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Newton gauge cosmological perturbations for static spherically symmetric modifications of the de Sitter metric

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Static coordinates can be convenient to solve the vacuum Einstein's equations in presence of spherical symmetry, but for cosmological applications comoving coordinates are more suitable to describe an expanding Universe, especially in the framework of cosmological perturbation theory (CPT).
Using CPT we develop a method to transform static spherically symmetric (SSS) modifications of the de Sitter solution from static coordinates to the Newton gauge.

We test the method with the Schwarzschild de Sitter (SDS) metric and then derive general expressions for the Bardeen's potentials for a class of SSS metrics obtained by adding to the de Sitter metric a term linear in the mass and proportional to a general function of the radius. Using the gauge invariance of the Bardeen's potentials we then obtain a gauge invariant definition of the turn around radius.

We apply the method to an SSS solution of the Brans-Dicke theory, confirming the results obtained independently by solving the perturbation equations in the Newton gauge. The Bardeen's potentials are then derived for new SSS metrics involving logarithmic, power law and exponential modifications of the de Sitter metric. We also apply the method to SSS metrics which give flat rotation curves, computing the radial energy density profile in comoving coordinates in presence of a cosmological constant.

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