

Laura Colzi



Title

Nitrogen isotopes in the interstellar medium: a chemical journey across the Galaxy

Abstract

One of the most important tools to investigate the chemical history of our Galaxy and our own Solar System is to measure the isotopic fractionation of chemical elements. This is the process that distributes the less abundant stable isotopes of an element in different molecules. The isotopic ratios are governed by two main processes: 1. chemical evolution of the whole Galaxy due to stellar nucleosynthesis; and 2. local fractionation effects.

For the case of nitrogen (N), the $^{14}\text{N}/^{15}\text{N}$ isotopic ratio found for the proto-Solar nebula, 440, is significantly higher than that measured in pristine Solar System materials, like comets (around 140). This suggests a local chemical enrichment of ^{15}N during the Solar System formation. However, the causes of the ^{15}N -enrichment are still uncertain.

In this talk I will briefly review the state-of-the-art of the astronomical observations and theoretical chemical models devoted to the study of nitrogen fractionation. I will show the overall behavior of the $^{14}\text{N}/^{15}\text{N}$ ratio across the Galaxy. In particular, based on a large survey of star-forming regions, we have confirmed that the $^{14}\text{N}/^{15}\text{N}$ ratio increases with the galactocentric distance. This overall trend can be explained by nucleosynthesis Galactic chemical evolution models.

Furthermore, I will present the first interferometric maps of N-fractionation of N_2H^+ towards a star-forming region. Our results highlight the importance of local effects, and in particular of isotope-selective photodissociation of N_2 , in determining the ^{15}N -enrichments in star-forming regions.

Laura Colzi

Curriculum Vitæ et Studiorum

Personal Data

✉ Centro de Astrobiología (CSIC-INTA), Ctra. de Torrejón a Ajalvir km 4, 28850, Torrejón de Ardoz, Madrid - Spain

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Nationality Italian

Date of birth 16/09/1991

Professional Experience

01/08/2020- Present **Postdoc position**, *Centro de Astrobiologia (CSIC-INTA)*, Torrejon de Ardoz, Madrid - Spain.

04/03/2020- 31/07/2020 **Visitor Scientist**, *INAF - Arcetri Astrophysical Observatory*, Florence (FI) - Italy.

Education

11/2016- 04/03/2020 **European PhD (Doctor Europæus) in Physics and Astronomy, curriculum of Astronomy**, *Università degli Studi di Firenze*, Florence (FI) - Italy, Supervisor: Dott. Francesco Fontani, Co-Supervisor: Prof. Guido Risaliti.

2013- 2016 **Master's Degree in Physical and Astrophysical Sciences, curriculum of Astrophysics**, *Università degli Studi di Firenze*, Florence - Italy, with a final grade of 110/110 cum laude.

2010- 2013 **Bachelor's Degree in Physics and Astrophysics**, *Università degli Studi di Firenze*, Florence - Italy, with a final grade of 104/110.

2005- 2010 **High School Diploma (commercial technical Institute)**, *I.T.C Paolo Dagonari*, Prato - Italy, with a final grade of 100/100.

PhD

Title *Isotopic fractionation study towards massive star-forming regions across the Galaxy.*

Supervisor Dott. Francesco Fontani, INAF - Osservatorio Astrofisico di Arcetri, fontani@arcetri.astro.it.

Co- Supervisor Prof. Guido Risaliti, Università degli Studi di Firenze, guido.risaliti@unifi.it.

Notes Redacted in English and defended on 4th March 2020.

Master's thesis

- Title *Isotopic fractionation of Nitrogen in molecular clouds with massive star formation.*
- Supervisor Dott. Francesco Fontani, INAF - Osservatorio Astrofisico di Arcetri, fontani@arcetri.astro.it.
- Co-supervisor Prof. Guido Risaliti, Università degli Studi di Firenze - Dipartimento di Fisica e Astronomia, INAF - Osservatorio Astrofisico di Arcetri, guido.risaliti@unifi.it, risaliti@arcetri.astro.it.
- Notes Redacted in Italian and defended on 26 October 2016.

Bachelor's thesis

- Title *Current sheet collapse and magnetic reconnection in the framework of resistive magnetohydrodynamic.*
- Supervisor Dott. Simone Landi, Università degli Studi di Firenze - Dipartimento di Fisica e Astronomia, simone.landi@unifi.it.
- Notes Redacted in Italian and defended on 12 December 2013.

Seminars

✳ **AstroBigné seminar at Arcetri Astrophysical Observatory**, March 31, 2020, Florence, Italy.

Title: "Enhanced nitrogen fractionation at core scales: the high-mass star-forming region IRAS 05358+3543".

AstroBigné is a series of seminars that are held at the Osservatorio, with the goal of interconnecting the community of people working there, spreading new ideas and results, creating and reinforcing synergies between groups and individuals.

Conferences and workshops

✳ **Fractionation of isotopes in space: from the solar system to galaxies**, October 10-13, 2016, INAF - Osservatorio Astrofisico di Arcetri, Florence, Italy.

Presentation of POSTER: "Nitrogen and Hydrogen fractionation in high-mass star forming cores through observations of HCN and HNC".

The main goal of this meeting is to bring together observers, theoreticians and experimentalists interested in the fractionation of elements from any kind of astrophysical background.

✳ **Francesco's Legacy - Star Formation in Space and Time**, June 5-9, 2017, Istituto degli Innocenti, Florence, Italy.

Presentation of POSTER: "Nitrogen fractionation in high-mass star forming cores and its Galactic trend".

The goal of this conference is to gather observational and theoretical experts in the various aspects of the star formation process addressed by Francesco Palla in his career, to outline the advances in these studies and to discuss the prospects for future developments.

✳ **YERAC: Young European Radioastronomers Conference**, September 18-21, 2017, Area della Ricerca CNR, Bologna, Italy.

Presentation of TALK: "Nitrogen fractionation in high-mass star forming cores and its Galactic trend".

The purpose of YERAC is for undergraduate, graduate and young post-doctoral students in radio astronomy from all over Europe to meet each other and present their work. 'Europe' includes any country from Russia in the East to Portugal in the west, plus affiliates of the European VLBI Network, RadioNet or other current bodies.

✳ **IV Workshop sull'Astronomia Millimetrica in Italia**, November 07-10, 2017, Area della Ricerca CNR, Bologna, Italy.

Presentation of POSTER: "Nitrogen fractionation across the Galaxy: Observations of the $^{14}\text{N}/^{15}\text{N}$ ratio in a large sample of high-mass star-forming cores".

The meeting brings together the Italian community interested in research into the (sub)millimetric field. Projects that use tools in the (sub)millimeter have been discussed, together with the synergies with instruments in other bands. Italian technical contribution to the instruments have also been given.

✳ **ASTRO-Winter Modeling**, February 15-16, 2018, Department of Chemistry "Giacomo Ciamician", Bologna, Italy.

The annual Winter Modeling meetings act as a platform to exchange ideas and promote collaborations within the broad community of researchers working in the multidisciplinary field of Computational Chemistry and, in the spirit of filling the gap between theory and experiment, also provide the opportunity to interact with experimentalists.

✳ **Prebiotic Molecules in Space and Origins of Life on Earth**, March 19-23, 2018, Physikzentrum Bad Honnef, Bad Honnef, Germany.

Presentation of POSTER: "Nitrogen fractionation in high-mass star forming cores across the Galaxy". **Best Poster Award.**

The aim of this conference was to bring together astrochemists working on prebiotic molecules in space, Solar System scientists, the exoplanet community, geochemists and biophysicists.

✳ **Cosmic Rays: the salt of the star formation recipe**, 2-4 May, 2018, Department of Physics and Astronomy in Arcetri, Firenze, Italy.

Presentation of POSTER: "Carbon isotope chemistry in intermediate- and high-mass star forming cores".

The workshop has the goal of bringing together experts in theory and simulations of cosmic-ray propagation, astrochemists, and observers to share ideas, discuss about recent and present results, and identify the key challenges regarding the chemistry and the physics of cosmic rays for the near future.

✳️ **Astrochem2@2018: Chemical Evolution in our Galaxy**, 13-16 June, 2018, Fonderia n.1, Follonica, Italy.

Contributed TALK: "Nitrogen fractionation in high-mass star-forming cores across the Galaxy".

As a continuation of the first Italian Workshop on Astrochemistry, held in March 2016 at Palazzo Strozzi (Firenze), the focus of this 2nd edition is still the synergy between astronomers and chemists to comprehend the chemical complexity and evolution in our Galaxy.

✳️ **IAU General Assembly 30 - Focus Meeting: Radial Metallicity Gradients in Star-Forming Galaxies**, 28-28 August, 2018, Vienna, Austria

Contributed TALK: "Nitrogen isotopic ratio across the Galaxy".

This Focus Meeting was forum to discuss the recent and future advances in the field of the spatial distribution of metallicity in galaxies, including the Milky Way.

✳️ **Fractionation, Astrochemistry and Star/Planet formation**, September 19-21, 2018, Chalmers University, Göteborg, Sweden.

INVITED TALK: "Nitrogen fractionation in high-mass star-forming regions across the Galaxy".

✳️ **From Stars to Planets II**, 17-20 June, 2019, Chalmers Conference Center, Gothenburg, Sweden

Presentation of POSTER: Enhanced nitrogen fractionation at core scales: the high-mass star-forming region IRAS 05358+3543".

Star formation, planet formation, astrochemistry and exoplanet studies are undergoing rapid, revolutionary advances and this conference aims to bring together researchers in these fields, especially to explore and develop new connections.

✳️ **Astrochemistry: From nanometers to megaparsecs**, 24-28 June, 2019, Chalmers Conference Center, Gothenburg, Sweden

Contributed TALK: Enhanced nitrogen fractionation at core scales: the high-mass star-forming region IRAS 05358+3543".

The scientific purpose of this symposium is to highlight the fundamental connection between the theory of microscopic processes studied on Earth and the understanding of phenomena in a wide range of space environments.

✳️ **Congresso Nazionale di Astrochimica e Astrobiologia (proto-) planetaria**", 21-23 October, 2019, Castello di Duino, Duino, Trieste, Italy

Contributed TALK: "Enhanced nitrogen fractionation at core scales: the high-mass star-forming region IRAS 05358+3543".

The scientific purpose of this congress is to put together the Italian communities of protostellar and protoplanetary astrochemistry, planet formation, exoplanets atmospheres and astrobiology.

* **Astrochemical Frontiers - Quarantine Edition**", 15-19 June, 2020, VIRTUAL MEETING

Contributed TALK: "[Carbon isotopic fractionation in molecular clouds \(video from minute 02:10:35\)](#)".

The scientific purpose of this conference is to give the opportunity to astrochemists to present their works during the COVID-19 pandemic.

* **European Astronomical Society Annual Meeting (EAS2020) - Special Session "The molecular journey from stars to disks"**, 29 June - 03 July, 2020, VIRTUAL MEETING

Contributed TALK: "Enhanced nitrogen fractionation at core scales: the high-mass star-forming region IRAS 05358+3543".

The session was focused on the study of molecules and their isotopologues and what they can teach us about the journey of molecules in our Galaxy.

PhD schools

* **KROME - Computational School**, September 19-21, 2016, Villa il Gioiello, Arcetri, Florence, Italy.

Lectures and step-by-step tutorials about KROME: it has been developed to solve the chemical and thermal evolution of the gas in astrophysical problems.

* **9th IRAM 30m Summerschool 2019**, September 6-13, 2019, Pradollano, Granada, Spain

The 9th IRAM 30m summerschool combined lectures on millimeter astronomy with observations using the 30m telescope.

Other Events

* **PhDday⁸ - the day dedicated to the PhD students**, May 24, 2017, Polo Scientifico, Sesto Fiorentino (FI), Italy.

Presentation of TALK: "Chemical evolution of Intermediate- and Highmass star forming regions".

The PhDday is an event that brings together the academia from different fields of study and undergraduate students to allow building a scientific research network in the University of Florence.

* **PhDday⁹ - the day dedicated to the PhD students**, May 31, 2018, Polo Scientifico, Sesto Fiorentino (FI), Italy.

Presentation of TALK: "Nitrogen fractionation and its Galactic trend".

✳ **International Astronomical Union Early Career Astronomer Online Discourse Series:**

- **"The IAU: What does it do? How to get involved?" & "Careers discussion"**, Prof Dr. Ewine F. van Dishoeck (IAU President), October 15, 2020.
- **"Careering through astrophysics"** Prof. Dr. Jocelyn Bell Burnell (University of Oxford), October 22, 2020.
- **"ESO: the most powerful telescopes and a community of practice"** Prof. Dr. Xavier Barcons (ESO Director General), October 29, 2020.
- **Workshop "How to present online?"** Hans Van de Water (The Floor is Yours), November 12, 2020.
- **"A colorful career in star formation from optical to radio wavelengths"** Dr. Ágnes Kóspál (Konkoly Observatory), November 27, 2020.

Courses

✳ **Advanced Python for Astronomy**, November 2016, Osservatorio Astrofisico di Arcetri, Florence, Italy.

Overview of some advanced aspects of the Python programming language, with particular focus on scientific and astronomical packages.

✳ **Online courses from the "Academia Maria de Maetzu"** of the Centro de Astrobiología, Torrejon de Ardoz, Madrid, Spain:

- **"Round table on biomarkers"**, Victor Rivilla, Jorge Plá, Laura Sánchez and Victor Parro, September 30, 2020.

- **"Venusian Babies: Analytical Methods and Interpretation of Results"**, Marta Ruiz Bermejo, November 17, 2020.

✳ **Space projects cycle from the "Academia Maria de Maetzu"** of the Centro de Astrobiología, Torrejon de Ardoz, Madrid, Spain:

- **"Project Management in a Space Exploration Project"**, Roser Urquí, October 13, 2020.

- **"Systems Engineering is the interdisciplinary approach governing the total technical effort to transform requirements into a system solution"**, Carlos Pérez, October 27, 2020.

- **"Quality Assurance in Space Projects"**, M^a del Rosario Canchal Moreno, November 10, 2020.

- **"Space Qualification Process"**, Andoni Gaizka Moral, November 24, 2020.

Participation in Large Scientific Collaborations

✳ Part of the *GUAPOS* (G31.41+0.31 Unbiased ALMA sPectral Observational Survey) team. P.I: Maite Beltrán.

✳ Part of the *ALCHEMI* (The ALMA Comprehensive High-resolution Extragalactic Molecular Inventory) Large Program. P.Is: Sergio Martín, Nanase Harada, Jeff Mangum.

Grants and Funding

* **RadioNet support for Short Term Mission to the MPI für extraterrestrische Physik.** I have received funding from the European Union's Horizon 2020 research and innovation programme under grant agreement No 730562 [RadioNet].

* **RadioNet support, within the Transnational Access Programme, to visit IRAM Grenoble for project S18AQ.** I have received funding from the European Union's Horizon 2020 research and innovation programme under grant agreement No 730562 [RadioNet].

* **RadioNet support, within the Transnational Access Programme, to visit the IRAM 30m radiotelescope for the project 040-19.** I have received funding from the European Union's Horizon 2020 research and innovation programme under grant agreement No 730562 [RadioNet].

* **Joint Alma Observatory (JAO) Visitor Program, to visit the ALMA central office in Santiago de Chile.** I have received funding from the JAO Visitor Program and I will visit ALMA in Santiago de Chile, two months in 2020, to work with Sergio Martín with data arising from the ALMA Large program ALCHEMI. **Note: The visit is postponed to a new date, to be decided, due to COVID-19.**

Astronomy skills

* Use of *MADCUBA* (Madrid Data Cube Analysis on ImageJ) that is a software developed in the Center of Astrobiology of Madrid (Martín et al. 2019).

* Use of *CLASS*, *GREG*, *MAPPING*, *CLIC* and *ASTRO* software of GILDAS package.

* Use of *Astropy*, a community Python library for astronomy.

* Observing experience with IRAM 30m radiotelescope and calibration/reduction experience with NOEMA data.

* Merging of interferometric maps and single-dish maps.

* Use of the ALMA Observing Tool to prepare proposals.

* Use and implementation of the chemical code PyRate (Sipilä et al. 2015) to study isotopic fractionation of molecules.

Observational experience

* Calibration and Reduction of the NOEMA project S16AK: Are Hydrogen and Nitrogen fractionation related in massive star forming cores? - Related publication: Colzi et al. 2018b.

* Calibration and Reduction of the NOEMA project S18AQ: Is nitrogen fractionation in nitrile bearing species and N_2H^+ related in massive star-forming cores?

* IRAM 30m observations of the project 163-18: Where is the missing (but not depleted!) phosphorus?

* IRAM 30m observations of the project 040-19: Is N-fractionation regulated by isotope-selective photodissociation?

Computer skills

Operating systems Mac OS X, Windows

Languages Python, \LaTeX , Fortran, C++

Mentoring

* Supervisor of the Master Thesis student Raúl Blanco Furones of the *Universidad Complutense* in Madrid. The title of his project is "Study of isotopic ratios towards a Galactic molecular cloud".

Languages

Italian Mother Tongue

Other languages: self-assessment European language level ([CEFR](#))

		Understanding		Speaking		Writing
		Listening	Reading	Spoken interaction	Spoken production	
English	Intermediate	B2	B2	B2	B1	B2
Spanish	Intermediate	B2	B1	B1	B1	A2
French	Elementary	A2	B1	A1	A1	A2

Publications

* **L. Colzi**, F. Fontani, P. Caselli, C. Ceccarelli, P. Hily-Blant and L. Bizzocchi, 2017, "Nitrogen and hydrogen fractionation in high-mass star forming cores from observations of HCN and HNC", *Astronomy & Astrophysics*, **609**, A129.

* **L. Colzi**, F. Fontani, V. M. Rivilla, A. Sánchez-Monge, L. Testi, M. T. Beltrán, and P. Caselli, 2018, "Nitrogen fractionation in high-mass star-forming cores across the Galaxy", *MNRAS*, **478**, 3693.

* F. Fontani, A. Vagnoli, M. Padovani, **L. Colzi**, P. Caselli, V. M. Rivilla, 2018, "Protonated CO₂ in massive star-forming clumps", *MNRAS*, **481**, L79.

* **L. Colzi**, F. Fontani, P. Caselli, S. Leurini, L. Bizzocchi, G. Quaia, 2019, "First interferometric study of enhanced N-fractionation in N₂H⁺: the high-mass star-forming region IRAS 05358+3543", *MNRAS*, **485**, 5543.

* F. Fontani, G. Quaia, C. Ceccarelli, **L. Colzi**, C. Favre, C. Kahane, P. Caselli, C. Codella, L. Podio, S. Viti, 2020 "No nitrogen fractionation on 600 au scale in the Sun progenitor analogue OMC-2 FIR4 ", *MNRAS*, **493**, 3412.

* V. M. Rivilla, **L. Colzi**, F. Fontani, M. Melosso, P. Caselli, L. Bizzocchi, F. Tamassia, L. Dore, 2020 "DC3N observations towards high-mass star-forming regions", *MNRAS*, **496**, 1990.

- * **L. Colzi**, O. Sipilä, E. Roueff, P. Caselli, F. Fontani, 2020 "Carbon isotopic fractionation in molecular clouds", *A&A*, **640**, A51.
- * A. Coletta, F. Fontani, V. M. Rivilla, C. Mininni, **L. Colzi**, Á. Sánchez-Monge, and M. T. Beltrán, 2020 "Evolutionary study of complex organic molecules in high-mass star-forming regions", *A&A*, **641**, A54.
- * M. Melosso, L. Bizzocchi, A. Adamczyk, E. Canè, P. Caselli, **L. Colzi**, L. Dore, B. M. Giuliano, J-C. Guillemin, M-A. Martin-Drumel, O. Pirali, A. Pietropoli Charmet, D. Prudenzano, V. M. Rivilla, F. Tamassia, 2020 "Extensive ro-vibrational analysis of deuterated-cyanoacetylene (DC₃N) from millimeter-wavelengths to the infrared domain", *JQSRT*, **254**, 107221.
- * C. Mininni, M. T. Beltrán, V. M. Rivilla, A. Sánchez-Monge, F. Fontani, T. Möller, R. Cesaroni, P. Schilke, S. Viti, I. Jiménez-Serra, **L. Colzi**, A. Lorenzani, L. Testi, 2020 "The GUAPOS project: G31.41+0.31 Unbiased ALMA sPectral Observational Survey – I. Isomers of C₂H₄O₂", *accepted for publication in A&A*, [arXiv:2009.13297](https://arxiv.org/abs/2009.13297).

Proceedings

- * **L. Colzi**, F. Fontani, V. M. Rivilla A. Sánchez-Monge, L. Testi, M. Beltrán, P. Caselli, 2017, "Nitrogen Fractionation Across the Galaxy: Observations of the ¹⁴N/¹⁵N Ratio in A Large Sample of High-Mass Star-Forming Cores", *Memorie della SAIt*, **88**, 728.
- * **L. Colzi**, 2017, "Nitrogen fractionation in high-mass star forming cores and its Galactic trend", *Workshop sull'Astronomia Millimetrica in Italia*, **18**.
- * **L. Colzi**, F. Fontani, V. M. Rivilla A. Sánchez-Monge, L. Testi, M. Beltrán, P. Caselli, 2018, "Nitrogen isotopic ratio across the Galaxy through observations of high-mass star-forming cores", *Astronomy in Focus XXX, presented at IAU XXX General Assembly, Vienna, Austria. Proceedings of the IAU, 2020*, pp. 277-277.

PI-Observative projects

- * PI of the IRAM-NOEMA project S18AQ: "Is nitrogen fractionation in nitrile bearing species and N₂H⁺ related in massive star-forming cores?".
- * PI of the IRAM-30m project 040-19: "Is N-fractionation regulated by isotope-selective photodissociation?".
- * co-I of 4 IRAM-30m projects, 1 ALMA (Cycle 5) project and 1 ALMA (Cycle 6) project.

Organisation activities

- * I have organised the S.P.O.K. (Stars and Planets Oriented Koffee), that is a star formation group informal meeting at the *Osservatorio Astrofisico di Arcetri*, during my PhD.

* Currently, I am one of the organisers of the MAC=Ap (Madrid Astro Chemical APeritivo) meeting of the astrochemical group at the *Centro de Astrobiologia*, CSIC, Madrid.

Outreach

* Participation in the scientific dissemination activities of the "Associazione Astronomica Amici di Arcetri".

* Organiser of the event for children at the Astrophysical Observatory of Arcetri (Florence, Italy): "Bambineide" the 27th May 2017.

* Speaker of the dissemination seminar at the Astrophysical Observatory of Arcetri (Florence, Italy) titled "From nebulae to asteroids" the 9th July 2019. This was one of the seminars of the summer event at the observatory called "Arcetri's Nights".

Other

Driving licence(s) Class B