General Relativity and Quantum Cosmology

A new approach for doing theoretical and numeric work with Lemaitre-Tolman-Bondi dust models

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We introduce quasi-local integral scalar variables for the study of spherically symmetric Lemaitre-Tolman-Bondi (LTB) dust models. Besides providing a covariant, and theoretically appealing, interpretation for the parameters of these models, these variables allow us to study their dynamics (in their full generality) by means of fluid flow evolution equations that can be handled with simple numerical techniques and has a significant potential for astrophysical and cosmological applications. These evolution equations can also be understood in the framework of a gauge invariant and covariant formalism of spherical non-linear perturbations on a FLRW background. The covariant time splitting associated with the new variables leads, in a natural way, to rephrase the known analytic solutions within an initial value framework in which covariant scalars are given by simple scaling laws. By using this re-parametrization of the analytic solutions, we re-examine and provide an alternative outlook to various theoretical issues already treated in the literature: regularity conditions, an Omega parameter, as well as the fitting of a given LTB model to radial profiles of density or velocity at different cosmic times. Other theoretical issues and numeric applications will be examined in separate articles.

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