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From Gravitostatics to Gravitodynamics: The space-time dependent gravity field by Eulerian versus Lagrangean force fields: Examples

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The Cartesian moments of the mass density of a gravitating body and the spherical/ellipsoidal harmonic coefficients of its gravitational field are dependent in a peculiar way. In particular, the products of inertia can be expressed by the spherical/ellipsoidal harmonic coefficients of the gravitational potential as derived by Mac Cullagh formulae for a rigid body. Here, the Mac Cullagh formulae are extended to a deformable body, which is restricted by radial symmetry in order to apply the Love-Shida hypothesis and its ellipsoidal extension. The mass conservation law allows a representation of the incremental mass density by respective excitation functions. A representation of an arbitrary Caresian monome is always possible by sums of solid spherical/ellipsoidal harmonics multiplied by powers of the radius or its ellipsoidal analogue. Introducing these representations into the definitions of the Cartesian moments, an extension of the Mac Cullagh formulae is obtained. In particular, for excitation functions with a vanishing harmonic coefficient of degree zero, the diagonal incremental moments of inertia can be expressed by excitation coefficients. Four types of excitation functions are considered: (i) tidal excitation, (ii) loading potential, (iii) centrifugal potential, and (iv) transverse surface stress. One application of the results could be a model computation of the lenght-of-day variations and polar motion, which depend on the moments of inertia.