PhD name: Barchiesi Luigi
PhD Cycle: XXXV
Tutor: Vignali Cristian Co-tutor: Francesca Pozzi

RESEARCH PROJECT: Obscured AGN in X-rays deep fields: tracing accretion and star-formation processes at z~1-3

Scientific background

The presence of scaling relation between the mass of the supermassive Black Hole (SMBH) and several properties of the host galaxy (i.e. mass, luminosity, velocity dispersion; e.g., Kormendy & Richstone 1995) led to theorize that the growth of the SMBH and of the galaxy in which it is hosted are connected (e.g. Silk & Rees 1998). The BH-galaxy co-evolution paradigm predicts that an intense phase of star formation (SF) is triggered by a wet merger, a fraction of the gas reservoir of the galaxy is funneled towards the SMBH and turns on the Active Galactic Nuclei (AGN) activity, which, in turns, provides feedback that regulates the SF. Due to the large quantity of gas, the majority of the AGN radiation is absorbed and the source appears as an obscured AGN. Although several obscured AGN selection methods are available, a complete census of these objects cannot be achieved using only a single observing-band method. The X-ray radiation, originated in the innermost region of the AGN, is a good tracer of the AGN intrinsic emission; however, when the nucleus is obscured by column densities as large as $\sim 10^{24}$ cm^{-2}, even hard X-rays are severely depressed. Mid-infrared wavelengths can be effectively used as a complementary selection method, as the extincted optical radiation is re-emitted at these wavelengths after being thermally reprocessed by the obscuring torus. In these cases, complementary observations (i.e. mid-IR emission from dust reprocessing the AGN emission, high-ionization emission lines) are necessary to achieve a good census of the AGN population.

PhD project

The main topic of my project is the study of the BH-galaxy co-evolution paradigm, with the aim of finding evidence for co-evolution and investigating how the AGN and the host-galaxy influence each other, with a particular focus on the most-obscured, thus most-elusive, Compton-Thick (CT) AGN. The goal of this project is to determine if the presence of the AGN has the effect of enhancing or suppressing the host-galaxy SF (with respect to non-active galaxies), if the ISM can contribute to a fraction of the AGN obscuration and if there is a connection with the small- or large-scale environment.

Second PhD year

During this second year I tackled the project in three ways.

- The first one is using [NeV]3426Å high-ionization line (its potential assures us that the emission is AGN related) to select obscured AGN at redshift $0.8<z<1.2$, where high SFR and AGN activity are expected. In the first PhD year, I performed an X-ray spectroscopic analysis of 94 [NeV]-selected obscured AGN and obtained the AGN intrinsic luminosity and amount of obscuration. During the II year, I performed an optical-to-FIR analysis of the Spectral Energy Distribution (SED) of these sources using the new COSMOS2020 photometric catalogue. It allows us to separate the AGN emission, in particular, the torus mid-IR emission, from the galaxy emission. We used the latter to estimate the stellar mass (M_*), the star formation rate (SFR), as well as the molecular gas content (M_{mol}) of the galaxies. We built a mass- and redshift-matched parent sample of normal galaxies, and its comparison with the [NeV] sample indicates that the [NeV] AGN sample seems to lack a population of “quiescent” galaxies, i.e. it has, on average, a higher fraction of sources within the Main Sequence (MS) of SF-galaxies, and shows little evidence for AGN quenching the SF. As the two samples have similar amounts of cold gas available to fuel the SF (according to the 850μm-derived M_{mol}), this difference points towards a higher efficiency in forming stars in the [NeV]-selected sample. The comparison with the prediction from the in-situ co-evolution model (Mancuso et al. 2016, Lapi et al. 2018) suggests

that [NeV] is an effective tool to select galaxies in the obscured growth phase of the BH-galaxy co-evolution paradigm, with the "quenching phase" still to come for most of the sample and only few galaxies showing evidence for a quenched star formation. I am currently finalizing the paper and it will be submitted in few weeks.

- The second topic focuses on the study of the SPICA-Athena synergies in detecting and characterizing AGN up to very high-redshift, with a particular emphasis to CT-AGN. Following the unexpected and arbitrary exclusion of the SPICA mission from the final ESA M5 competition and the consequent cancellation of the whole project, we shifted the focus of our work in studying the synergies between Athena and new-generation cryogenic IR telescopes, using a SPICA-like telescope and the NASA Origins Space Telescope (OST) as templates. We found that, with the deepest Athena and SPICA-like (or OST) surveys, we will be able to photometrically detect in the IR more than 90% of all the AGN. Athena will be extremely powerful in detecting and discerning moderate- and high-luminosity AGN, allowing us to properly select AGN even when the mid-IR torus emission is 'hidden' by the host galaxy contribution. We find that the most obscured and elusive CT-AGN will be exquisitely sampled by SPICA-like mission or OST, and that Athena will allow a fine characterization of the most luminous ones. This will provide a significant step forward in the process of investigating the BH accretion rate evolution up to very high redshift (z≥4). Results were published on PASA (Barchiesi et al.) in June 2021.

- Finally, as my Marco polo project, I am focusing on the cold gas content of high-redshift galaxies. The study of cold molecular gas is fundamental in the investigation of the co-evolution, as it is the fuel for both SF and AGN activity, and it allows for the growth of the stellar and SMBH mass. Exploiting the expertise at the Astronomy Department of the University of Geneva, I am focusing on investigating and studying the origin of the wide spread of molecular gas fraction (f_{mol}=M_{mol}/(M_{mol}+M_*)) in the ALPINE survey (118 UV-selected SF-galaxies in the redshift range 4 < z < 6 with ALMA observations to cover the [CII] emission line; Le Fèvre et al. 2020). We are studying a sub-sample of objects with extreme values of molecular gas fraction (f_{mol} < 0.1 and f_{mol} > 0.9), aiming to characterize the properties of these sources and investigate whether the extreme gas fraction may be related to galaxies in different evolutionary phases or if there are relations with some of the galaxy properties (e.g. SFR, sSFR, t_{depl}, metallicity, SFH) or obscured AGN activity.

WORKSHOPS, CONFERENCES & MEETINGS

February 5, 2021, FAME Bologna. Talk: "X-ray analysis and broad-band properties of [NeV]-selected type 2 AGN"

March 10, 2021, Weekly PhD Seminar. Talk: "X-ray analysis and broad-band properties of [NeV]-selected type 2 AGN"

June 28 – July 2, 2021, EAS 2021 EUROPEAN ASTRONOMICAL SOCIETY ANNUAL MEETING. Poster: "X-ray analysis and broad-band properties of [NeV]-selected type 2 AGN"

PhD SCHOOLS

June 1-5, 2021, Summer school in statistic for astronomer XVI. Penn state University.

June 12-23, 2021, International summer school of the Interstellar Medium of galaxies, from the epoch of Reionization to the Milky Way.

INTERNAL COURSES

April 19-23, 2021 "Gamma Ray Burst: from observations to physical properties"

May 5-14, 2021 "Writing, talking and presenting in Science"

ISA LECTURES

January 12, 2021 “Extreme events: how to describe and predict them using mathematical theories.” by Sandro Vaienti

March 23, 2021 "Mathematics that counts" by Michele D'Adderio

RESEARCH PERIOD ABROAD

August – December 2021, Visiting student at Geneve Observatory, Switzerland. Research collaboration with Prof M. Dessauges-Zavadsky to work on AGN and SF contribution to dust luminosity in the ALPINE sample.

COMPETITIVE TELESCOPE/COMPUTER TIME ALLOCATIONS

OTHER RELEVANT ACTIVITIES

Member of the SPICA GalEvol Trasversal Work Package 2 (TWP2): “SPICA synergies with X-ray (ATHENA)”

2020 & 2021 Laboratory Assistant of the Master course “Astrophysics Laboratory” (X-ray module with prof. Vignali)

PUBLICATIONS

First author articles

Barchiesi, L., Pozzi, F., Vignali, C., Carrera, F., Vito, F., Calura, F., . . . Tombesi, F. (2021). The role of SPICA-like missions and the Origins Space Telescope in the quest for heavily obscured AGN and synergies with Athena. *Publications of the Astronomical Society of Australia, 38*, E033. doi:10.1017/pasa.2021.26

Barchiesi, L., Vignali, C., Pozzi, F., Gilli, R., Mignoli, M., et al. COSMOS2020: [NeV]-selected obscured growing AGN at $z \sim 1$. Paper close to submission

Collaboration

Bisigello, Laura, C. Gruppioni, A. Feltre, F. Calura, F. Pozzi, C. Vignali, **L. Barchiesi**, G. Rodighiero, and M. Negrello, “Simulating the Infrared Sky with a Spritz.” A&A, 651 (2021) A52 DOI: 10.1051/0004-6361/202039909

Bisigello, L. , Gruppioni, C. , Calura, F. , Feltre, A. , Pozzi, F. , Vignali, C. , **Barchiesi L.**,... “Simulating IR spectro-photometric surveys with a SPRITZ”. *Publications of the Astronomical Society of Australia,* submitted