

## Teleparallel versions of Friedmann and Lewis-Papapetrou spacetimes

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Some minor errors have been observed which led to a change in the final result. Correcting these errors simplifies the results.

Recently, we have investigated [1] the teleparallel versions of the Friedmann models as well as the Lewis-Papapetrou solution. The tetrad and the torsion fields are obtained for both spacetimes. The tensor part of the torsion tensor of the Weitzenböck connection is given by

$$t_{\lambda\mu\nu} = \frac{1}{2}(T_{\lambda\mu\nu} + T_{\mu\lambda\nu}) + \frac{1}{6}(g_{\nu\lambda}V_{\mu} + g_{\nu\mu}V_{\lambda}) - \frac{1}{3}g_{\lambda\mu}V_{\nu}, \quad (1)$$

where  $\lambda, \mu, \nu = 0, 1, 2, 3$ . When we take the variations of the indices of  $t_{\lambda\mu\nu}$  in Eq. (1), there occurred some errors which affect the tensor part. If we correct these errors, the non-zero components of the tensor part, for the Friedmann models, will change to

$$t_{010} = \frac{1}{3f_{\kappa}(\chi)}\{1 - f'_{\kappa}(\chi)\} = t_{100}, \quad (2)$$

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$$t_{001} = -2t_{010}, \quad (3)$$

$$t_{212} = \frac{1}{6}a^2 f_k(\chi)\{1 - f'_k(\chi)\} = t_{122}, \quad (4)$$

$$t_{221} = -2t_{212}, \quad (5)$$

$$t_{313} = \frac{1}{6}a^2 f_k(\chi)\{1 - f'_k(\chi)\} \sin^2 \theta = t_{133}, \quad (6)$$

$$t_{331} = -2t_{313}, \quad (7)$$

instead of those given by Eqs. (32)–(39) in [1].

Also, an error of minus sign has been found in Eq. (48) which affects the rest of the part. Inserting this minus sign, the corrected version of Eq. (48) is given by

$$A^{(1)} = \frac{1}{3h}\{g_{00}T^0_{32} + g_{02}(T^2_{32} - T^0_{30})\}, \quad (8)$$

where  $h = \sqrt{-g} = \rho e^{(\gamma-\psi)}$ . When we use this corrected form, the axial-vector becomes

$$\mathbf{A} = \frac{-1}{3\rho} e^{3\psi-\gamma} (\omega' \hat{e}_\rho + \dot{\omega} \hat{e}_z) \quad (9)$$

instead of Eq. (51) in [1]. This shows that when  $\omega$  is a function only of  $z$ , the axial-vector will stand along the radial direction, i.e.,

$$\mathbf{A} = \frac{-1}{3\rho} e^{3\psi-\gamma} (\omega' \hat{e}_\rho). \quad (10)$$

If  $\omega$  is a function of  $\rho$  only then it is given by

$$\mathbf{A} = \frac{-1}{3\rho} e^{3\psi-\gamma} (\dot{\omega} \hat{e}_z), \quad (11)$$

i.e., the axial vector will lie along  $z$ -direction. For  $\omega$  to be constant, the axial-vector vanishes identically, i.e.,

$$\mathbf{A} = 0. \quad (12)$$

The spin precession of the Dirac particle in torsion gravity will also be simplified to

$$\frac{d\mathbf{S}}{dt} = \frac{1}{2\rho} e^{3\psi-\gamma} (\omega' \hat{e}_\rho + \dot{\omega} \hat{e}_z) \times \mathbf{S} \quad (13)$$

and the corresponding extra Hamiltonian will be

$$\delta H = \frac{1}{2\rho} e^{3\psi-\gamma} (\omega' \hat{e}_\rho + \dot{\omega} \hat{e}_z) \cdot \sigma. \quad (14)$$

## Reference

1. Sharif, M., Jamil Amir, M.: Gen. Rel. Grav. **38**, 1735 (2006)