RadioNet support for Short Term Missions (staff exchange)
Application form

STM Information	
Applicant 's Name	Laura Colzi
Applicant's Affiliation	Università di Firenze, Italy – INAF, Arcetri Atrophysical Observatory (Florence, Italy)
Host Institute	Max-Planck-Institüt für extraterrestrische Physik, Giessenbachstrasse 1, D-85748, Garching bei München, Germany Contact Person: Prof. Dr. Paola Caselli, e-mail: caselli@mpe.mpg.de, Phone: +49-89-30000-3400 In attachment, there is a copy of the invitation letter.
Date of the STM	Expected start date: January 8th, 2018 Expected end date: February 9th, 2018
Total Cost of STM	1500 euros
Other sources of funding	Scholarship funds from the University of Florence

Request *(max. 2,5 pages)*

Topic	I will perform a part of my PhD Thesis in the Center for Astrochemical Studies (CAS) at Max Planck Institute for Extraterrestrial Physics (MPE). I will work with Prof. Paola Caselli and Dr. Olli Sipilä to implement an existing chemical model to understand nitrogen fractionation in high mass star forming cores. From an observational point of view, a way to understand why ^{15}N (less abundant isotope of nitrogen) is enriched with respect to ^{14}N is to measure and compare the abundances of molecules through (sub)mm observations of molecular transitions: to do that, radiotelescopes with single-dish antenna and interferometers (higher spatial resolution with respect to single-dish antenna) are needed. In particular, we have observations taken at IRAM-30m in June 2015: 27 high-mass star forming cores were observed in the receivers at 3 and 2mm, and through the ground state rotational transition of $H^{13}CN$ and $HN^{13}C$ (and ^{15}N-isotopologue) we have measured the $^{14}N/^{15}N$ ratios in order to compare one with each other (Colzi et al. 2017 submitted to A&A). We have also other IRAM-30m observations of additional 66 high-mass star forming cores with which we have implemented the statistics, and we are also searching for a Galactocentric trend of the $^{14}N/^{15}N$ ratios, in the same molecules, HCN and HNC (Colzi et al. in prep). Moreover, we have NOEMA interferometric observations of the ground state transition of N_2H^+, $^{15}NNH^+$, $N^{15}NH^+$, and N_2D^+ towards the protocluster IRAS 05358+3543, which harbors protostars in different evolutionary stages: from these data, we will determine the emission morphology of the various molecules at angular scales of few arcseconds, which will allow us to derive the fractionation of nitrogen and hydrogen in cores with different ages. My work at MPE has the goal of interpreting these observational results (and others in the future) with a modeling astrochemical work.
Proposed work	The stable less abundant isotope of nitrogen, ^{15}N, is enriched in comets and carbonaceous chondrites with respect to the value measured in the Protosolar Nebula (PSN), but the reasons for ^{15}N enrichment are still highly uncertain. For example, $HC^{15}N$ and $H^{15}NC$ are thought to be formed through the dissociative recombination of $HC^{15}NH^+$: in fact, Terzieva & Herbst (2000) found that the reaction that causes the most of N-fractionation is the exchange reaction between ^{15}N and HCNH+: $^{15}N + HCNH^+ \rightarrow N + HC^{15}NH^+ + 35.1K$, but they assumed that this reaction could occur without an energy barrier. The most recent and complete chemical models (Roueff et al. 2015) are implemented with the recent discovery that this reaction has an energy barrier and indicate that ^{15}N should not be enriched in

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	these molecules during the evolution of a star-forming core, not even at the very early cold phases. The model of Roueff et al. (2015) have reviewed some of the reactions in ^{15}N-fractionation, and concluded that other modeling work is necessary to fully understand the relation of the two fractionation processes. Sipilä et al. (2015) employed gas phase and gas-grain models to investigate chemical abundances in physical conditions that correspond to starless cores, and they have developed new chemical reactions sets including the deuterated forms of species with up to six atoms. My work at MPE has the aim of implementing a reduced version of this chemical network by introducing the ^{15}N-bearing form of species with up to 4/5 atoms, and run the models in order to simulate how it works for high-mass star forming cores. Moreover, in our work on HCN/HC^{15}N (and HNC/H^{15}NC), we computed the ^{14}N/^{15}N considering the isotopogues H^{13}CN and HN^{13}C, which have the advantage of being optically thin with respect to those including the ^{12}C, but require to be corrected for the ^{12}C/^{13}C ratio. In this respect, our models will need to contain also chemical reactions that take C-fractionation into account, as done by Roueff et al. (2015). Finally, we will compare the abundances that will come out from our new models, and discuss them with other existing similar works.
Cross-disciplinary	It is well known how in astrochemistry it is important the collaboration of three types of researchers: observers, modelers, and laboratory experts. In our Star Formation Group in the Observatory of Arcetri (Florence) most of the researchers are specialized in the analysis of observations, taken with the best existing radio telescopes (NOEMA, IRAM-30m, ALMA, VLA), as well as with instruments operating at different wavelengths. Therefore, to compare our results with astrochemical models most of the times we have to ask our collaborators in other Institutes, making the process of data analysis less efficient. This part of my PhD thesis in collaboration with the experts in astrochemical models at MPE will be an opportunity for me and for all the Arcetri star-formation group to implement the internal knowledges. Moreover, thanks to the link between MPE and Arcetri created by me, in the future new students could start to work in our group (for Master thesis or PhD thesis) and could have the chance to learn something both from an observational point of view and from the models.
Impact	Because transitions of molecules having less abundant isotopes are expected to be fainter, in general, our observations need to have more and more sensitive receivers, and also broader frequency bands. This last requirement is particularly relevant for astrochemical studies because larger receiver bands will provide more molecular transitions in a single spectrum. These reasons lead the industries to produce even more refined radio-receivers for radiotelescopes like IRAM-30m or for the antennas which compose the NOEMA interferometer.
Curriculum Vitae	In attachment, there is a copy of my Curriculum Vitae.

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Max-Planck-Institut für extraterrestrische Physik

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28 June 2017

Dear Ms. Colzi,

It is a pleasure to invite you to spend one month (from January 8th until February 9th, 2018) at the Center for Astrochemical Studies at the Max-Planck Institute for Extraterrestrial Physics to carry out the project within the context of RadioNet. During your stay, you will learn about astrochemical codes and upgrade the current version available at my Institute, so that the future code will include the rare isotopes 15N and 13C. This will allow direct comparison between observations and model predictions, improving our understanding of the chemical fractionation you have measured toward regions of high-mass star formation, and it will expand your expertise.

With kind regards

Paola Caselli

Prof. Dr. Paola Caselli
Director of the Center for Astrochemical Studies
at the Max-Planck-Institute for Extraterrestrial Physics

Laura Colzi

Curriculum Vitæ et Studiorum

Personal Data

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✉ Università degli Studi di Firenze, Dip. di Fisica e Astronomia, Via G. Sansone 1 - 50019 Sesto Fiorentino (FI) - Italy

Nationality Italian

Date of birth 16/09/1991

Education

11/2016 - Present **PhD student in Physics and Astronomy, curriculum of Astronomy**, *Università degli Studi di Firenze*, Florence (FI) - Italy, Supervisor: Dott. Francesco Fontani.

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 Dagomari*, Prato - Italy, with a final grade of 100/100.

PhD project

Title *Chemical evolution of intermediate- and high-mass star forming regions.*

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

Short description On the basis of my master's thesis, in my PhD research project I will continue to study the chemical evolution, in a more general way, in high- and intermediate-mass star formation regions, using samples of sources different from that used in the thesis work. The PhD goal will be to analyze different osservational data to test laboratory work and/or theoretical models. Observations will be made with single dishes (e.g. IRAM-30m) and interferometers (e.g. NOEMA). Furthermore, a modeling work will be done.

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.

Short description The two stable less abundant isotopes of nitrogen and hydrogen, ^{15}N and D, are both enriched in comets and carbonaceous chondrites with respect to the values measured in the Protosolare Nebula (PSN). This raises the question whether the two enrichments have a common origin, and if they are linked to the past chemical history of the Solar System. Because our Sun was born in a rich cluster, possibly including massive stars, to understand this and constrain chemical models, measurements of ^{14}N/^{15}N and H/D ratios in massive, dense star forming cores are mandatory. For this purpose we have observed this cores through the rotational transitions HN^{13}C, H^{13}C, HC^{15}N (J=1-0) and DNC(J=2-1) with the IRAM-30m Telescope toward a sample of high-mass star forming cores that belong to three evolutionary categories of star formation process.

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.

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

❋ **Francesco's Legacy - Star Formation in Space and Time**, June 5-9, 2017, Istituto degli Innocenti, Florence, Italy.
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.
Presentation of POSTER: "Nitrogen fractionation in high-mass star forming cores and its Galactic trend".

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.

Astronomy skills

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

Computer skills

Operating systems: Mac OS X, Windows

Languages: LaTeX, Fortran, C++, Maple, IDL, Visual Basic, Visual RPG

Languages

Italian: Mother Tongue

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

		Understanding		**Speaking**		**Writing**
		Listening	Reading	Spoken interaction	Spoken production	
English	Intermediate	*B2*	*B1*	*B1*	*A2*	*B1*
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", *submitted to Astronomy & Astrophysics*

Other

Driving licence(s) Class B