

Vacuum fluctuations in non-globally hyperbolic spacetimes

Barroso, Vitor S.; Pitelli, João Paulo M.

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Semi-classical Gravity relies on one's ability to proceed with the quantization of fields on a background from General Relativity (see Ref. [1]). Such a procedure is usually done in globally hyperbolic spacetimes, where the Cauchy problem associated with the wave equation is well-posed. On the other hand, in non-globally hyperbolic spacetimes, predictability is completely lost, which jeopardizes the quantization procedure. Nevertheless, Wald argues, in Ref. [2], that one recovers a consistent dynamical evolution of fields by finding the positive self-adjoint extensions of the spatial component of the differential wave operator. In Ref. [3], Ishibashi and Wald show this scheme is the only prescription for dynamics whose outcomes are physically reasonable. In spacetimes such as the Global Monopole or anti-de Sitter, in which global hyperbolicity is absent, the physical prescription for dynamics corresponds to the imposition of a set of boundary conditions at the naked singularity (see Ref. [4]) or at the conformal infinity (see Ref [5]), respectively. We examine the effects these non-Dirichlet boundary conditions have on physically relevant quantities, e.g., the expectation value of the stress-energy tensor. In the Global Monopole[6], we have found an analytical contribution to the fluctuations of the stress tensor depending exclusively on the boundary condition parameter, and independent of the topological structure of the manifold. Our results resemble those of Minkowski with a point removed. For anti-de Sitter, our analysis led to the breakdown of some invariances of the spacetime[7]. The imposition of a non-Dirichlet boundary condition at the conformal infinity for one of the modes of the wave equation results in an energy density distribution depending on the radial coordinate. A price is paid for adopting Wald's and Ishibashi's prescription for dynamics in adS, i.e., the violation of energy conditions and the appearance of a privileged frame.

References

- [1] N. D. Birrell and P. C. W. Davis, *Quantum fields in curved space*, (Cambridge University Press, 1982).
- [2] R. M. Wald, *Dynamics in nonglobally hyperbolic, static space-times*, J. Math. Phys. **21**, 2802 (1980).
- [3] A. Ishibashi and R. M. Wald, *Dynamics in non-globally-hyperbolic static spacetimes II: General analysis of prescriptions for dynamics*, Class. Quant. Grav. **20**, 3815 (2003).
- [4] J. P. M. Pitelli and P. S. Letelier, *Quantum Singularities Around a Global Monopole*, Phys. Rev. D **80**, 104035 (2009).
- [5] A. Ishibashi and R. M. Wald, *Dynamics in non-globally-hyperbolic static spacetimes III: Anti-de Sitter spacetime*, Class. Quant. Grav. **21**, 2981 (2004).
- [6] Barroso, V. S. and Pitelli, J. P. M., *Vacuum fluctuations and boundary conditions in a global monopole*, Phys. Rev. D **98**, 065009 (2018).
- [7] Barroso, V. S. and Pitelli, J. P. M., *Non trivial boundary conditions for scalar fields propagating in anti-de Sitter*, In preparation (2019).