

Perturbative S-matrix unitarity ($S^\dagger S = 1$) in R^2 gravity

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We investigate the relation perturbative unitarity and renormalizability in quantum gravity. In particle theories point of view, Llewellyn Smith conjectured that renormalizability and tree-unitarity at high energy give the same conditions for theories. If we apply this conjecture to gravity theory, it is shown that Einstein gravity is not renormalizable and does not hold perturbative unitarity at high energy. One candidate of quantum gravity, the quadratic gravity ($R_{\mu\nu}^2$ gravity or higher derivative gravity), is a renormalizable theory, but it contains negative norm states and hence does not satisfy tree-unitarity. This gives that the quadratic gravity is one of a counterexample of Llewellyn Smith's conjecture. In this talk, I introduce that Llewellyn Smith's conjecture and our contribution. Especially, we show that in a higher derivative theory, the unitarity bound at tree level (tree unitarity) is violated but S -matrix unitarity ($S^\dagger S = 1$ or often called pseudo-unitarity) is satisfied. The point is our new conjecture that renormalizability and S -matrix unitarity at high energy give the same conditions for theories.

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