



Universiteit
Leiden
The Netherlands

Non-linear astrochemical kinetics: theory and applications

Dufour, G.C.

Citation

Dufour, G. C. (2022, June 21). *Non-linear astrochemical kinetics: theory and applications*. Retrieved from <https://hdl.handle.net/1887/3421318>

Version: Publisher's Version
License: [Licence agreement concerning inclusion of doctoral thesis in the Institutional Repository of the University of Leiden](#)
Downloaded from: <https://hdl.handle.net/1887/3421318>

Note: To cite this publication please use the final published version (if applicable).

LIST OF PUBLICATIONS

Refereed publications

1. *The Composition of Ice Mantles in Dark Clouds: Stochastic Simulations of Gas-grain Chemistry*
Dufour, G., Lamberts, T., Linnartz, H., Charnley, S. B., Qasim, D., Fedoseev, G. (2022), in preparation
2. *Oscillations in Gas-grain Astrochemical Kinetics*
Dufour, G., Charnley, S. B. & Lindberg, J., Mon. Not. R. Astron. Soc. (2022), submitted
3. *New Bistable Solutions in Molecular Cloud Chemistry: Nitrogen and Carbon Autocatalysis*
Dufour, G. & Charnley, S. B., Astrophys. J. 909 (2021) 171
4. *Astrochemical Bistability: Autocatalysis in Oxygen Chemistry*
Dufour, G. & Charnley, S. B., Astrophys. J. 887 (2019) 67
5. *A new study of the chemical structure of the Horsehead nebula: the influence of grain-surface chemistry*
Le Gal, R., Herbst, E., **Dufour, G.**, Gratier, P., Ruaud, M., Vidal, T. H. G., Wakelam, V., Astron. Astrophys. 605 (2017) 16

CURRICULUM VITAE



I was born to Marie-Cécile and Bruno Dufour, on the 7th of June 1991 in Floirac, France. I grew up in Cenon until I was 7 years old, moved to Saint-Caprais de Bordeaux for few years, then ended up in Haux where my parents decided to build their own house from the ground up. I have two younger brothers, Vincent, born in 1993, and Jérémy, born in 1999. I went to primary school of Saint-Caprais de Bordeaux from my 7 years old until 12. Then I went to François Mitterrand middle school, in Créon, until I got 16. I obtained the French Certificate of general education, allowing me to integrate François Mauriac high school in Bordeaux. At 18 years old, I obtained the

scientific baccalaureate, which allowed me to enter the Faculty of Sciences in Talence. I graduated from a Chemistry degree in 2013 at the age of 21 years old. Then, in 2014, I decided to participate in the Erasmus program during a year in Málaga, Spain, doing a master in Physics-Chemistry at Málaga University. After graduation, I did an internship during few months in modeling and performing experiments on carbon nanotubes. Then, I came back to Bordeaux to proceed with a master in Physics, starting directly in the second year. In 2015, I started doing several months of internship in the observatory of Bordeaux, learning about astrochemical modelling. Then I obtained my master in Physics in June. From July 2015 until March 2016, I took a sabbatical, during which I traveled, worked in different types of jobs and sought a PhD abroad. In April 2016, on my way to turn 26 years old, I moved to Washington DC, USA, to start a Research Assistant position at NASA Goddard Space Flight Center (GSFC), while starting at the same time a PhD at Leiden University, in the Netherlands. In this period I have been working on astrochemical modeling with a focus on chemical bistability and gas-grain reaction networks. This thesis presents the PhD research results acquired during six years at NASA GSFC in collaboration with Leiden University.

ACKNOWLEDGEMENTS

Fist of all, I am especially grateful to Steven B. Charnley for giving me the opportunity to come to the United States and to pursue a PhD with Leiden University. What a challenge choosing to understand and prove a 30 years old debated research project in a four years PhD project. But after trials, tribulations, delays and mostly persistence, we can clearly see the light at the end of the tunnel. Finally, bistability and oscillations will be seen as part of plausible solutions in a range of astrochemical models. Thank you for trusting me with this challenging research topic.

Another challenge of this PhD was dealing with the atypical format. I was a contractor at the Catholic University of America, working full time at NASA Goddard Space Flight Center (GSFC) and in same time regularly for few months to Leiden University. I am grateful to Prof. A.G.G.M. (Xander) Tielens for guiding the process of the abroad PhD, as well as Prof. dr. H.V.J. Linnartz for accepting to be my PhD promotor. Thank you Harold for patiently helping me with the collaboration, the lodging in Leiden, the correction of the different parts of the manuscript and for guiding me through the PhD procedure. From Leiden University, I would like to thank also Thanja Lamberts, Gleb Fedoseev and Danna Qasim to actively participate in the collaboration research described in this thesis.

Going back to the US, where my life has been for the last six years, I want to mentioned several people to whom I am grateful. From the start, Martin Cordiner, you accepted to host me for three months in your beautiful home. Even though you didn't know me and my English level at the time was not there yet, you and your wife, Mei-Lin, received me with open arms. Also, at the start, I had to learn Python and FORTRAN programming languages, thank you for taking the time to answer all my programming questions and guiding me on the different models. I continue with the NASA group; Stefanie Milam, seeing new people getting involved in the group you decided to create bi-weekly meetings and happy hours. I appreciate your initiatives to create a more social and supportive environment. Similarly to Natasha Johnson and Daniel Glavin, thank you for all your efforts to connect with the staff, and mostly students, during the pandemic.

On a more personal level, in six years so much has happened and changed. From the love ones that left to the ones that recently have been born. *La vie m'a montré très tôt sa beauté et ses défauts. J'ai vécu des batailles que je ne pensais pas gagner mais qui m'ont renforcées. Comme le mentionne Édith Boukeu, "le cancer est un adversaire redouté. Il est très souvent vaincu par ceux qui n'abandonnent pas le combat".*

Maman, merci d'avoir été courageuse. Tata Dany, ne perds pas espoir. Mais des fois peu importe la bataille, les personnes que l'on aime s'en vont. À ma mamie, Annick Lorreyte, ton sourire et tes doux câlins me manqueront toujours. À ma mémé, Yvonne Alcantarini, ton caractère bien trempé et ton humour me donneront toujours le sourire. À ma tatie, Sylvie Fourneau, merci pour ta tendresse et de t'être battue jusqu'au bout. Je veux remercier ma famille, mon papa, ma maman et mes frères d'être présents dans ma vie, de m'aimer et de m'avoir encouragée pendant ces six longues années. Et aussi mes grand-parents, mes tontons, mes taties, mes cousins, mes cousines, tous ayant été des fervents supporteurs même quand le bureau des plaintes était débordé. Merci d'avoir tous cru en moi. À Rosalie, Léanne, Tiago, Antoine, Lia et mon futur petit neveu qui sont nos rayons de soleil.

I want to acknowledge the love and support that I received from a multitude of friends in the US and in Europe, as well as from my church community. The District Church has played a pivotal role in my life in the last four years. At last, and the opposite of least, thank you God for making it all possible.

Gwénaëlle C. Dufour



Universiteit
Leiden