Hollands, Stefan; **Wald, Robert M.**

Quantum fields in curved spacetime. (English) Zbl 1357.81144

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Summary: We review the theory of quantum fields propagating in an arbitrary, classical, globally hyperbolic spacetime. Our review emphasizes the conceptual issues arising in the formulation of the theory and presents known results in a mathematically precise way. Particular attention is paid to the distributional nature of quantum fields, to their local and covariant character, and to microlocal spectrum conditions satisfied by physically reasonable states. We review the Unruh and Hawking effects for free fields, as well as the behavior of free fields in deSitter spacetime and FLRW spacetimes with an exponential phase of expansion. We review how nonlinear observables of a free field, such as the stress-energy tensor, are defined, as well as time-ordered-products. The "renormalization ambiguities" involved in the definition of time-ordered products are fully characterized. Interacting fields are then perturbatively constructed. Our main focus is on the theory of a scalar field, but a brief discussion of gauge fields is included. We conclude with a brief discussion of a possible approach towards a nonperturbative formulation of quantum field theory in curved spacetime and some remarks on the formulation of quantum gravity.

MSC:

81T20 Quantum field theory on curved space or space-time backgrounds
83C47 Methods of quantum field theory in general relativity and gravitational theory

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