High Energy Physics - Theory

Singularities in Horava-Lifshitz theory

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Singularities in $(3+1)$-dimensional Horava-Lifshitz (HL) theory of gravity are studied. These singularities can be divided into scalar, non-scalar curvature, and coordinate singularities. Because of the foliation-preserving diffeomorphisms of the theory, the number of scalars that can be constructed from the extrinsic curvature tensor K_{ij}, the 3-dimensional Riemann tensor and their derivatives is much large than that constructed from the 4-dimesnional Riemann tensor and its derivatives in general relativity (GR). As a result, even for the same spacetime, it may be singular in the HL theory but not in GR. Two representative families of solutions with projectability condition are studied, one is the (anti-) de Sitter Schwarzschild solutions, and the other is the Lu-Mei-Pope (LMP) solutions written in a form satisfying the projectability condition - the generalized LMP solutions. The (anti-) de Sitter Schwarzschild solutions are vacuum solutions of both HL theory and GR, while the LMP solutions with projectability condition satisfy the HL equations coupled with an anisotropic fluid with heat flow. It is found that the scalars K and $K_{ij}K^{ij}$ are singular only at the center for the de Sitter Schwarzschild solution, but singular at both the center and $ r = (3M/|\Lambda|)^{1/3}$ for the anti-de Sitter Schwarzschild solution. The singularity at $ r = (3M/|\Lambda|)^{1/3}$ is absent in GR. In addition, all the generalized LMP solutions have two scalar curvature singularities, located at either $r = 0$ and $r=r_{s} > 0$, or $r=r_{1}$ and $r= r_{2}$ with $r_{2} > r_{1} > 0$, or $r=r_{s} > 0$ and $r = \infty$, depending on the choice of the free parameter λ.

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