

**Relativity in the problems of astronomical
reference systems and Earth rotation:
status and prospects**

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Relativistic astronomical reference systems

- **problems with the asymptotic regime**
- **problems with Earthbound observer**

Relativity and the problem of Earth rotation

Basis: Einstein's theory of gravity (GRT)

EXACT THEORY:

- uniformly rotating ($\Omega = \Omega \mathbf{e}_z$) axisymmetric body can be treated; the scalar quantities S , Ω and I (spin, angular-velocity and principle moment of inertia) are well-defined (e.g., Komar 1959)
- to first order in Ω , 'rigid bodies' can be defined and one finds a 'Newtonian-like' Euler-theory apart from

$$M_{ab} \neq - \text{STF}(I_{ab})$$

M: mass-quadrupole tensor; I: moment of inertia tensor

In the post-Newtonian approximation:

- PN spin vector for isolated system (e.g., Fock 1959)
- PN spin vector & expression for torque in the gravitational N-body problem (DSX 1993)
- PN Tisserand-axes, Ω , and moment of inertia tensor (Klioner 1996)
- **Newtonian** nutation theory with PN torque for $\Delta\varepsilon$, $\Delta\psi$ (Bizouard et al., 1992)

Fock, V., 1959, Theory of space, time and gravitation, Pergamon; Damour, T., Soffel, M., Xu, C., 1993, Phys.Rev. D47, 3124, Klioner, S., 1996, in: Ferraz-Mello, S. et al., (eds.) Dynamics, Ephemerides and Astrometry of the Solar System, IAU; Bizouard, C. et al., 1992, in: Les Journées 1992, N.Capitaine (ed.)

Largest terms in that ,Newtonian+PN-torque‘ approach:

$$\Delta\Psi = 3 \times 10^{**(-7)} \sin \Omega \qquad \Delta\varepsilon = 4 \times 10^{**(-7)} \cos \Omega$$

PN generalization of the Newtonian Euler theory
for a rigid Earth: the rigid multipole moment formalism
(Klioner et al., 2001)

The PN moment of inertia tensor and all mass-multipole
moments rotate rigidly, i.e.,

Local theory working with a displacement field

has been pursued by Xu, Wu, Soffel and Klioner

1. fundamental paper on elastic deformable astronomical bodies in PN approximation using a formalism by Carter & Quintana (1972;1973), Cartesian coordinates

Xu,C., Wu,X., Soffel, M., 2001, Phys.Rev. D 63, 043002

2. Extension to spherical coordinates; junction conditions for surface and internal layers

Xu,C., Wu,X., Soffel, M., Klioner, S., 2003, Phys.Rev. D 68, 064009

3. Expansion of relevant equations in terms of generalized spherical harmonics (scalar-, vector-, tensor spherical harmonics); first for non-rotating ground state

Wu,X., Xu,C., Soffel, M., 2004, in preparation

Problems with that approach, work to be done:

- expansion in terms of generalized spherical harmonics for rotating ground state; possibly only for the largest PN-terms
- estimation of orders of magnitude for the real Earth; identification and understanding of certain PN-terms
- relation with observables or Earth-rotation-parameters is unclear
- the use of that formalism in the frame of a perturbative approach (classically: rigid body + transfer functions) is unclear