Preface

Relativistic quantum field theory was conceived in the late 1920s as a framework unifying the two fundamental theories that revolutionized physics in the twentieth century: Quantum Mechanics and the Special Theory of Relativity. *Algebraic Quantum Field Theory* (AQFT) is relativistic quantum field theory regarded from a certain perspective, emphasizing localization of observables in space and time. It has its roots in the pioneering work of Rudolf Haag and Arthur Wightman from the 1950s and is a well-established branch of mathematical physics, distinguished by clear conceptual foundations and mathematically sound arguments.

AQFT is also called *Local Quantum Physics* which is the title of a monograph by Rudolf Haag[1] that summarizes the results and insights achieved by many researchers up to the mid-1990s. Since then a number of new developments have taken place. In May 19–23, 2014 a workshop with the title "Algebraic quantum field theory: Its status and its future" was held at the Erwin Schrödinger Institute for Mathematical Physics (ESI) in Vienna. The present volume reflects many of the themes discussed at this workshop but all contributions were written specially for this volume. The first contribution, by Klaus Fredenhagen, is a general introduction to the fundamentals of AQFT while other chapters focus on more specialized topics. The chapter by Fredenhagen and Katarzyna Rejzner in particular, shows how perturbative constructions of models with interactions fit elegantly into the formalism of AQFT.

One of the strengths of the algebraic approach is that it can be naturally applied when the underlying space-time manifold is curved, thus allowing to take important aspects of General Relativity into account. A large number of results on the characterization of physically important states, general covariance, perturbation theory, and renormalization, both on flat and curved space-times, have been obtained in the past 20 years and several of the contributions deal with these topics.

The introductory chapter by Klaus Fredenhagen has a section on AQFT on curved space times, the chapter by Marco Benini and Claudio Dappiaggi treats

[1]Rudolf Haag, Local Quantum Physics: Fields, Particles, Algebras, 2nd Ed., Springer 1996.

models of free quantum fields on such space-times, and that of Igor Khavkine and Valter Moretti is concerned with quasi-free Hadamard states. The contribution of Christopher Fewster and Rainer Verch deals with locally covariant AQFT on curved space-times employing the language of category theory, besides discussing selection criteria for physical states in terms of various stability conditions. The chapter by Thomas-Paul Hack and Nicola Pinamonti is concerned with applications of AQFT to cosmology. Here also, semiclassical back reaction of quantum fields on the metric of space-time is taken into account. The contribution by Dorothea Banhs, Sergio Doplicher, Gerardeo Morsella, and Gherardo Piacitelli goes further into the direction of quantum gravity by replacing classical space-time by a quantum space-time where the coordinates form a noncommutative algebra.

Conformal quantum field theory, that has several important applications in condensed matter physics, is a model example where algebraic structures and inequivalent Hilbert space representations that go far beyond standard Lagrangian field theory arise naturally. The chapter by Karl-Henning Rehren reviews this topic from a modern perspective. Pieter Naaijkens treats in his contribution Kitaev's quantum double model from a local quantum physics point of view. This is a further example where the algebraic and local way of thinking leads to important insights in a situation that is not directly connected with relativistic quantum theory but rather with condensed matter physics and quantum information theory.

The last chapter, by Gandalf Lechner, is concerned with new methods for constructing models of relativistic quantum fields. Here, a basic tool is the Tomita-Takesaki modular theory of von Neumann Algebras and the fact that the modular group and reflection of an algebra generated by a relativistic quantum field localized in a space-like wedge is explicitly known. Using these techniques, a large class of models in two space-time dimensions, that are so far inaccessible by other means, can be constructed. A further method described in this chapter is the use of deformations of the wedge algebras of known models to obtain new models.

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