Studying the distribution of accreting supermassive black-holes on the cosmic web

The most recent observational campaigns have placed the total number of galaxies in the Universe in the trillions. The majority, if not all of them, are thought to host at their centers large black holes, millions or even a billion times heavier than our Sun. These beasts build up their mass over time by devouring material from their surroundings. During this process they emit huge amounts of energy that impacts the physical conditions of the surrounding interstellar and intergalactic medium, with far-reaching implications for the formation and evolution of stars, galaxies and large-scale structures in the Universe. Despite the ubiquity of black holes among galaxies, observations show that at any given time only a tiny fraction, fewer than 1 in 1000, are active, i.e. accreting material and growing their masses at a significant rate. The vast majority appear dormant. This observational fact had led astronomers to debate the physical conditions and environments that may be responsible for the activation of supermassive black holes. Are there specific triggering mechanisms required to initiate an accretion event at the centers of galaxies (e.g. interations between galaxies)? Or is black-hole growth a stochastic phenomenon that occurs naturally as part of the normal life-cycle of the stars and gas in galaxies and does not require specific triggers or favourable conditions?

To answer these questions astronomers are trying to isolate those factors that can potentially modulate the level of activity in the centers of galaxies. One of them is the environment, which measures the local density of matter in the neighborhood of extragalactic sources. It is well established that matter in the Universe is organized in filaments, groups and clusters separated by large voids. The conditions in these diverse environments of the cosmic web vary widely in terms of density of matter, frequency of galaxy encounters, and temperature of the intergalactic medium. We know that these different conditions imprint observable signatures on galaxies and affect the way they evolve with time. It is therefore natural to wonder if the position of a galaxy on the cosmic web also determines the activity of its central “supermassive” black hole.

The PhD project will focus on the role of environment in the activation of supermassive black holes at the centres of galaxies. Tools and methods will be developed to measure observationally the local density of galaxies in the vicinity of AGN. Semi-empirical models will be used to interpret these results and link the distribution of AGN on the cosmic web with different scenarios for the fueling of supermassive black holes. The PhD project combines observational and modeling work. It will be carried out in collaboration with the National Observatory of Athens and the University of Southampton and will use the diverse expertise on both observations and theory offered by the BiD4BEST nodes.