Preface

The theory of causal fermion systems is an approach to fundamental physics. In different limiting cases, causal fermion systems give rise to the standard model of particle physics and gravity on the level of classical field theory [45] as well as to quantum field theory [58, 24]. In view of these results, causal fermion systems are a promising candidate for a unified physical theory. The dynamics of a causal fermion system is described by a novel variational principle: the causal action principle. From the mathematical perspective, causal fermion systems provide a general framework for describing non-smooth geometries and for formulating and analyzing dynamical equations in this non-smooth setting.

This book is intended as an easily accessible introduction to the theory of causal fermion systems. After giving the physical and mathematical background (Part I), the theory of causal fermion systems is introduced (Part II). We proceed by providing mathematical methods that can be regarded as a toolbox for analyzing causal fermion systems (Part III). We conclude with an outlook on the applications (Part IV).

In order to address as large an audience as possible, the book contains extensive preliminaries that cover both physical and mathematical aspects. We have two typical audiences in mind when writing these preliminaries: physicists with only basic knowledge of mathematics and mathematicians without physical background.

The book is based on three main resources: first, the lecture notes of the spring school "Relativistic Fermion Systems" held in Regensburg in April 2013, adapted for the spring school "Causal Fermion Systems" held in Regensburg in March 2016; second, the lecture "Causal Variational Principles" given at the University of Regensburg in the summer semester 2017; and finally, the online course "An Introduction to Causal Fermion Systems" held in the summer semester 2021.

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