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SMBH Relativistic Mass and Missing Dark Matter

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Abstract

The extremely high angular velocity of some SMBHs is the origin of their relativistic rotational energy that results in their relativistic mass. The relativistic mass of SMBHs increases their 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 ρ_{PE} is Planck energy density of SQS in intergalactic space, ρ_{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:

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

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 ω is the angular velocity. We will calculate rotational kinetic energy of stellar objects by the equation below:

$$E_{rotational} = \frac{mr^2\omega^2}{2} \quad (4).$$

Rotational energy is additionally diminishing the energy density of SQS ρ_{cE} in the centre of the stellar object accordingly to the following equation:

$$\rho_{cE} = \rho_{PE} - \frac{mc^2 + \frac{1}{2}mr^2\omega^2}{V} \quad (5),$$

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:

$$F_g = \frac{(m_1 + \frac{E1_r}{c^2}) * (m_2 + \frac{E2_r}{c^2})G}{r^2} \quad (6),$$

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:

$$a = \frac{mG}{r^2} \quad (7).$$

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

$$a = \frac{(m + \frac{E_r}{c^2})G}{r^2} \quad (8).$$

2. Calculations of gravitational acceleration due to Earth and Sun angular velocity

Usually, we calculate gravitational acceleration on the Earth and Sun's surface as these two stellar objects are not rotating. We will calculate gravitational acceleration on their surfaces, taking into account their angular velocity using equation (8). Gravitational acceleration on the Earth's surface if Earth would not rotate would be $9{,}807\ ms^{-2}$. Gravitational acceleration on the Earth's surface when Earth is rotating is of the same value. Earth's kinetic rotational energy value is $6{,}4449 \cdot 10^{29} kgm^{2}s^{-2}$. Converting this energy into the mass we get a value $7{,}1610 \cdot 10^{12} kg$. This increase of mass is too small, to increase gravitational acceleration.

Using equation (8) we calculate that the gravitational acceleration on the Sun's surface if Sun would not rotate is $273{,}79\ ms^{-2}$. Sun's kinetic rotational energy value is $3{,}9592 \cdot 10^{42} kgm^{2}s^{-2}$. Converting this energy into the mass we get a value $4{,}3991 \cdot 10^{25} kg$. This increase in mass is not big enough to increase gravitational acceleration. Gravitational acceleration on the Sun's surface when the Sun is rotating is of the same value as when the Sun would not rotate.

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

Black holes with big masses and high angular velocities could have a bigger increase in relativistic masses and, consequently, an increase in gravity. The relativistic mass of a given SMBH is the sum of its mass at rest and its 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}.

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

$$E_{rotational} = 8{,}4557 \cdot 10^{48} kgm^2 s^{-2}$$

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 [5,6]. These observations have led to the theoretical speculations of dark matter existence.

We calculated the gravitational force on the single proton on the Cygnus X-1 surface is $3{,}8286 \cdot 10^{3-15} N$. The cross-sectional area of the proton is $2{,}2966 \cdot 10^{-30} m$, which means that the pressure created because of continuous transformation of matter into fresh energy that is pushing protons in the direction of jet is bigger than $1{,}6670 \cdot 10^{15}\, Nm^{-2}$. Astronomical observations are confirming that the jet of Cygnus X-1 is an extremely powerful event, which means the pressure of fresh energy is much stronger than the gravitational force.

ASASSN–14li black hole rotates 1 time in 2 minutes, which means angular velocity of ASASSN–14li is 0,0524 s^{-1} [7]. Tangential rotation speed v is about half of light speed [8]. 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 $4{,}9727 \cdot 10^{36} kg$ [9].

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

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

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 [10], which means angular velocity of GRS 1915+105 is 7225 s^{-1}. It has radius about 90 km (between 70 and 110 km) [11], mass about 14 solar mases [12].

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

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

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 [13]. 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.

Since the publication of special relativity in 1905 the idea was brought into physics that the measurement of a given event depends on the position of the observer. This is a wrong concept, GPS proved that relative rate of clocks is valid for all observers [13]. The same is valid for the rotational velocities of galaxies. The idea, that from the Earth we could measure different rotational velocities of the galaxies as they actually are, seems wrong: "The motivation to proposing that fictitious forces may arise relative to the observational frame of a galaxy originates in one basic argument: the observational frame (K') could not be treated with certainty as inertial from the first place. This assumption was not tested and was taken as "ground truth" mostly due to its implicit nature. Testing such an assumption may require a model that takes into account the various possible phenomena (in different scales) that affect the determination of a local inertial frame. In this work we have demonstrated that a single degree of freedom is sufficient in order to represent the possible relative motion between the observational frame (K') and the local inertial frame (K) of a given disk galaxy. Relying on this degree of freedom, we have demonstrated that the additional gravitational field in K', due to fictitious forces, closely resembles the gravitational field of a dark halo. Additionally, a model that predicts the (non-inertial) rotational velocities in K' was developed. Applying the new model to a wide sample of RCs produced very accurate results" [14].

When a given stellar object is rotating, it interacts with the SQS energy. One of the results of this interaction is the so-called "frame-dragging effect", also known as "Lense–Thirring effect". Rotation of the stellar object also rotates SQS, which is its actual kinetic rotational energy. Kinetic energy of a moving or rotating physical object is the energy of SQS that is involved. By high-speed rotating SMBH this kinetic energy becomes huge and additionally decrease energy density of SQS in the centre of SMBH which results in stronger gravity.

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 [13]. 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. All relativistic effects on the universal macrolevel are observer-invariant and have physical origin in the variable energy density of the superfluid quantum space [15]. The curvature of the space model of GR applied inside black holes has led to the wrong conclusion of infinite gravity force in the centre of black holes [16]. This model was never experimentally proved and is not confirmed by astronomical observations. For the interior of black holes, Newton's shell theorem is valid. There is no objection against it. In the centre of the black holes, the energy density of SQS is so low that atoms become unstable. They transform back into elementary particles that form in SMBH huge jets [2]. Recent research that studied the distribution and morphologies of Fornax Cluster dwarf galaxies suggest dark matter does not exist [17]. It would be opportune to calculate the effects of the relativistic masses of rotating SMBHs in the Fornax group on the gravity force of the group, as suggested in this paper.

5. Conclusions

The angular velocity and relativistic mass of SMBHs are observer-invariant and are the result of the pure technicality of the SMBH interaction with the superfluid quantum space. Relativistic mass additionally diminishes SQS, which results in stronger gravity, which is the partial answer to dark matter.

References

[1] Amrit Sorli, Stefan Celan, Niko Gorjup, Superfluid quantum space, Einstein's principle of equivalence, and Bohr's complementary principle, *Advanced Studies in Theoretical Physics*, **16** (2022), no. 3, 115-120. https://doi.org/10.12988/astp.2022.91847

[2] Amrit S. Sorli, Stefan Celan, Niko Gorjup, Physical Aspects of Penrose's Black Hole Singularities, *Advanced Studies in Theoretical Physics*, **16** (2022), no. 4, 191-200. https://doi.org/10.12988/astp.2022.91893

[3] Miller Jones J. et al., Cygnus X-1 contains a 21–solar mass black hole—Implications for massive star winds, *Science*, **371**, Issue 6533. https://www.science.org/doi/10.1126/science.abb3363

[4] Black hole Encyclopaedia http://blackholes.stardate.org/objects/factsheet-Cygnus-X-1.html (2021).

[5] Pavel E. Mancera Piña et al. Off the Baryonic Tully–Fisher Relation: A Population of Baryon-dominated Ultra-diffuse Galaxies, *ApJL*, **883** (2019), L33. https://doi.org/10.3847/2041-8213/ab40c7

[5] van den Bergh, S. Galaxy haloes and the missing mass problem, Structure and properties of nearby galaxies; Proceedings of the Symposium, Bad Muenstereifel, West Germany, August 22-26, 1977. (A79-13481 03-90) Dordrecht, D. Reidel Publishing Co., 1978, p. 247-263; Discussion, p. 263-265. https://articles.adsabs.harvard.edu/full/1978IAUS...77..247V

[6] Wall M., This Huge Black Hole Is Spinning at Half the Speed of Light! (2019) https://www.space.com/42953-black-hole-spins-at-half-light-speed.html

[7] Grant A., Shredded star yields estimate of a black hole's spin, https://physicstoday.scitation.org/do/10.1063/pt.6.1.20190111a/full/

[8] Jeffrey E., et al., "The Spin of the Near-Extreme Kerr Black Hole GRS 1915+105", *ApJ*. **652** (1) (2006), 518–539. (2006). https://doi.org/10.1086/508457

[9] Nilsen J. et al., The physics of the "heartbeat" state of GRS 1915+105, *ApJ*, **737** (69) (2011). https://iopscience.iop.org/article/10.1088/0004-637X/737/2/69

[10] Hurley D.J., et al., The mass of the black hole in GRS 1915+105: new constraints from infrared spectroscopy, *Monthly Notices of the Royal Astronomical Society*, **430** (2013), Issue 3, 1832-1838. https://doi.org/10.1093/mnras/stt001

[11] Krolik J. et al. ASASSN-14li: A model tidal disruption event, *ApJ*, **827** (2016), 127. https://iopscience.iop.org/article/10.3847/0004-637X/827/2/127/pdf

[12] Amrit Sorli, Stefan Celan, Niko Gorjup, Physical origin of the relative rate of clocks in GPS and errors of relative motion concept, *Advanced Studies in Theoretical Physics*, **16** (2022), no. 4, 191-200. https://doi.org/10.12988/astp.2022.91893

[13] Roy Gomel, Tomer Zimmerman, The Effects of Inertial Forces on the Dynamics of Disk Galaxies , *Galaxies*, **9** (2) (2021), 34. https://doi.org/10.3390/galaxies9020034

[14] Šorli A., Čelan Š., Advances of Relativity Theory, *Physics Essays*, **34,** 2 (2021). https://doi.org/10.4006/0836-1398-34.2.201

[15] Penrose, R., Gravitational Collapse and Space-Time Singularities, *Phys. Rev. Lett.*, **14** (1965), 57. https://doi.org/10.1103/PhysRevLett.14.57

[16] Elena Asencio, Indranil Banik, Steffen Mieske, Aku Venhola, Pavel Kroupa, Hongsheng Zhao, The distribution and morphologies of Fornax Cluster dwarf galaxies suggest they lack dark matter, *Monthly Notices of the Royal Astronomical Society*, **515** (2022), Issue 2, 2981-3013. https://doi.org/10.1093/mnras/stac1765

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