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Determination of AGN outflows physical properties: a new approach to kinematical modelling

Observations and simulations show that outflows in active galactic nuclei (AGN) contain gas in different phases, having galaxy-wide impact on the host galaxy.
A proper characterization of the outflow physical properties is necessary to assess questions regarding the energy exchange mechanism between the AGN wind and the inter stellar medium (ISM) i.e. the feedback mechanism, which is now a standard ingredient in galaxy formation models, necessary to explain the steep decline of the galaxy mass function and for establishing the black hole vs. bulge correlations.
So far, a range of more than three orders of magnitude is observed in the derived wind energetics for a fixed AGN luminosity, both for molecular and warm ionised outflows (Cicone et al. 2014, Fiore et al. 2017).
In order to compare observations with theoretical predictions, an in-deep study of the multi-phase outflows energetics through full-comprehensive kinematical models must be carried out.
To provide an accurate determination of the multi-phase outflow properties I propose an innovative approach that I have already tested on spatially resolved MUSE data during my Master thesis.

Here I will briefly describe the main project of my Ph.D. Thesis. I want to characterize the physical properties and energetics of multi-phase AGN outflows, assessing the impact on the host galaxies at different cosmic times by employing various Integral Field new generations spectrographs.

I will carry out my project working in collaboration with the Arcetri extragalactic group.

Multi-phase outflow physical properties determination: I will characterize the properties of AGN outflows working on sources selected from public surveys with archival data available and Guaranteed Time Observations (GTO) programs. To enlarge the sample, I also expect to submit several observational proposals to VLT, ALMA and JWST to better characterize the multi-phase outflow impact on the active galaxies, from high to low redshift.

• **MAGNUM** survey: This survey's aim is to shed light on the feedback mechanism in nearby sources (D_L< 50 Mpc) showing prominent ionized outflows (e.g., Cresci et al. 2015, Venturi et al. 2017, Mingozzi et al. 2019). During my Master thesis I analyzed four AGN selected from this survey; in my Ph.D. thesis I will complete this analysis, providing accurate estimates of the physical properties of ionized outflows in the remaining sample of 6 galaxies.

• **SUPER** survey: This survey includes 39 AGN selected in the X-rays and cover the redshift range $z \approx 2-2.5$. A selected sub-sample of 8 targets, with ionized emission detected, also have **ALMA** data for the molecular phase. Analyzing the multiphase winds properties in this sub-sample is fundamental to understand if there and what is the link between different gas phases, and how they shape the galaxy properties in terms of gas depletion, heating and compression and subsequent star formation quenching or enhancement at high redshift (Carniani et al. 2015, Cresci & Maiolino 2018).

• **ERIS GTO**: INAF will receive GTO time which in part will be devoted to study AGN-feedback processes and outflows at the cosmic noon ($z \approx 1$-3). Exploiting its adaptive optics performance and high spectral resolution, this newly installed spectrograph at the VLT will reveal the detailed kinematical structures of AGN driven winds at the cosmic noon. I will apply my kinematical model to characterize the wind ionized phase, well traced by [OIII] emission. Applying my kinematical model to ERIS data I expect to enlarge the sample of fully characterized AGN outflows also to the high redshift universe, providing a reliable method to estimate not only the wind impact at different cosmic times but also to finally determine the wind powering mechanism, by comparing my results with theoretical predictions (Zubovas & King 2014, King & Pounds 2015).

• **JWST GTO and public data:** Using the Integral Field Unit capabilities of NIRSpec and MIRI, JWST will study the impact of high-z quasars on their hosts at high redshift with unprecedented spatial resolution, giving the chance for a full characterization of multi-phase AGN-driven outflows.

Finally I want be to combine my kinematic model with a photoionization model which is being develop in the last year at the Arcetri observatory, with the aim to properly determine the ionized and molecular outflow mass, solving one of the greatest uncertainties in outflow physical properties determination.

References *(in order of appearance): Cicone et al. 2014, A&A, 562, A21; Fiore et al. 2017, A&A, 601, A143; Cresci et al. 2015, ApJ, 799, 82; Venturi et al. 2017, Frontiers, 4; Mingozzi et al. 2019 A&A, 622, A146; Carniani et al. 2015, A&A, 580, A102; Cresci & Maiolino 2018, Nature Astronomy, 2, 179-180; Zubovas & King 2014, MNRAS, 439, 400-406; King & Pounds 2015, ARA&A, 53, 115;*