black hole in the case of a spin direction like the Earth. A particle of the accretion disc flows in.

When a particle of the accretion disc flows in as shown in the figure, its path will be bent by the vector cross product in eq.(5). Closer to the black hole, the gyrotation force is larger, and it will be curved with a short radius.

Father away from the black hole, it will be curved less and have a larger radius. The effect is a bit reinforced by the gradient of the Newtonian gravity.

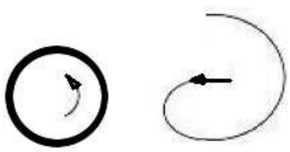

Fig. 3 : Top view. The gyrotation field is larger near the black hole and will bend the path of an incoming particle more strongly than farther away from it.

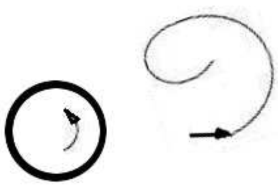

Fig. 4 : Top view. Away from the black hole, the gyrotation field is smaller and will less curve the path of an outgoing particle than closer by it.

Consequently, accretion discs will always progress in a prograde way, whatever the original velocity direction of the disc's particle is.

The thickness of the accretion disc depends upon the disc 's temperature and on the strength of the gyrotation field. Slow spinning stars and black holes will have a low gyrotation field strength for a same mass.

In the case of a thin disc, eq. (6) may be simplified by putting $\boldsymbol{\omega} \cdot \mathbf{r} = 0$, which results in:

$$\boldsymbol{\Omega} = -\frac{G\,I}{2\,r^3 c^2}\boldsymbol{\omega} \tag{7}$$

Which for a ring gives:

$$\boldsymbol{\Omega} = -\frac{G\,mR^2}{2\,r^3 c^2}\boldsymbol{\omega} \tag{8}$$

wherein R is the rings' radius.

4. How to measure the spin of a black hole

There are a few essential parameters required to measure the specific angular momentum of a black hole based upon an accretion disc.

Remember, the accretion disc is always prograde with the black hole. The most important parameter is the following:

1) How much curved are the vortexes in the accretion disc ?

The major parameter is the curvature of the particles in the vortexes that are formed in the accretion disc.

The stronger curved, the stronger the gyrotation field is. This parameter is strongly related to the number of vortexes and the turbulence of the accretion disc. The stronger the gyrotation field, the more compact vortexes will be created and the more turbulent the disc becomes.
Other parameters are:

2) How close to the black hole is the accretion disc ?

The closer the accretion disc is to the black hole, the weaker the black hole. Indeed, if the particles' path are not much curved nearby the black hole (fig. 3 and 4), they will not be pulled back and they will be able to stay close to the black hole. The gyrotation force is weak and the specific angular momentum as well. Only the Newtonian gravity will be able to act.

3) How thick is the accretion disc ?

The thicker the accretion disc, the more mass it can contain, but also, the weaker the gyrotation field can be. Remember, the gyrotation field flattens the surrounding matter to a disc. With a weak gyrotation field, the thickness increases. The quantity of matter of an accretion disc in the free space should however not influence the thickness much, because it can spread outwards, away from the black hole.

4) Is the accretion disc's temperature known ?

Depending of the compression and the turbulence, the accretion disc's temperature can rise. Another case is when the black hole has a companion star: sucked matter from a companion star has another temperature than old accretion discs. When the temperature is known, the pressure can be found.

5) What is the global prograde speed of the accretion disc ?

This is an ambiguous parameter, maybe not directly relevant. At high black hole spins, the accretion disc's vortexes are so tiny and so energetic that strong local turbulence occur. So, this parameter will be overruled by the turbulence parameter.

5. Conclusion

From this paper follows that accretion discs of fast spinning stars and black holes are always globally prograde. The motion of gas particles from accretion discs will form vortices that, if the gyrotation field is strong, are strongly curved. More away from the black hole they are wider curved, so that they doesn't form closed circles or ellipses, but a progressive path in prograde direction.

Furthermore, it is shown that the major parameter for the deduction of the specific angular momentum of a spinning star (or of a black hole) is the curvature of the vortexes in the accretion disc. The stronger the curvature, the stronger the gyrotation field. Other, directly related parameters are the turbulence and the temperature of the accretion disc.

The distance of the accretion disc to the black hole is also indicating the strength of gyrotation: the closer the disc is to the black hole, the weaker the gyrotation field is.

The accretion disc's global speed doesn't seem to be a determining factor, since fast spinning black holes doesn't necessary result in a fast global speed, but essentially in strongly curved vortexes and a strong turbulence in the accretion disc.

References

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