Black holes are among the most fascinating objects of the Universe. They are today at the core of our understanding of gravitation. They provide essential hints towards a theory of quantum gravity. They constitute the main emission source of gravitational waves, which will play a central role in future astrophysics. Black holes are also central in mathematical relativity, and the proof of their stability is still today a challenging problem. In the last decades, several analogies between gravity and fluid mechanics have been developed. This interdisciplinary approach has led to many innovative methods and successful results, which have deepened our understanding of black holes, fluids or superfluids. More recently, such an analogy was used by various experimental groups, which were able to successfully reproduce several key effects of black hole physics using fluid systems.

The aim of this project is to develop the mathematical tools to open a new avenue in this interdisciplinary field: the understanding of nonlinear dynamics. In other words, how waves are affected by a background flow or spacetime, and subsequently modify their dynamics. It will focus on three research directions: the analogue of the Hawking effect, superradiant instabilities, and resonances. This project will bring an experienced researcher in analogue models in a strong mathematical physics group, within the Institute of Mathematics of Burgundy (IMB). The objective is to exploit modern mathematics to develop new tools for the joint analysis of black holes and fluids. It will rely on the one hand on mathematical methods of integrable models, and spectral theory of non self-adjoint operators, two fields in which the host group has a traditionally strong expertise, and on the other hand on the knowledge in General Relativity and analogue models of the experienced researcher.