Title:

Non-linear perturbations of cosmological models and black hole spacetimes

Supervisor:
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Description of the project:

One of the outstanding challenges in General Relativity — the relativistic theory of gravity—is to gain analytic control of the solutions to the Einstein field equations in the large: physical questions in General Relativity require knowledge of the non-linear behaviour and properties of solutions to non-linear partial differential equations. Such undertaking is, very often, only feasible in the case where the solutions under consideration are suitably close—that is, a perturbation—to an (usually) explicitly known background solution. The standard approach to this problem has been the study the evolution and properties of linearised perturbations. This approach, however, offers a limited understanding of non-linear mechanisms. The objective of the present project is to analyse fully non-linear evolution problems in a range of settings in General Relativity ranging from cosmology to the theory of black holes. The insights gained from the study of non-linear perturbations is key to understand the physical content of General Relativity as the background solution are often attractors of the theory.

The approach to these problems will be based on a number of techniques of conformal geometry and the theory of partial differential equations recently developed by the supervisor—see the bibliography enclosed. The project will be mainly analytical, but it will involve certain amount of computer algebra and some numerical simulations.

References:
