Hadamard renormalisation for charged scalar fields

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The study of quantum fields in curved spacetime can be seen as a first approximation to a full theory of quantum gravity. One considers spacetime classically while matter fields propagating within this background are quantised. This is summarised by Einstein's semiclassical equations that couple the classical Einstein tensor to the quantum expectation value of the stress-energy tensor associated to the matter field. The stress-energy tensor is formally divergent and so it must be renormalised in order to extract a finite expression that can be used to investigate physical effects. Unlike in Minkowski space, where normal ordering is preferred, there is no unique renormalisation method when spacetime becomes curved and this is intimately tied to the lack of a unique vacuum state in curved spacetimes. The Hadamard renormalisation method provides a powerful and axiomatic approach in curved spacetime. This procedure has been developed by Decanini and Folacci for massive neutral scalar fields in a general spacetime of arbitrary dimension. Motivated by the study of superradiant scattering in charged black holes, we extend their work to include charged scalar fields in spacetimes with a classical, background gauge field and explicitly demonstrate the Hadamard renormalisation procedure in four dimensions.

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