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On the Possibility of Gravity Control by Magnetic Field

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Abstract: This short paper describes the spatial curvature generation by magnetic field.
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Relationship between the Essence of Gravity and Magnetic Field

As is well known in General Relativity, gravity is generated by a curved space. The curvature of space and the size of curved space region determine the gravitational acceleration. Curvature of space is formed in a concentric sphere state around the celestial body by the mass of celestial body like the Earth.

Minami derived the equation of curvature of space induced by magnetic field in 1988 [1]. It was found that this equation was accordance with the equation that Levi-Civita considered (i.e., the static magnetic field creates scalar curvature) by Minami in 1995[2].

$$R^{00} = \frac{4\pi G}{\mu_0 c^4} B^2 = 8.2\times 10^{-38} B^2$$

where $\mu_0 = 4\pi \times 10^{-7} (H/m)$,
$c = 3\times 10^8 (m/s)$,
$G = 6.672\times 10^{-11} (N \cdot m^2 / kg^2)$,
B is a magnetic field with Tesla and
R^{00} is a major component of spatial curvature ($1/m^2$).

The major component of curvature of space R^{00} can be produced by not only mass density but also magnetic field *B* (see APPENDIX A: Curvature Control by Magnetic Field). Above equation indicates that the major component of spatial curvature can be controlled by magnetic field.

The curvature of flat space R^{00} is zero (strictly speaking, only 20 independent components of Riemann curvature tensor R_{pijk} are zero), then the gravitational acceleration becomes zero. A curved space is generated not only by mass density but also by magnetic field or electric field. In case that the intensities of the magnetic field B and the electric field E are equal, the value of $(1/2 \cdot \varepsilon_0 E^2)$ is about seventeen figures smaller than the value of $(B^2 / 2\mu_0)$. As a consequence, the electric field only negligibly contributes to the spatial curvature as compared with the magnetic field. Accordingly, it is effective that the space can be curved by magnetic field. Since the region of curved space produces the field of acceleration, the massive body existing in this acceleration field (i.e. curved space region) is moved in accordance with Newton's second law.

Ultimately, it can be said that the magnetic field can be made equivalent to the gravitational field by the action of curving the space [3-6].

APPENDIX A: Curvature Control by Magnetic Field

Let us consider the electromagnetic energy tensor M^{ij}. In this case, the solution of metric tensor g_{ij} is found by

$$R^{ij} - \frac{1}{2} \cdot g^{ij} R = -\frac{8\pi G}{c^4} \cdot M^{ij} \tag{A.1}$$

Eq. (A.1) determines the structure of space due to the electromagnetic energy.

Here, if we multiply both sides of Eq.(A.1) by g_{ij}, we obtain

$$g_{ij}\left(R^{ij}-\frac{1}{2}\cdot g^{ij}R\right)=g_{ij}R^{ij}-\frac{1}{2}\cdot g_{ij}g^{ij}R=R-\frac{1}{2}\cdot 4R=-R \tag{A.2}$$

$$g_{ij}\left(\frac{-8\pi G}{c^4}\cdot M^{ij}\right)=-\frac{8\pi G}{c^4}\cdot g_{ij}M^{ij}=\frac{-8\pi G}{c^4}\cdot M_i^i=\frac{-8\pi G}{c^4}M \tag{A.3}$$

The following equation is derived from Eqs.(A.2) and (A.3)

$$R=\frac{8\pi G}{c^4}\cdot M\ . \tag{A.4}$$

Substituting Eq.(A.4) into Eq.(A.1), we obtain

$$R^{ij}=-\frac{8\pi G}{c^4}\cdot M^{ij}+\frac{1}{2}\cdot g^{ij}R=-\frac{8\pi G}{c^4}\cdot\left(M^{ij}-\frac{1}{2}\cdot g^{ij}M\right) \tag{A.5}$$

Using antisymmetric tensor f_{ij} which denotes the magnitude of electromagnetic field, the electromagnetic energy tensor M^{ij} is represented as follows;

$$M^{ij}=-\frac{1}{\mu_0}\cdot\left(f^{i\rho}f_{\rho}^{\ j}-\frac{1}{4}\cdot g^{ij}f^{\alpha\beta}f_{\alpha\beta}\right),\qquad f^{i\rho}=g^{i\alpha}g^{\rho\beta}f_{\alpha\beta} \tag{A.6}$$

Therefore, for M, we have

$$\begin{aligned} M&=M_i^i=g_{ij}M^{ij}=-\frac{1}{\mu_0}\cdot\left(g_{ij}f^{i\rho}f_{\rho}^{\ j}-\frac{1}{4}\cdot g_{ij}g^{ij}f^{\alpha\beta}f_{\alpha\beta}\right)\\ &=-\frac{1}{\mu_0}\cdot\left(f^{i\rho}f_{i\rho}-\frac{1}{4}\cdot 4f^{\alpha\beta}f_{\alpha\beta}\right)=-\frac{1}{\mu_0}\cdot\left(f^{i\rho}f_{i\rho}-f^{i\rho}f_{i\rho}\right)=0\end{aligned} \tag{A.7}$$

Accordingly, substituting $M=0$ into Eq.(A.5), we get

$$R^{ij}=-\frac{8\pi G}{c^4}\cdot M^{ij} \tag{A.8}$$

Although Ricci tensor R^{ij} has 10 independent components, the major component is the case of $i=j=0$, i.e., R^{00}. Therefore, Eq. (A.8) becomes

$$R^{00}=-\frac{8\pi G}{c^4}\cdot M^{00}\ . \tag{A.9}$$

On the other hand, 6 components of antisymmetric tensor $f_{ij}=-f_{ji}$ are given by electric field E and magnetic field B from the relation to Maxwell's field equations

$$\begin{aligned} &f_{10}=-f_{01}=\frac{1}{c}\cdot E_x,\ f_{20}=-f_{02}=\frac{1}{c}\cdot E_y,\ f_{30}=-f_{03}=\frac{1}{c}E_z\\ &f_{12}=-f_{21}=B_z,\ f_{23}=-f_{32}=B_x,\ f_{31}=-f_{13}=B_y\\ &f_{00}=f_{11}=f_{22}=f_{33}=0\end{aligned} \tag{A.10}$$

Substituting Eq.(A.10) into Eq.(A.6), we get

$$M^{00} = -\left(\frac{1}{2}\cdot\varepsilon_0 E^2 + \frac{1}{2\mu_0}\cdot B^2\right) \approx -\frac{1}{2\mu_0}\cdot B^2 \tag{A.11}$$

Finally, from Eqs.(A.9) and (A.11), we obtain

$$R^{00} = \frac{4\pi G}{\mu_0 c^4}\cdot B^2 = 8.2\times 10^{-38}\cdot B^2 \quad (B\ in\ Tesla) \tag{A.12}$$

Where $\mu_0 = 4\pi\times 10^{-7}(H/m)$, $\varepsilon_0 = 1/(36\pi)\times 10^{-9}(F/m)$, $c = 3\times 10^8(m/s)$, $G = 6.672\times 10^{-11}(N\cdot m^2/kg^2)$, B is a magnetic field in Tesla and R^{00} is a major component of spatial curvature $(1/m^2)$.

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