

Romane Le Gal

Post-doctoral Researcher at Harvard University

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Research Interests

- **Astrochemistry from molecular clouds to planet-forming disks:**

Modeling the chemical evolution of star-forming regions, from prestellar stages to planetary nebulae.

- **Millimetric and sub-millimetric observations:**

Single-dish and interferometric observations towards prestellar regions, protostars and circumstellar disks, including their data-analysis.

Education and Degrees

- 2011 – 2014 **Ph.D. in Astrophysics**, Institut de Planétologie et d'Astrophysique de Grenoble (IPAG), Grenoble Alpes University, France
- 2010 – 2011 **M.S. Degree in Subatomic Physics and Astroparticles**, Grenoble Alpes University, France, *honors*
- 2008 – 2011 **M.S. Degree in Engineering and Mechanical Physics**, National Engineering School of Higher Education in mechanical physics (SUP-MECA), Paris, France
- 2005 – 2008 **Classes Préparatoires aux Grandes Ecoles d'Ingénieurs**,
Option: Physics & Chemistry, Lycée Saint-Louis, Paris, France
- 2005 **Scientific Baccalaureate**, Lycée Claude Monet, Paris, France, *honors*

Research Experience

- 09/2017 – Present **Post-doctoral researcher** at Harvard University, Cambridge, Massachusetts, USA
Advisor: Karin Öberg
- 01/2015 – 08/2017 **Research Associate** at University of Virginia, Charlottesville, USA
Advisor: Eric Herbst
- 10/2011 – 12/2014 **Ph.D. thesis**, Institut de Planétologie et d'Astrophysique de Grenoble (IPAG), France
Subject: *Nitrogen chemistry in dark clouds*
Supervisors: Pierre Hily-Blant and Alexandre Faure
- 03/2011 – 07/2011 **Research internship**, Laboratoire de Physique Subatomique et de Cosmologie (LPSC), within the PLANCK group, Grenoble, France
Subject: *Study of gravitational lensing on the CMB with Planck satellite*
Supervisors: Laurence Perotto and Juan-Francisco Macias-Perez
- 04/2010 – 08/2010 **Research internship**, Laboratoire de Physique Subatomique et de Cosmologie (LPSC), within the PLANCK group, Grenoble, France
Subject: *Measurement of CMB anisotropies with Planck and WMAP satellites*
Supervisors: Juan-Francisco Macias-Perez and Guillaume Hurier
- 02/2009 **Engineering internship** in business aircraft SNECMA (SAFRAN group)
Subject: *Management/Production*
Supervisor: René Villalta

Teaching Experience

- 10/2011 – 07/2014 **Teaching Assistant (French “Monitorat”): Teaching duties in Physics and Mathematics**, 192 hours, Grenoble University, France
1st year university level: 142 hours *Colors in Sciences*, interdisciplinary teaching unit linking Physics, Chemistry and Biology
3rd year university level: 50 hours *Mathematics for Engineering*
 - 2005 – 2008 **Tutoring:** Mathematics, Physics, Chemistry
Student from 6th to 12th Grades
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Mentoring Experience

- Summer 2018 **Sophomore student from Caltech University mentored for a summer internship at Harvard:** Madison Brady
 - 2015 - 2017 **4 Graduate Students mentored at the University of Virginia:** Christopher Shingledecker, Dominique Maffucci, Andrew Burkhardt, Ceci Xue
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Services & Outreach

- Since 02/2018 **Scientific supervisor of GinGo:** Innovative “Open Access” platform in development. The primary objective of this tool is to promote open access to scientific knowledge. Eventually, GinGo will become a platform where it will be possible to publish, edit and consult freely the best of scientific content (<https://gingo.io/home>). My role is to ensure the relevance and consistency of the scientific content published online and to manage and develop collaborative relationships with major national and international research centers.
- 03/2017 **Organization of a science festival and in charge of the communication in the local press:** For the previous five years, Ruckersville Elementary School (Virginia, USA) has organized a “science fair”. Typically, this exhibition attracts about 300 participants. On the initiative of Tony Remijan (Astrophysicist at the National Radio Astronomy Observatory - NRAO, Charlottesville, VA, USA), we have elaborated various exhibitions and demonstrations as interactive as possible ranging from a planetarium to chemical experiments. I was also in charge of contacting the local press so that the event was broadcasted in the area.
- 07/2016 – Present **InterStellar Abundance (ISA) Database:** The ISA database is a compilation of observed abundances in the ISM. In collaboration with the astronomers Pierre Gratier and Valentine Wakelam (from the Laboratory of Astrophysique of Bordeaux (LAB), France), we are building a new database which in the long term will gather the observed abundances of diverse molecules in a variety of astrophysical environments, as started for TMC-1 (<http://isa.obs.u-bordeaux1.fr>). I am part of the “scientific comity” in charge of adding the data with a careful and critical review when different values are available for the same source. An engineer of the LAB, Fabrice Mendes, also contributes to the development of this database project. Beside, we will also create a Twitter account to announce our new additions.

- 05/2016

Organization of the visit of the Leander McCormick Observatory of Charlottesville: organization of french visit of the Leander McCormick Observatory for the French Alliance of Charlottesville, in collaboration with Ricky Patterson (caretaker and historian of the observatory). We also prepared pedagogical activities to familiarize the public to Astronomy. 21 children accompanied by their parents, attended this successful event.

Selection of accepted astronomical observation proposals

- 08/2018 ALMA cycle 6, B-rated: *Probing the Sulfur Chemistry in Protoplanetary Disks* (PI)
- 08/2018 ALMA cycle 6, A-rated - Large Program: *The Chemistry of Planet Formation* (co-I)
- 11/2017 SMA, B-rated: *Localization of Interstellar CH₂D⁺: Deuteration in warm conditions* (Co-PI)
- 11/2017 SOFIA, rated Priority 1: *Targeted Extension of EXES Molecular Line Survey Towards Orion IRc2* (Co-I)
- 04/2016 IRAM-30m, B-rated: *C₃O origin and extent in the L1544 prestellar core* (Co-I, observatrice)
- 11/2013 IRAM-30m, A-rated: *Measuring the gas-phase C/O abundance ratio in dark clouds* (PI)
- 04/2013 IRAM-30m, B-rated: *Nitrogen chemistry in dark clouds: the HCN:HNC abundance ratio* (PI)
- 11/2011 IRAM-30m, B-rated: *Isotopic fractionation of nitrogen in the dense and cold ISM* (PI)

Skills

- Observations: Millimeter and submillimeter spectroscopic observations with single dish telescopes and interferometers (IRAM-30m, Onsala-20m, HSO, GBT, SMA, ALMA)
 - Modeling: Astrochemistry, chemical gas-phase & gas-grain networks
 - Languages: French (native), English (fluent), and German (basic)
 - Computer science: Operating systems: Mac OS X, UNIX/GNU Linux, Windows
 - Programming: Fortran, Python, Shell, C/C++
 - Softwares: GILDAS, HIPE, LaTeX, Gnuplot, IDL
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International publications in leading international scientific journals

- [18] **Le Gal, R.**, Öberg, K., I., Loomis, R., et al. *Sulfur chemistry in protoplanetary disks: CS and H₂CS*, 2019, ApJ, submitted
- [17] Burkhardt A. M., Shingledecker, C. N., **Le Gal, R.**, McGuire B., A., Remijan A. J., & Herbst, E. *Modeling C-shock Chemistry in Isolated Molecular Outflows*, 2019, ApJ, in revision
- [16] Maffucci, D. M., Wenger T. V., **Le Gal, R.**, & Herbst, E. *Astrochemical kinetic grid models of groups of observed molecular abundances: Taurus molecular cloud 1 (TMC-1)*, 2018, ApJ, 868, 41 [\[URL\]](#)
- [15] Guzman, V., Öberg, K. I., Carpenter, J., **Le Gal, R.**, Qi, C., & Pegues, J. *H₂CO ortho-to-para ratio in the protoplanetary disk HD 163296*, 2018, ApJ, 864, 170 [\[URL\]](#)
- [14] Vastel, C., Quénard, D., **Le Gal, R.**, Wakelam, V., Andrianasolo, A., Caselli, P., Vidal, T., Ceccarelli, C., Lefloch, B., & Bachiller, R. *Sulphur chemistry in the L1544 pre-stellar core*, 2018, MNRAS, 478, 5514 [\[URL\]](#)
- [13] Shingledecker, C. N., Tennis, J., **Le Gal, R.**, & Herbst, E. *On comic ray-driven grain chemistry in cold core models*, 2018, ApJ, 861, 20 [\[URL\]](#)
- [12] Rangwala, N., Colgan, S., **Le Gal, R.**, Acharyya, K., Huang X., Lee, T. J., Herbst, E., deWitt, C., Richter, M., Boogert, A., & Mark McKelvey, M. *High Spectral Resolution SOFIA/EXES Observations of C₂H₂ towards Orion-IRc2*, 2018, ApJ, 856, 9 [\[URL\]](#)
- [11] Fuente, A., Goicoechea, J., Pety, J., **Le Gal, R.**, Martín-Doménech, R., Gratier, P., Guzmán, V., Roueff, E., Loison, J.-C., Muñoz-Caro, G. M., Wakelam, V., Gerin, M., Riviere-Marichalar, P., & Vidal T. H. G. *First detection of interstellar S₂H*, 2017, ApJL, 851, L49 [\[URL\]](#)
- [10] **Le Gal, R.**, Xie, C., Herbst, E., Talbi, D., Guo, H., & Muller, S. *The ortho-to-para ratio of H₂Cl⁺: Quasi-classical trajectory calculations and new simulations in light of new observations*, 2017, A&A, 608, A96 [\[URL\]](#)
- [9] **Le Gal, R.**, Herbst, E., Dufour G., Gratier, P., Ruaud, M., Vidal, T. H. G., & Wakelam, V. *A new study of the chemical structure of the Horsehead nebula: the influence of grain-surface chemistry*, 2017, A&A, 605, A88 [\[URL\]](#)
- [8] Shingledecker, C., **Le Gal, R.**, & Herbst, E., *A new model of the chemistry of ionizing radiation in solids: CIRIS*, 2017, PCCP, 19, 11043-11056 [\[URL\]](#)
- [7] **Le Gal, R.**, Herbst, E., Xie, C., Li, A., & Guo, H., *The ortho-to-para ratio of interstellar NH₂: Quasi-classical trajectory calculations and new simulations*, 2016, A&A, in press [\[URL\]](#)
- [6] Shingledecker, C. N., Bergner, J., **Le Gal, R.**, Öberg, K., Hincelin, U., & Herbst, E., *On the inference of the cosmic-ray ionization rate ζ from the HCO⁺-to-DCO⁺ abundance ratio: the effect of nuclear spin*, 2016, ApJ, in press [\[URL\]](#)
- [5] Persson, C.M., Olofsson, A.O.H., **Le Gal, R.**, Wirström, E.S., Hassel, G.E., Herbst, E., Olberg, M., Faure, A., Hily-Blant, P., Black, J.H., Gerin, M., Lis, D. & Wyrowski, F., *Ortho-to-para ratio of NH₂. Herschel-HIFI observations of ortho- and para- NH₂ rotational transitions towards W31C, W49N, W51 and G34.3+0.1*, 2016, A&A, 586, A128 [\[URL\]](#)
- [4] **Le Gal, R.**, Hily-Blant, P., Faure, A., Pineau des Forêts, G., Rist, C., & Maret, S., *Interstellar chemistry of nitrogen hydrides in dark clouds*, 2014, A&A, 562, A83 [\[URL\]](#)
- [3] Hily-Blant, P., Pineau des Forêts, G., Faure, A., **Le Gal, R.**, & Padovani, M., *The CN/C¹⁵N isotopic ratio towards dark clouds*, 2013, A&A, 557, A65, [\[URL\]](#)
- [2] Faure, A., Hily-Blant, P., **Le Gal, R.**, Rist, C., & Pineau des Forêts, G. *Ortho-para selection rules in the gas-phase chemistry of interstellar ammonia*, 2013, ApJ, 770, L2, [\[URL\]](#)

[1] Rist, C., Faure, A., Hily-Blant, P. and **Le Gal, R.**, *Nuclear-spin selection rules in the chemistry of interstellar nitrogen hydrides*, 2013, J. Phys. Chem. A, 117, 9800 [\[URL\]](#)

Conference Proceedings

[1] **Le Gal, R.**, Hily-Blant, P., and Faure, A. *Dark cloud chemistry of nitrogen hydrides with the Herschel Space Observatory* [\[URL\]](#)

International conferences (19 since 2012)

- 07/2018 **Talk:** *Astrochemical modeling of photon-dominated regions: the Horsehead nebula case*
Conference: "Astrochemistry: Past, Present & Future" (Caltech, Pasadena, Californie, Etats-Unis)
- 07/2018 **Invited talk:** *Interstellar molecular complexity: observations vs models*
Conference: "Société Française d'Astronomie et d'Astrophysique (SF2A)" (Bordeaux, France)
- 06/2018 **Poster:** *Probing the Sulfur Chemistry in Proto-Planetary Disks*
Conference: "Physique et Chimie du Milieu Interstellaire (PCMI)" (Marseille, France)
- 04/2018 **Poster:** *Probing the Sulfur Chemistry in Proto-Planetary Disks*
Conference: "Simons Collaboration on the Origins of Life (SCOL) Symposium" New York City, NY, Etats-Unis)
- 03/2018 **Invited talk:** *Ortho-to-para ratios of hydrides as powerful cosmic probes*
Conference: "Hydride Chemistry: From Earth to Space" (Telluride, Colorado, Etats-Unis)
- 11/2017 **Talk:** *Astrochemistry of PDR: modeling of the Horsehead nebula*
Conference: "Harvard-Heidelberg 2017 Star Formation Across the Universe" (CfA, Cambridge, Massachusetts, Etats-Unis)
- 09/2017 **Talk:** *A new study of the chemical structure of the Horsehead nebula: the influence of grain-surface chemistry*
Conference: "Astrochemical conference KIDA 2017" (Bordeaux, France) [\[URL\]](#)
- 06/2017 **Talk:** *The Key Role of Nuclear-Spin Astrochemistry*
Conference: "International Symposium on Molecular Spectroscopy (ISMS)" (Champaign-Urbana, Illinois, Etats-Unis) [\[URL\]](#)
- 05/2017 **Talk:** *OPRs as powerful interstellar diagnostics*
Conference: "Nuclear spin effects in astrochemistry" (Grenoble, France) [\[URL\]](#)
- 12/2016 **Talk:** *Ortho-to-para ratio of dihydride species*
Conference: "The Hydride toolbox" (Paris, France) [\[URL\]](#)
- 04/2016 **Talk:** *The ortho-to-para ratio of NH₂ at different temperatures*
Conference: "COST ORIGINS: From Star and Planet Formation to Early Life" (Vilnius, Lithuania)
- 10/2014 **Poster:** *Interstellar chemistry of nitrogen hydrides with Herschel*
Conference: "Physique et Chimie du Milieu Interstellaire (PCMI)" (Rennes, France)
- 06/2014 **Talk:** *Interstellar chemistry of nitrogen hydrides in dark clouds* **with conference proceedings:** *Dark cloud chemistry of nitrogen hydrides with the Herschel Space Observatory* [\[URL\]](#)
Conference: "Société Française d'Astronomie et d'Astrophysique (SF2A)" (Paris, France)

- 10/2013 **Poster:** *Interstellar nitrogen chemistry revised with the Herschel satellite*
Conference: "The Universe Explored by Herschel" (Noordwijk, The Netherlands)
 - 06/2013 **Invited talk:** *Interstellar chemistry of nitrogen hydrides*
Conference: "Processus physico-chimiques d'intérêt astrophysique : La chimie de l'azote " (St-Florent, France)
 - 04/2013 **Poster & 1 minute talk:** *An updated network for dark cloud nitrogen chemistry* – * **2nd Poster Price*** [\[URL\]](#)
Conference: "From Stars to Life" (Gainesville, Floride, Etats-Unis)
 - 01/2013 **Talk:** *Chemistry of nitrogen hydrides in dark clouds*
Kick-off Meeting: French ANR "Hydrides" (Grenoble, France)
 - 11/2012 **Poster:** *Interstellar chemistry of nitrogen hydrides in dark clouds*
Conference: "Physique et Chimie du Milieu Interstellaire (PCMI)" (Paris, France)
 - 03/2012 **Poster & 1 minute talk:** *The ambivalent role of H_3^+ in the ortho/para thermalization of H_2*
Conference: "From Atoms to Pebbles. Herschel's view on Star and Planet formation" (Grenoble, France)
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Seminars (7 since 2012)

- 02/2019 *Sulfur Chemistry in Planet-forming Disks*, ITC Luncheon Seminars, Harvard-Smithsonian Center for Astrophysics (Cambridge, USA)
- 01/2018 *How astrochemistry unravels our cosmic origins*, Séminaire de l'Institut d'Astrophysique de Grenoble (IPAG) (Grenoble, France)
- 01/2018 *How astrochemistry unravels our cosmic origins*, Séminaire de l'Institut de Recherche en Astrophysique et Planétologie (IRAP) (Toulouse, France)
- 01/2018 *How astrochemistry unravels our cosmic origins*, Séminaire du Laboratoire d'Astrophysique de Bordeaux (LAB) (Bordeaux, France)
- 03/2016 *Ortho-to-para ratios of molecules as tracers of cold interstellar chemistry*, "Astronomical Sciences Seminar" (*Virginia Tech*, Blacksburg, VA, USA)
- 09/2014 *Interstellar chemistry of nitrogen hydrides with Herschel*, "ESO lunch Seminar" (Garching, Allemagne)
- 09/2012 *Interstellar chemistry of nitrogen in dark clouds*, "ESO science short Seminar" (Santiago, Chili)