General Relativity and Quantum Cosmology

Black hole perturbation in parity violating gravitational theories

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We study linear perturbations around the static and spherically symmetric spacetime for the gravitational theories whose Lagrangian depends on Ricci scalar and the parity violating Chern-Simons term. By an explicit construction, we show that Hamiltonian for the perturbation variables is not bounded from below in general, suggesting that such a background spacetime is unstable against perturbations. This gives a strong limit on a phenomenological gravitational model which violates parity. We also provide a necessary and sufficient condition for the theory to belong to a special class in which no such instability occurs. For such theories, the number of propagating modes for $\ell \ge 2$ is three, one from the odd and the other two from the even. Unlike in the case of $f(R)$ theories, those modes are coupled each other, which can be used as a distinctive feature to test the parity violating theories from observations. All the modes propagate at the speed of light. No-ghost condition and no-tachyon condition are the same as those in $f(R)$ theories. For the dipole perturbations, the odd and the even modes completely decouple. The odd mode gives a slowly-rotating BH solution whose metric is linearized in its angular momentum. We provide an integral expression of such a solution. On the other hand, the even mode propagates at the speed of light. For the monopole perturbation, in addition to a mode which just shifts the mass of the background BH, there is also one even mode that propagates at the speed of light.

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