Approximate symmetries and dynamic black holes

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Research Group: Geometry, Analysis & Gravitation

Project description:

Background

The development of a mathematical theory of black holes (BHs) has been central for bringing General Relativity (GR) into the mainstream of Theoretical Physics. This picture has been broadly confirmed by the numerical simulations of dynamical BHs and by observations —the latter include not only the detection of gravitational waves by interferometric gravitational wave detectors but also photographs of BHs by the Event Horizon Telescope. Research in the last decades has given rise to a well-developed mathematical understanding of stationary (i.e. time-independent) BHs. The situation is less far less satisfactory in the case of dynamical ones. Current mainstream analytic efforts are restricted to the nonlinear perturbations of stationary BHs.

Aims of the project

Due to the lack of a suitable mathematical framework, insights into the dynamical strong regime of BHs are only accessible via numerical simulations. The main goal of this project is to develop the theoretical understanding of dynamical BHs in the non-perturbative regime through a new theoretical toolkit involving approximate symmetries and geometric inequalities. The project builds on notions of approximate symmetries analysed by the supervisor and aims at extending them to explore properties of dynamical BHs from a geometric point of view and, crucially, connecting this theoretical framework with current observations. This project is of a multidisciplinary character, combining the physical aspects of BHs along with subtle mathematical tools. The project provides an alternative view to a subject which has, for long, been restricted to the perturbative regime of BHs. It makes a perfect fit in the large-scale initiative dedicated towards understanding these objects in the context of recent observations of gravitational waves. In particular, the research programme has relevant applications in GR perturbation theory, extreme mass ratio inspiral (EMRI) modelling and gravitational wave. Moreover, the results of this project will inform the construction of initial data for numerical relativity and gravitational wave astrophysics.

Further information:

How to apply

Entry requirements

Fees and funding