PhD Thesis Project Proposal
INAF – Osservatorio Astrofisico di Arcetri

Title – Coevolution of Black Holes and Galaxies: dual black holes, outflows and feedback

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Period: November 2023 - November 2026

Description –
Supermassive Black Holes (SMBH) are present at the centre of most galaxies, in some cases in the form of bright Active Galactic Nuclei (AGN). They grow hierarchically together with the galaxies, and it is widely accepted that the SMBH, especially in their active phase, play a key role in shaping the evolution of the host galaxy. In particular, they are thought to be responsible for the global shut-down of star formation, especially in massive galaxies. Galaxy-wide gas outflows have been discovered in most AGN, which could be the drivers of the black-hole galaxy coevolution and responsible for the star formation quenching. Several key questions are however still open, both on the origin and growth mechanism of these SMBH, as well as on the properties and effects of their gas outflows on the hosts (feedback).

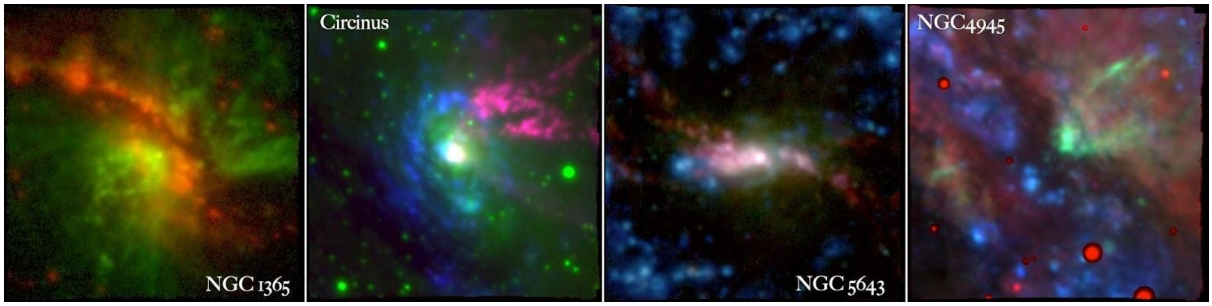

Fig 1. Example of AGN driven outflows from MUSE data of local galaxies. The [OIII] line emission tracing the outflow and the ionisation, the Ha emission tracing the star formation, and the stellar continuum are shown in different colors.

Objectives – **The growth of Supermassive Black Holes: the search for dual BH**
All the cosmological models of galaxy formation predict the existence of a widespread population of dual AGNs, i.e., pairs of SMBH in the same galaxy due to a past merging event. Only a very small number of such systems are known at z>1 with separations below 8kpc, i.e., in the same galaxy. Our group has recently developed and validated an innovative method to select such systems in the database of the Gaia satellite (Mannucci et al 2022). In this thesis work the candidate will analyze a large set of data already granted at the best instrumentation currently available (including VLT-MUSE, VLT-ERIS, LBT-LUCI, and KeckOSIRIS) to obtain, for the first time ever, the fraction of dual AGNs and their distribution in separation at z>1, allowing to test some crucial predictions of the cosmological models.

Outflows and feedback: the effects of BH on host galaxies.
Many observations of AGN outflows have been obtained in recent years, detecting ionised and molecular gas ejected from the galaxies at velocities up to 1/10 of light speed. In some

cases, these velocities are high enough to escape the gas from the galaxy, but it is still not clear if the mass loading factors are high enough to determine the global star formation shutdown required by the models (quenching). During the thesis work, the candidate will use new-generation instruments at the major world facilities, including the James Webb Space Telescope, to investigate the properties of the outflowing gas and its effects on the host galaxies, trying to collect further evidence to answer these fundamental questions (see e.g. Cresci et al. 2015, Maiolino et al. 2017, Cresci & Maiolino 2018, Carniani et al. 2017, Venturi et al. 2021, Tozzi et al. 2021). In particular, the candidate will use "integral field" spectroscopic data in the optical to study in great detail the kinematics, geometry, physical conditions of ionised outflows in local active galaxies, obtained with the instrument MUSE at the VLT. The results obtained will be compared and used to interpret the observations at high redshift obtained in the near-IR with ERIS at VLT and with NIRSpec on JWST, two instruments that will start observing during 2022.

Available Data – The thesis project is intended to use the latest generation "integral field" spectroscopic data, using instruments like **MUSE** at VLT, one of the most productive instruments ever at the largest telescopes in the world (https://www.eso.org/sci/facilities/develop/instruments/muse.html). Most importantly, it will allow the candidate to use the very first scientific data obtained in the framework of the Guaranteed Time Observations (GTO) at brad new facilities like the Adaptive Optics assisted spectrograph **ERIS** at VLT (https://www.eso.org/sci/facilities/develop/instruments/eris.html), and the unprecedently deep and sharp data of **NIRSpec** on board of the new James Webb Space Telescope (https://www.cosmos.esa.int/web/jwst-nirspec). This will allow the candidate to work on cutting edge data, acquire a unique experience with the latest generation integral field instruments and start publishing in a particular active research field with great prospects.