Numerical investigation of particle dynamics in strong gravity

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Research Group: Geometry, Analysis & Gravitation

Project description:

In this project the student will develop and use numerical relativity (NR) simulations to investigate particle dynamics in strong gravity regimes. The main goal is to characterise the dark matter structures that form around isolated and binary black holes, as a function of the particle mass, spin, and self-interaction strength, and quantify their impact on gravitational wave and electromagnetic ("multimessenger") signatures in black hole mergers, to probe and constrain the particle nature of dark matter. However, with the code that is developed there are opportunities to study other novel features of particles in strong gravity such as interference in neutrino oscillations, high energy particle scattering and the eccentric Kozai-Lidov effect.

A key outstanding question in cosmology is the nature of dark matter. NR work on DM has focussed heavily on light (sub eV) bosonic scalar and vector particles, due to resonances in length scales that permit "hairy" BH solutions and the existence of stable solitonic objects like boson stars in asymptotically flat backgrounds. However, to seriously confirm or rule out light particles using GW observations, we need comparative studies over the full range of possible masses. For this reason, fully relativistic N-body simulations, which permit virialisation of particles and quantification of their gravitational backreaction, must be tackled. Only a handful of such codes exist and numerical methods for such simulations have not been extensively developed. A key part of the work will therefore involve developing particle methods for the state of the art, high performance computing code GRChombo, for which several QMUL staff are lead developers (www.grchombo.org).

Whilst C++ coding and use of high-performance computing will be a key part of the project, potential students will not be required to have prior experience in these fields. Enthusiasm, tenacity, and a willingness to learn such methods will be considered the most important attributes.

Further information:

How to apply

Entry requirements

Fees and funding