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## Laboratory studies of water ice in space : optical and photochemical properties

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# List of publications

- *Laboratory spectroscopy and astronomical significance of the fully-benzenoid PAH triphenylene and its cation*  
**V. Kofman**, P. J. Sarre, R. E. Hibbins, I. L. ten Kate and H. Linnartz in *Molecular Astrophysics*, 7 (2017) 19–26.
- *The ALMA-PILS survey: detection of CH<sub>3</sub>NCO towards the low-mass protostar IRAS 16293-2422 and laboratory constraints on its formation*  
N. F. W. Ligterink, A. Coutens, **V. Kofman**, H. S. P. Müller, R. T. Garrod, H. Calcutt, S. F. Wampfler, J. K. Jorgensen, H. Linnartz, E. F. van Dishoeck in *Monthly Notices of the Royal Astronomical Society*, 469 (2017) 2219–2229.
- *A multifunctional setup to record FTIR and UV-vis spectra of organic molecules and their photoproducts in astronomical ices*  
**V. Kofman**, M. J. A. Witlox, J. Bouwman, I. L. ten Kate and H. Linnartz in *Review Scientific Instruments*, 89 (2018) 053111.
- *The Refractive Index of Amorphous and Crystalline Water Ice in the UV-vis*  
**V. Kofman** J. He., I. L. ten Kate, H. Linnartz in *The Astrophysical Journal*, 875 (2019), 131-139.
- *The protective role of water ice on the vacuum UV photo-degradation of embedded glycine*  
**V. Kofman**, H. T. Jense, N. F. W. Ligterink, I. L. ten Kate, H. Linnartz, in preparation.



# Curriculum vitae

I was born on January 3rd 1989 in Alphen aan den Rijn, the Netherlands. I spent most of my childhood time in Heerenveen. All of my life I have had an interest in technology, science, and space. In my early years this mostly manifested in taking things apart to 'fix' them. Unfortunately, in most cases, only the first step was taken and the object in question was not broken to begin with. Some of my fondest childhood memories include building a hovercraft out of retired vacuum cleaners and power-drill batteries (I do not think my mother knew where those batteries came from). I went to the Bornego college in Heerenveen, where, together with one of my best friends, our graduation project involved building a levitating magnetic train. The project was a success, until everything melted. My academic education started at the Rijksuniversiteit Groningen, where I studied chemistry. I completed my Bachelor's degree in 2011 after spending a year of my studies abroad in Uppsala, Sweden. My final project involved the synthesis of manganese-based water-oxidation catalysts, within the context of renewable energy efforts. It was the source of the manganese that got me interested in the chemistry outside the round-bottom flask, and I decided to continue with a masters program in geochemistry in Utrecht, the Netherlands. During my sojourn in Utrecht, I worked on projects involving both inorganic (minerals phases, including manganese) and organic (chemical remains of algae) geochemistry. I choose to pursue a more fundamental project in the form of this PhD project. In the four years in Leiden I assisted with the planetary science course for first-year students, presented my work at several national and international meetings and it was with great pleasure I helped organize several PEPSci (Planetary and Exoplanetary Science) meetings, where my old and new scientific interests could be combined. During my third year, I met Geronimo Villanueva, with whom I dived deep into the world of molecular spectroscopy. Geronimo welcomed me back as a postdoctoral researcher at NASA Goddard Space Flight Center, where I currently apply spectroscopy to exoplanets.



# Acknowledgments

Without the effort, patience, time, and commitment from other people, this thesis would not have been possible. First and foremost, Harold and Inge Loes, thank you for your guidance, support, and patience. Although we did not always agree on the contents or methods, I have tremendous respect for the way you allowed me to find my own way, make mistakes and pursue my research. Especially during the last years, Xander you have been a great support and even though we unfortunately 'were not allowed to get distracted by the science!' your input has definitely improved that as well. Peter, I still count myself lucky for working together with you on my first project, not only was it a great pleasure, I learned much about optical spectroscopy, DIBs and academics in general. Geronimo, your guidance, support, and trust have meant a lot to me, and even though our molecule hasn't made into this piece of work, your contribution goes beyond this book. With our beautiful work in this thesis Jiao, your contribution is clear. I never knew working together could be so much fun! I learned much from you during our project together, and most of all, really enjoyed the project. Supervision of students is part of the job at a university, but if the conditions are met, the right student presents itself, and takes the work from your hands! Hidde, I'm sure you'll do great in your future studies. Much of the knowledge in a lab is transferred from generation to generation, and the Sackler Laboratory has been a fruitful place to learn. I have had the benefit of working with a great number of bright and experienced people. My 502 friends, our office always was a pleasure. Thanks for putting up with my singing, chatting and sometimes bad moods. You were always there for questions related to science, bureaucracy, or life in general. Across the hall, into the lab, is where I had so many insightful talks, and I want to thank a number of people for these: Daniel, Dongfeng, Gleb, Gustavo, Jean-Baptiste, Jordy, and Sergio. My direct colleagues Danna, Jeroen, Michal, Xavier, and the people mentioned earlier, I'll miss our coffee times, lunches and Domino's together. Andreas, it was a great pleasure of working in the same group as you. Let me know if you need someone to carry your bags in the Atacama desert, or anywhere else in the world (maybe some of those caves?). Just outside of the office, Alex and Arthur, you were the best neighbors one could

wish for: Arthur, your help with photochemistry, kinetics, and astronomy has been invaluable, and Alex, planet formation makes sense now! You two were always available to 'borrow a scientific cup of sugar' so to speak. To the PEPSci team, we accomplished a rare thing. We made cross-disciplinary not just a word, but we put it into effect. I look back on our meetings with great pleasure. Alex, Bram, Nina and Terasa, good luck keeping things rolling. Edgar, your positivity and energy were great to share in. It's really time we go and find our regular bar here in DC! I'll miss our walks, Claudia. The practical and technical support of the secretaries, the computer group and workshop have made this work possible: in particular Aart, Martijn, Raymond and Peter, your help has been invaluable. A very special thanks goes out to my mother, who has always supported me, wherever I went, and whatever I did. Be sure you realize that this thesis would not have been possible without you. Finally, Dorien, thanks for putting up with the late hours, early mornings and weekends spent on this thesis, for being there when I needed it and forgiving me when my lack of planning messed up yours.