ALMA MATER STUDIORUM
UNIVERSITÀ DI BOLOGNA

DIPARTIMENTO DI FISICA E ASTRONOMIA
Department of Physics and Astronomy - DIFA

PhD project in ASTROPHYSICS

Title of the Project: Observations of cold gas outflows in massive galaxies

Supervisor : Sirio Belli

Scientific Case:
In the first few billion years after the Big Bang, massive galaxies begin to experience "quenching", a process which rapidly shuts down their star formation activity and turns them into passive, gas-poor systems. It has long been suspected that feedback by supermassive black holes plays a key role in this process; however, the exact mechanism responsible for galaxy quenching has been a major outstanding question for more than a decade. Studies of gas outflows driven by supermassive black holes in high-redshift galaxies have mostly been focused on the ionized phase, which is easier to observe but appears to be too weak to be able to cause quenching. Colder gas phases (neutral and molecular) are expected to be stronger but are also much harder to detect. Finally, the James Webb Space Telescope (JWST) has now enabled a major step forward, with the discovery of strong outflows of neutral gas in massive galaxies that are experiencing quenching at z∼2 (Belli, Park et al. 2024; Davies, Belli et al. 2024). These observations represent the first direct evidence of galaxy quenching by feedback from supermassive black holes, and were made possible by the unprecedented sensitivity of JWST, which is necessary to detect faint neutral gas absorption lines.

Outline of the Project:

The goal of the project is to carry out a systematic study of neutral outflows in massive galaxies from the local universe to Cosmic Noon (z∼2) and beyond. This can be done by analyzing deep spectra of galaxies and measuring the Na D and Ca H,K absorption lines against the stellar continuum. At high redshift, only JWST is capable of detecting neutral gas: several JWST spectra suitable for this analysis are already publicly available, and several more will likely be obtained in the near future. At intermediate and low redshift, the sensitivity of ground-based observatories is sufficient to detect neutral gas. The student will use data from large galaxy surveys, as well as more targeted observations, to measure the properties of neutral gas outflows as a function of redshift. This analysis will lead to an understanding of the role played by supermassive black holes in galaxy quenching and its evolution with cosmic time.

The student will be part of the Bologna-based, ERC-funded *Red Cardinal* project, and will also work in collaboration with an international network of colleagues.

Contacts: Sirio Belli (sirio.belli@unibo.it)