Project 5.4. Geometric Structures and Applications in Theoretical Cosmology and Nonholonomic Mechanics

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Background:

In recent years there has been a growing interest in the study of differential geometric structures beyond the setting of classical Riemannian geometry. Of particular interest are certain classes of so-called Cartan geometries, in particular parabolic geometries. These include conformal structures, CR structures, projective structures, geometries of differential equations, and geometries of distributions.

Many of these geometries have been applied in mathematical and physical theories, such as classical field theory, relativity theory, string theory, geometric control theory, and robotics. In particular, conformal geometry plays an important role in Penrose's Conformal Cyclic Cosmology programme.

The PhD research will be part of the GRIEG project "SCREAM: Symmetry, Curvature Reductions and EquivAlence Methods" at the interface of geometry, algebra, and the theory of differential equations. This project is carried out as a collaboration between
research teams in Warsaw, Poland, and Tromso, Norway. It aims to examine a variety of geometric structures along the lines of the central themes of the SCREAM proposal and to explore applications in mathematics and physics.

During the course of the PhD project the student will learn a variety of classical and
modern methods from differential geometry and Lie theory, and will acquire symbolic computer calculation skills. As part of the PhD training, international research visits are planned.

Aim:

The goal of the project is to implement and refine the techniques available for the study of Cartan geometries in order to answer questions of fundamental importance for a variety of geometric structures beyond the classical setting.

Depending on the qualifications and interests of the student the PhD project will focus either on:

1) Conformal geometry and applications to Penrose's Conformal Cyclic Cosmology programme.

2) The study of certain geometric structures that are related to non-holonomic mechanical systems, in particular geometric robots and special contact geometries.

Requirements:

- A very good knowledge of differential geometry and at least one of the following fields: the theory of Lie groups and Lie algebras, classical mechanics, general relativity theory,
- An interest in geometry and applications in physics,
- Willingness to collaborate and work in a team