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Perturbative unitarity bounds from entanglement

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When is it necessary to compute loop corrections in cosmology, or to introduce new physics in a theory? For which values of the parameters does perturbation theory break down? In particle physics, sharp bounds for the validity of the perturbative expansion are given by partial wave unitarity. Unfortunately these bounds don't extend to curved spacetime where scattering experiments are difficult or impossible to define. In this talk we propose to use the growth of entanglement as a breakdown diagnostic for perturbation theory in general field theories. This diagnostic can be readily used in cosmological spacetimes and does not require taking any flat spacetime limit. More in detail, given an EFT we trace out all Fourier modes but a single one. Then, we develop a diagrammatic technique to compute the so-called purity of the resulting density matrix in perturbation theory. Bounds on the coupling constants are then derived when the perturbative purity violates its unitarity constraints. We study these bounds on flat spacetime, where we compare them to those from partial waves showing that purity bounds can be sometimes weaker, but other times they exist when no partial wave bounds exist. We also study them in de Sitter for a variety of interactions that appear in inflationary models, and show that the breakdown of perturbation theory is parametrically different from flat space for operators of large dimension.

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