# SMBH relativistic gravity and dark matter

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**Abstract**

The extremely high rotation of some SMBHs is the origin of their relativistic rotational energy that results in their relativistic mass. Relativistic mass creates their relativistic gravity which is a partial answer to the missing dark matter.

**Keywords**: kinetic energy of rotating SMBH, gravity, dark matter

## 1. Introduction

We extended the mass-energy equivalence principle to the superfluid quantum space (SQS) which is the physical origin of the universal space. Every stellar object is diminishing the energy density of SQS in its centre exactly for the amount of its energy [1]:

$$E = mc^2 = (\rho_{PE} - \rho_{cE})V \qquad (1),$$

where $\rho_{PE}$ is Planck energy density of SQS in intergalactic space, $\rho_{cE}$ is the energy density of SQS in the centre of the stellar object and $V$ is the volume of the stellar object. Rearranging equation (1) we can calculate the diminished energy density of SQS in the centre of a stellar object:

$$\rho_{cE} = \rho_{PE} - \frac{mc^2}{V} \qquad (2).$$

SQS model is taking into account the kinetic energy of rotating stellar objects. We calculate kinetic rotational energy by the following equation:

$$E_{rotational} = \frac{1}{2} I\omega^2 \quad (3),$$

where $I$ is the moment of inertia around the axis of rotation ($I = mr^2$, where $m$ is mass and $r$ is the radius of the stellar object), and $\omega$ is the angular velocity. Rotational energy is additionally diminishing the energy density of SQS $\rho_{cE}$ in the centre of the stellar object accordingly to the following equation:

$$\rho_{cE} = \rho_{PE} - \frac{mc^2 + \frac{1}{2} I\omega^2}{V} \quad (4),$$

The additionally diminished energy density of SQS in the centre of a stellar object will increase the gravitational potential and so gravity force [2]. Gravity force between two rotating stellar objects will increase due to their rotation according to the following equation:

$$F_g = \frac{(m_1 + \frac{E1_r}{c^2}) * (m_2 + \frac{E2_r}{c^2}) G}{r^2} \quad (5),$$

where $E1_r$ is the kinetic rotational energy of mass $m_1$ and where $E2_r$ is the kinetic rotational energy of mass $m_2$ . Gravitational acceleration $a$ on the given non-rotating stellar object with mass $m$ is following:

$$a = \frac{mG}{r^2} \quad (6).$$

Gravitational acceleration $a$ on the given rotating stellar object with mass $m$ is as follows:

$$a = \frac{(m + \frac{E_r}{c^2}) G}{r^2} \quad (7).$$

## 2. Calculations of gravitational acceleration due to Earth and Sun rotation and black hole rotation with the mass of the Sun

Usually, we calculate gravitational acceleration on the Earth and Sun's surface as these two stellar objects are not rotating. We will do calculations taking into account their rotation using equation (7). Gravitational acceleration on the Earth's surface when Earth is not rotating is 9,807 $ms^{-2}$. Gravitational acceleration on the Earth's surface when Earth is rotating is the same. Gravitational acceleration on the Sun's surface when Sun is not rotating is 274 $ms^{-2}$. Gravitational acceleration on the Sun's surface when Sun is rotating is 274 $ms^{-2}$. Earth and Sun have their kinetic rotational energies that do not influence gravitational forces because they are too small.

Let's take a black hole with the mass of the Sun. Its radius is 3000 m. We will take that its orbital velocity is the same as of the Sun, $\omega = 2{,}865329607243705 \cdot 10^{-6} s^{-1}$. Kinetic rotational energy of such a black hole is following:

$$E_{rotational} = \frac{mr^2\omega^2}{2} \quad (8).$$

$$E_{rotational} = \frac{1{,}9891 \cdot 10^{30} kg * (3000m)^{2} * (2{,}8653 \cdot 10^{-6} s^{-1})^{2}}{2}$$

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$$E_{rotational} = 7{,}3487 \cdot 10^{25} kgm^2 s^{-2}.$$

Converting this energy into mass, we get: 816519989 kg. This increase of the mass is too small to increase the gravitational acceleration on the surface of such rotating black hole respectively when the same black hole is not rotating.

## 3. Calculations of relativistic gravity of SMBHs due to their high angular velocity

Black holes with big mases and high angular velocity could have some additional relativistic mass that we have seen in previous chapter is not the case with our Sun. Relativistic mass is the sum of mass at rest and kinetic rotational energy:

$$m_{relativistic} = m_{rest} + \frac{m_{rest} r^2 \omega^2}{2c^2} \qquad (9).$$

Cygnus X-1 black hole mass is 21,2 times bigger of the Sun's mass [3], its radius is 63000 m, it rotates 800 times per second [4], which means that angular velocity of Cygnus X-1 is 5026 $s^{-1}$.

$$E_{rotational} = \frac{1{,}9891 \cdot 10^{30} kg * 21{,}2 * (63000m)^2 * (5026\, s^{-1})^2}{2}$$

Converting this energy into mass, we get: $9{,}3952 \cdot 10^{31} kg$. Mass of Cygnus X-1 that would not rotate would be $4{,}2169 \cdot 10^{31} kg$. Actual relativistic mass of the rotating Cygnus X-1 is $1{,}3612 \cdot 10^{32} kg$. This relativistic mass is the result of extreme high angular velocity of the Cygnus X-1 and should be taken into account when calculating its gravity force. Gravitational acceleration $a$ on the surface of the rest Cygnus would be $7.1915 \cdot 10^{11}\, ms^{-2}$. Gravitational acceleration $a$ on the surface of the rotating Cygnus is $2{,}2890 \cdot 10^{12} ms^{-2}$. The difference could explain one part of the missing mass in some galaxies which has given the idea of the dark matter existence, namely, the dynamics of some AGNs has shown that the rotation of stellar objects around the centre of AGN is such that requires much stronger gravity as could be proved by observed masses [5]. These observations have led to the theoretical speculations of dark matter existence.

ASASSN–14li black hole rotates 1 time in 2 minutes, which means angular velocity of ASASSN–14li is 0,0524 $s^{-1}$ [6]. Tangential rotation speed $v$ is about half of light speed [7]. We calculate radius of the ASASSN-14li by equation:

$$v = \omega r \qquad (10).$$

Radius of ASASSN-14li is 2862595420 m. Its mass is 2,5 million solar masses which is $4{,}9727 \cdot 10^{36} kg$ [8].

$$E_{rotational} = \frac{4{,}9727 \cdot 10^{36} kg * (2862595420m)^2 * (0{,}0524\, s^{-1})^2}{2}$$

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$$E_{rotational} = 5{,}5943 \cdot 10^{52} kgm^2s^{-2}.$$

Converting this energy into mass, we get: $6{,}2159 \cdot 10^{35} kg$. Mass of ASASSN–14li that would not rotate would be $4{,}9727 \cdot 10^{36} kg$. Relativistic mass of the rotating ASSASSN–14li is $5{,}5943 \cdot 10^{36} kg$. Gravitational acceleration $a$ of the rest ASASSN–14li would be $4{,}0502 \cdot 10^{7}\ ms^{-2}$. Gravitational acceleration $a$ of rotating ASASSN–14li is $4{,}5565 \cdot 10^{7} ms^{-2}$.

GRS 1915+105 black hole rotates 1150 times per second, which means angular velocity of GRS 1915+105 is 7225 $s^{-1}$ [9]. It has radius about 90 km (between 70 and 110 km) [10], mass about 14 solar mases [11].

$$E_{rotational} = \frac{2{,}7847 \cdot 10^{31} kg * (90000m)^{\,2} * (7225\ s^{-1})^{\,2}}{2}$$

$$E_{rotational} = 5{,}8873 \cdot 10^{48} kgm^2s^{-2}.$$

Converting this energy into mass, we get: $6{,}5414 \cdot 10^{31} kg$. Mass of GRS 1915+105 that would not rotate would be $2{,}7847 \cdot 10^{31} kg$. Relativistic mass of rotating GRS 1915+105 is $9{,}3261 \cdot 10^{31} kg$. Gravitational acceleration $a$ of the rest GRS 1915+105 would be $2.2946 \cdot 10^{11} ms^{-2}$. Gravitational acceleration $a$ of rotating GRS 1915+105 is $7.6846 \cdot 10^{11} ms^{-2}$.

## 4. Relativistic mass is real and is valid for all observers

In Relativity Theory, the relative rate of clocks and also relativistic mass depend on the position of the observer. If you are a stationary observer, a clock for you will have a slower rate as if you are an observer which is moving with the clock. Our research results confirm that rate of clocks depend only on the variable energy density of SQS and is valid for all observers [12]. The same is valid for relativistic mass, which is also depending only on the interaction of the moving physical object with SQS and is independent of the observer.

The rotational kinetic energy of the Earth is equal for the observer on the Earth's surface and for the observer on the satellite that is orbiting around the Earth. In the same way, the rotational kinetic energy of high rotating SMBH is the same for all observers. Calculation of the given stellar object velocity makes sense only in comparison with a stationary SQS. Einstein's concept [12]. Calculating the relative velocity of a given stellar object regarding whether it is moving closer to the Earth or away from the Earth makes not much sense. Its real velocity is the orbital velocity around the centre of an SMBH in a given galaxy. In this perspective, the relativistic mass of a given SMBH depends only on its mass, radius, and angular velocity and is valid for all observers.

## 5. Conclusions

Rotating stars around the AGNs in some galaxies are suggesting the existence of some missing "hidden mass" (named "dark matter") that is the cause of "hidden gravity".

We have shown in this article that the partial answer to the “hidden gravity” is the relativistic gravity of SMBHs due to their high values of rotational velocity.

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