

## Antonio Pensabene



### Title

Unveiling the multiphase ISM of  $z>6$  quasar host galaxies with ALMA

### Abstract

The host galaxies of  $z>6$  quasars are ideal laboratories to investigate the interplay between the accreting black hole and star formation and to characterize the interstellar medium (ISM) at cosmic dawn. The unprecedented capabilities of ALMA and NOEMA have opened a new window to study the galaxy evolution at early epochs at (sub-)mm wavelengths. By surveying multiple ISM tracers, we can probe the different phases of the star-forming medium and put first quantitative constraints on their physical properties for which there is little information at such high redshifts. In this talk I will present an ALMA multi-line survey of two  $z>6$  quasar host galaxies and their nearby serendipitous-discovered companions. These are among the most star-forming galaxies known to date at these redshifts that do not show evidence of AGN activity. By measuring the emission of various gas tracers ( $\text{OH}163\mu\text{m}$ ,  $\text{H}_2\text{O}$ , mid-/high-J CO,  $[\text{C I}]369\mu\text{m}$ ,  $[\text{C II}]158\mu\text{m}$ ,  $[\text{N II}]205\mu\text{m}$ ), we study the impact of the luminous accreting black hole and intense star formation on the ISM of the quasar hosts and their companions. In addition, by combining continuum emission in different frequency bands we place constraints on the dust properties. In this talk, I will show the power of multi-line studies of far-infrared diagnostics in order to dissect the physical conditions in the first massive galaxies as they emerge at the end of the Epoch of Reionization. This study lays the foundation for a follow-up campaign using NOEMA aiming to probe the warm dense phase of the ISM at  $z>6$ .

# CURRICULUM VITAE

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## PERSONAL INFORMATION

Name: **Antonio PENSABENE**  
Date of Birth: February 15, 1991  
Nationality: Italian  
  
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ORCID ID: 0000-0001-9815-4953

## ■ EDUCATION

		2018 – now
Qualification:	<b>Ph.D. (candidate) – Astrophysics</b>	
Institute:	INAF-OAS Osservatorio di Astrofisica e Scienza dello Spazio Via Gobetti 93/2, 40129, Bologna, Italy & DIFA-Department of Physics and Astronomy Alma Mater Studiorum – University of Bologna Via Gobetti 93/2, 40129, Bologna, Italy	
Ph.D. thesis:	Quasars at the dawn of cosmic time	
Supervisor:	Dr. Roberto Decarli	
Ph.D defence date:	TBD	
		2014 – 2017
Qualification:	<b>M.Sc. Degree – Physical and Astrophysical Sciences</b>	
Institute:	Università degli Studi di Firenze – Italy	
Ms.C. Thesis:	The ALMA view of the high redshift relation between supermassive black holes and their host galaxies	
Advisor:	Prof. Alessandro Marconi	
Final degree mark:	110 / 110 cum laude	
		2010 – 2014
Qualification:	<b>B.Sc. Degree – Physics and Astrophysics</b>	
Institute:	Università degli Studi di Firenze – Italy	
Ms.C. Thesis:	Determination of the critical acceleration in Modified Newtonian Dynamics by the analysis of galaxy rotation curves	
Advisor:	Prof. Alessandro Marconi	
Co-Advisor:	Dr. Edvige Corbelli	
Final degree mark:	109 / 110	
		2005 – 2010
Qualification:	<b>Scientific High School Diploma</b>	
Institute:	Liceo Scientifico N. Rodolico, Firenze, Italy	
Thesis:	The problem of longitude	
Advisor:	Dr. Carlo Baffa	
Final degree mark:	79 / 100	

## ■ RESEARCH AREA -----

Research interests: Astronomy at (sub-)mm wavelengths.  
Dynamics and interstellar medium in high- $z$  galaxies and quasar hosts.  
Co-evolution between supermassive black holes and their host galaxies.  
High- $z$  quasar discovery and identification.

Techniques: Interferometry at mm wavelengths.  
Optical and near-infrared imaging and long-slit spectroscopy.  
Archive data querying, data modelling and statistics.

Observational experiences: **Visitor Astronomer** in the following observing runs:  
- February 15-22, 2020 – 152cm Cassini telescope, Astronomical Observatory of Loiano, Italy.  
- November 9-13, 2019 – NOT, Roque de Los Muchachos Observatory, La Palma (Canary Islands, Spain)  
- July 18-27, 2019 – ESO/NTT, La Silla Observatory, Chile.  
- December 20-26, 2018 – ESO/NTT, La Silla Observatory, Chile.

Successful Service Mode proposals: **IRAM PdBI/NOEMA:**  
• “Unveiling the dense phase of the ISM in  $z > 6$  quasar host galaxies”, summer 2020.  
• “Shocked and warm molecular gas in hyper-luminous infrared quasars at  $z > 6$ ”, summer 2019.

## ■ PUBLICATIONS -----

- Refereed papers:
- 5) *An ALMA multi-line survey of the ISM in two quasar host—companion galaxy pairs at  $z > 6$* , Pensabene A., Decarli, R., Bañados E., Venemans B., Walter F., Bertoldi F., Fan X., Farina E. P., Li J., Mazzucchelli C., Novak M., Riechers D., Rix H.-W., Strauss M. A., Wang R., Weiß A., Yang J., and Yang Y., submitted to A&A.
  - 4) *Probing the Nature of High Redshift Weak Emission Line Quasars: A Young Quasar with a Starburst Host Galaxy*, Andika I. T., Jahnke K., Onoue M., Bañados E., Mazzucchelli C., Novak M., Eilers A., Venemans B., Schindler J., Walter F., Neeleman M., Simcoe R. A., Decarli R., Farina E. P., Marian V., Pensabene A., Cooper T. M., and Rojas A. F., [2020, ApJ, 903, 34](#).
  - 3) *Discovery of molecular gas fueling galaxy growth in a protocluster at  $z=1.7$* , D’Amato Q., Gilli R., Prandoni I., Vignali C., Massardi M., Mignoli M., Cucciati O., Morishita T., Decarli R., Brusa M., Calura F., Balmaverde B., Chiaberge M., Liuzzo E., Nanni R., Peca A., Pensabene A., Tozzi P., and Norman C., [2020, A&A, 641, L6](#).
  - 2) *The ALMA view of the high-redshift relation between supermassive black holes and their host galaxies*, Pensabene A., Carniani S., Perna M., Cresci G., Decarli R., Maiolino R., and Marconi A., [2020, A&A, 637, A84](#).
  - 1) *Testing the paradigm: First spectroscopic evidence of a quasar—galaxy Mpc-scale association at cosmic dawn*, Decarli R., Mignoli M., Gilli R., Balmaverde B., Brusa M., Capelluti N., Comastri A., Nanni R., Peca A., Pensabene A., Vanzella E., and Vignali C., [2019, A&A, 631, L10](#).

## ■ CONFERENCES & WORKSHOPS -----

Talks at conferences: • “SAZERAC-Sip: Quasars During Reionisation”, online conference, 2020, December 3-4.

- “Black Holes and Galaxies at the Edge of the Universe”, Ringberg Castle, Kreuth (Germany), 2020, March 1-6.
- “Views of the Interstellar Medium in galaxies in the ALMA era”, Bologna (Italy), 2019, September 2-6.
- “ALMA Science and Proposals Workshop”, Bologna (Italy), 2019, February 25-27.
- “AGN 13 - The Beauty and the Beast”, Milan (Italy), 2018, October 9-12.

- Other attended conferences, schools and workshops:
- “AGN Tournays 2020: Waiting for the Renaissance”, online seminars, 2020 October, 12-16.
  - “Dark and Quiet Skies for Science and Society”, online workshop, 2020 October, 5-9.
  - “SAZERAC: The Summer All-Zoom Epoch of Reionization Astronomy Conference”, telematic conference, 2020, July, 6-9.
  - “JWST Italian Proposal Preparation Workshop”, Bologna (Italy), 2020, April, 6-8.
  - “IAU Symposium 352: Uncovering the Early Galaxy Evolution in the ALMA and JWST era”, Viana do Castelo (Portugal), 2019, June 3-7.

## ■ ORGANIZATION OF EVENTS -----

- Conferences: **Member of the Local Organizer Committee of:**
- “Views of the Interstellar Medium in galaxies in the ALMA era”, Bologna (Italy), 2019, September 2-6.

## ■ TALKS -----

- Seminars:
- INAF-Arcetri Astrophysical Observatory, Florence, Italy, 2019, October 1.
  - ESO headquarter, Santiago, Chile, 2018, December 17.

## ■ EXPERIENCES -----

- Research period abroad:
- Visiting student at Kavli Institute for Cosmology, University of Cambridge, Cambridge (UK), May 2017.

## ■ OUTREACH ACTIVITIES -----

- Third mission:
- Coordinator of “UNI-PhDcast”. Project funded by University of Bologna for scientific dissemination via podcasting activities.
  - Scientific assistance at “Notti d’estate ad Arcetri 2018”, INAF-Arcetri Astrophysical Observatory, Firenze (Italy).

## ■ GRANTS & AWARDS -----

- **Stefano Magini Prize 2018** for the best Master Thesis on Astrophysics from an Italian University during 2017/2018.
- **6-months scholarship** on the “Study of the relation between black holes and galaxies in primordial Universe” funded by the Department of Physics and Astronomy, University of Florence, Italy during the period 2018, May-October. Supervisor: Prof. Alessandro Marconi.

## ■ LANGUAGES -----

- First language: Italian
- Other languages: English • Read: B2, Write: B2, Speak: B2

**■ ABILITIES & SKILLS** -----

Technical skills:

**Data retrieving, reduction & analysis:**

Wide experience in astronomical data reduction and analysis with CASA, and in data querying from the ESO, ALMA, and HST archives.  
Excellent practice with NED, SIMBAD and VizieR services.

**Programming languages known:**

Excellent skills with Python. Basic knowledge of IDL, Fortran, C and bash.  
Experience with Maple.

**Software and Operating Systems:**

Wide experience with MacOS systems, Linux releases and Microsoft Windows.

Excellent skills with LaTeX and Microsoft Office (and equivalent) software.  
Experience with graphics, digital sound mixing and sound engineer software (Adobe Photoshop, Ableton, Logic, Cubase).

Teaching skills:

Wide experience in private tutoring high-school and university students on mathematics and physics topics. Experienced also with SLD students.

**■ HOBBIES & INTERESTS** -----

I am interested in most of scientific research topics, popular science and scientific dissemination. I love arts in any form, in particular music. I play drums, Middle Eastern and African percussions and guitar. I like most of the existing sports, in particular basketball, climbing and football and I practiced athletics at professional level. I love wilderness, especially desert environments. I like trekking and hiking in mountains.