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BACKGROUNDS CONSTRAIN ON THE TORSION DETECTION[1]

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Abstract

Two kinds of sources of torsion are discussed, which are macroscopic rotation and aligned spin respectively. In the case of Dirac spin partical as a direct sensor for torsion, the detection of torsion-spin effect is constrained by the larger backgrounds strongly, which are magnetic-spin and rotation-spin. Increasing the source of the torsion is equaivalent to increasing the background itself. So, the new discovered conclusion on torsion gravity is that any Dirac particle experiments have no hope to give the evidence for torsion directly, which rules out many hopeful suggestions on the torsion detection. The promised indirect evidence for torsion, proposed recently, is reviewed.

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1 The motivation for the Torsion Gravity

The torsion, as an extention of Riemann spacetime geometry, was first introduced by Einstein and Cartan in 1920's, and the original attemption to unify gravity with electromagnetism was failed. Until 1960's, Sciama and Kibble constructed the ECSK theory into a gauge theory of gravitation in U4. The complete theoretical constructure of the torsion gravity has been worked out by Hehl et al [1,2], ie., MAG(Metric-Affine Gravity) in Riemannian-Cartan spacetime. On the link between ECSK and MAG, one can see [2].

At the macroscopic level, GR is the simplicity theory of gravity which is well tested with all the presentday experimental data. Why should we try to formulate a generalized version of this theory? The reasons are of theoretical character. At a macroscopic level, matter is characterized by a mass and a spin. From the point of view that both energy-momentum density and spin density define the spacetime structure, then, an independent spin concept requires a U4 with nonvanishing torsion [2]. On the other hand, gauge theory has been successfully renormalized, and U4 gravity can be obtained by a certain type of gauging. Moreover, MAG contains more field equations than GR does, which may propose freedoms for quantization.

On the macroscopic average, all kinds of torsion gravity take GR as their "classical limit", but, this does not imply that macroscopic gravity is necestions now arise. In what extend does torsion fravity modify the GR? In what circumstances can we give the evidence for torsion? Where can we find it?

2 The Sources of the Torsion and Its Background

To appreciate the source of the torsion, it is necessary to inspect the field equation in U_4 spacetime, which is obatined by the variation of the total Lagrangian L,

$$L = \frac{1}{2k'} L_G + L_M \tag{1}$$

where $k' = 8\pi G'/c^4$, $G' > G$ is determined by experiment [3], the matter Lagrangian L_M contains matter field and gravitational field, which is same,

although in different form, for the alternative torsion theory generally

$$L_M = L_M(\psi, \partial\psi, g, \partial g, Q) \tag{2}$$

where ψ, g, Q represent matter field, metric and torsion tensor respectively. L_G is the gravitational Lagrangian, different for various torsion theory. But the general form of L_G, including the quadratic terms in torsion, is given [4].

In the original ECSK version, the main character of equation is defined by L_m. There exists only a contact torsion-spin interaction determined by the algebraic equation of the torsion, so that no propagation of torsion is allowed and torsion can be nonzero only inside matter with aligned intrinsic spin [1,2]. Only in this special case or revised version, one can conclude an incomplete principle that "the only source of the torsion is intrinsic fundamental particle spin"[3].

The interaction energy between a spin and the aligned torsion Q will be [3,5]

$$E = -\vec{S} \cdot \vec{Q} \tag{3}$$

$$Q = (8\pi G/c^2) n (\hbar/2)(G'/G) \tag{4}$$

where n is the number density of the aligned spin. In fact, the conclusion of ECSK presents the pure character of the matter Lagrangian in some sense, on account of the simple gravitational Lagrangian used like GR. or,

$$E = -(2\pi G/c^2) n \hbar^2 (G'/G) \tag{5}$$

in the very ideal case, the completely polarized neutron star $n = 10^{45} m^{-3}$, the upper limit of G', according to [6], $G' = 10^{14} G$, the coupling energy $E \sim 10^{-24}(J)$, the corresponding line splitting $\Delta\nu \sim 1(Hz)$, a hopful result. However. the most disappointing thing is as follows. The polarized spins is not only the source of the torsion, but it is also the source of the amagnetic field on account of the anomalous magnetic moment of spin. The coupling energy between a magneton and the magnetic field is,

$$Em = -\vec{u} \cdot \vec{B} \tag{6}$$

where $B = \mu_0 u n$, $u = e\hbar/2m$ is the magnetic moment, $\mu_0 = 4\pi \times 10^{-7}(H/m)$, the ration between torsion-spin energy and magnetic-spin energy is

$$\begin{aligned} E/Em &= (8\pi G/c^2)(m/e)^2(1/\mu_0)\ (G'/G) \\ &= 10^{-36}(G'/G) \quad \text{for the neutron} \end{aligned} \tag{7}$$

from (8), we are forced to conclude that too small value of E/Em will lead to no observable consequence for the neutron star physics when the upper limit of G' is taken into account.

However, in MAG with quadratic gravitational Lagrangian, we can find that the rotating body will also be one of the soources of the torsion. In the special case, Weitzenbock spacetime [7], Nitsch [8] gives for the first time that the axial torsion occurs in the fifth order in (v/c), which represents a measure for the deviation from spherical symmetry. The absolute value of the axial torsion on the star is roughly

$$Q(R) = (Rs/R)^2 \Omega \tag{8}$$

where $Rs = 2GM/c^2$ is the Schwarzshild radius. R, Ω are the radius and the angular velocity of the star respectively.

On the surface of the earth, $Q(R) = 10^{-24} s^{-1}$ is hopelessly beyond present-day experimental detectability. For the general pulsar (rotating neutron star), $\Omega \sim 10^3 s^{-1}, Q(R) \sim 10 s^{-1}$, the axial torsion-spin energy $E' = Q(R) \cdot (\hbar/2) \sim 10^{-25}(J)$. Although it is a perspective result for the emission spectra of electron, despite the magnetic field, however, the rotation-spin energy makes it impossible to detect such an effect directly. Recently, Mashhoon, Hehl and Ni[9], in different manner, all have given the existence of an effect asssociated with the coupling of Dirac spin with rotation, and given by the Hamiltanian

$$H = -\gamma \vec{\Omega} \cdot \vec{s} \tag{9}$$

where $\gamma = (1 - \beta^2)^{-\frac{1}{2}}$ and $\beta = R\Omega/c$, $\gamma \sim 1$ here. The absolute ratio between the axial torsion-spin energy and rotation-spin energy is

$$E'/H = (R/R)^2 < 1 \tag{10}$$

Moreover, the effect of the star's rotation on the Dirac spin is $(Rs/R)\Omega$, equivalent to that of the additional rotation of the local frame with an angular velocity [10], which is also larger than that of the axial torsion-spin.

By seeing the analysis above, two kinds of sources of torsion are taken into account. One is originated from the aligned spin obtained by matter Lagrangian directly, the other is originated from the rotated star obtained by the quadratic gravitational Lagrangian. Unfortunately, the two kind sources of

the torsion are also the sources of the strong backgrounds, which are magnetic-spin and rotation-spin respectively.

Increasing the source of the torsion is equivalent to increasing the backgrounds, which makes the torsion detection into a desperate situation.

We are forced to get an important principle on the torsion detection physics that, "not only the small value of the torsion, but the unavoided backgrounds of the torsion make it impossible to detect torsion directly, in the case of Dirac particle as a sensor of torsion".

3 Is There Evidence for Torsion?

On account of the influence of the backgrounds, we can not find the evidence for torsion by observing the splitting of electron spectra . However, an interesting indirect evidence for torsion has been declared recently [11]. It is simply described as follows.

In the case of the net polarized neutron magnetic field of pulsar, the neutron spin precession arised from torsion-spin, rotation-spin and magnetic-spin will influence on the orientation of the magnetic field of pulsar, which makes the direction of magnetic field close to the rotation axis of pulsar step by step. The theoretical evolution, which conclude: most pulsars have smaller inclination at the age of $10^6 - 10^7\ yr$, the inclination of magnetic field decrease with increasing the age of pulsar. This conclusion fits for the astronomical observational distribution and the theoretical statistics of pulsar. The theoretical model on the evolution of magnetic field of pulsar has not been solved in astrophysics since 1970's [12]. Does torsion effect provide the only one possibility for solving the evolution of the magnetic field of pulsar?

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