One aim of this project is to develop a theory of conformally invariant differential operators which are canonically associated to submanifolds of Riemannian manifolds and to study the structure of $Q$-curvature. Another goal is to develop the holonomy theory of indefinite metrics and of conformal structures, in particular to study the global geometric structure of pseudo-Riemannian manifold with special holonomy.

## 1. $Q$-Curvature and Families of Conformally Invariant Differential Operators

In the last decade, the conjectural AdS/CFT-duality had fundamental influence on conformal geometry and related problems on geometric partial differential equations. In the project we deal with questions which are closely related to this interplay. In this connection, one central construction is the Fefferman-Graham "ambient metric" and the equivalent Poincaré-Einstein metric. A spectacular application of the ambient metric was the construction of conformally covariant powers of the Laplacian (GJMS-operators). These are geometric operators of independent interest. Their structure motivated Branson to introduce the notion of $Q$-curvature. In recent years, the study of $Q$-curvature developed into an extensive area of research on the cutting edge of various mathematical areas. The central problems of the project concern the structure of this higher order curvature notion, its generalizations and its applications.

## 2. Holonomy Problems for Conformal Structures and for Indefinite Metrics

Our interest in holonomy problems for indefinite metrics and conformal structures arose from the study of spinor field equations on Lorentzian manifolds. Many of such equations admit parallel spinors, Killing spinors, or conformal Killing spinors as (special) solutions, and holonomy groups can be used as the algebraic tool for the classification of the underlying geometric structures.

The recent progress in holonomy theory of Lorentzian metrics (classification results of T. Leistner) and of conformal structures (classification results of St. Armstrong, F. Leitner, J. Alt) provides a new basis for the study of such spinor field equations. Our project mainly focus on

- the relation between the solution of spinor field equations (parallel, Killing, conformal Killing etc. ) on one side and global and causal properties of Lorentzian manifolds (or more general pseudo-Riemanian manifolds) on the other,
- the classification of Lorentzian manifolds with large isometry group and special holonomy or special curvature properties,
- the study of geodesically complete and globally hyperbolic space-times with such spinor fields.