GR 22 Abstract

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Abstract

We investigate the relationship between the memory effect, asymptotic symmetries and infrared divergences in $d \geq 4$ dimensions. To this end we first investigate the asymptotic behavior of asymptotically flat solutions that admit a suitable expansion in powers of $1/r$ in full, nonlinear General Relativity. We show that he harmonic gauge condition can be imposed for $d > 4$ but cannot be imposed for $d = 4$ if there either is a flux of stress-energy at null infinity or if the Bondi news is nonvanishing. We explicitly obtain the recursion relations on the coefficients of the $1/r$ expansion implied by the wave equation as well as the "constraints" arising from the harmonic gauge. condition. We also characterize the "free data" needed to determine a solution. We then investigate the memory effect in full nonlinear General Relativity. We show that the memory effect is nonvanishing at Coulombic order in even dimensions and naturally splits into "ordinary memory" and "null memory". Null memory is associated with an energy flux to null infinity. We show that ordinary memory is associated with the metric failing to be stationary at one order faster fall-off than Coulombic in the past and/or future, as is the case for matter on inertial, timelike trajectories. In odd dimensions we show that the memory effect vanishes. The null memory is always of "scalar type" with regard to its behavior on spheres, but the ordinary memory can be of any (i.e., scalar, vector, or tensor) type. Scalar memory is described by a diffeomorphism, which is an asymptotic symmetry (a supertranslation) in $d = 4$ and a gauge transformation for $d > 4$. Vector and tensor memory cannot be described by diffeomorphisms. In $d \geq 4$ (even) we show the relationship between memory and charge/ flux expressions. Finally, we show that that the that the memory effect results in an infrared divergence of the "out state" in quantum gravity. We comment on the implications of this divergence on the Hilbert space structure of quantum fields.

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