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Microlocal analysis and interacting quantum field theories: renormalization on physical backgrounds. (English) Zbl 1040.81067

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Summary: We present a perturbative construction of interacting quantum field theories on smooth globally hyperbolic (curved) space-times. We develop a purely local version of the Stückelberg-Bogoliubov-Epstein-Glaser method of renormalization by using techniques from microlocal analysis. Relying on recent results of Radzikowski, Köhler and the authors about a formulation of a local spectrum condition in terms of wave front sets of correlation functions of quantum fields on curved space-times, we construct time-ordered operator-valued products of Wick polynomials of free fields. They serve as building blocks for a local (perturbative) definition of interacting fields. Renormalization in this framework amounts to extensions of expectation values of time-ordered products to all points of space-time. The extensions are classified according to a microlocal generalization of Steinmann scaling degree corresponding to the degree of divergence in other renormalization schemes. As a result, we prove that the usual perturbative classification of interacting quantum field theories holds also on curved space-times. Finite renormalizations are deferred to a subsequent paper.

As byproducts, we describe a perturbative construction of local algebras of observables, present a new definition of Wick polynomials as operator-valued distributions on a natural domain, and we find a general method for the extension of distributions which were defined on the complement of some surface.

MSC:

81T20	Quantum field theory on curved space or space-time backgrounds
35A18	Wave front sets in context of PDEs
35B20	Perturbations in context of PDEs
58J15	Relations of PDEs on manifolds with hyperfunctions
81T15	Perturbative methods of renormalization applied to problems in quantum field theory
35A27	Microlocal methods and methods of sheaf theory and homological algebra applied to PDEs

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