General relativistic elastic body, fluid, quasi-rigid body, quasi-liquid and others

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As we know the ideas on the elastic body, fluid, rigid body and liquid in the frame work of Newtonian physics are very useful even up to now for the understanding and calculating some practical problems. Although the general relativistic theory of elastic body, general relativistic hydrodynamics and post-Newtonian quasi-rigid body have been discussed by several authors (including our papers (PRD63, 043002(2001); D63,064001(2001);D68,064009(2003); D69, 024003(2004); D71,024030 (2005))), but there is no a complete discussion on all of these ideas to appear. As for the relativistic liquid the consideration is even less. The application of these ideas in the general relativity are important in the research field of astrophysics and geophysics, especially in case the post-Newtonian calculation have to be taken into account. The extended relativistic versions of these ideas can be revised the Newtonian results and also taken as the zero-order approximation in some calculation. In this paper, we shall give a complete discussion on all of these ideas in the first post-Newtonian (1 PN) approximation. We shall clarify the ideas on perfect elastic material, quasi-rigid body, quasi-liquid and so on with some precise mathematical forms. We shall also point out the meaning of the extended relativistic versions of these ideas and why we cannot use the relativistic version totally the same as in Newtonian case. For fluid we show the hydrodynamic equations of a non-perfect fluid in multiple coordinates systems (both local and global). In fact some calculation have to be done only in the local coordinate system. Some interior relations of these ideas are also considered.