Infrared spectroscopy of mass-selected aromatic and diamondoid molecular ions: a laboratory quest for the organic inventory in space

Alvaro Galue, H.

Citation for published version (APA):
Cooperation and sharing are essential ingredients in any scientific endeavor. I could not feel more fortunate because during my journey I have met great people, who from a place of humbleness and passion, shared their knowledge and motivation for science and life. These individuals had a great influence in my nowadays ideas, concepts and skills and are, through my own interpretation, all captured in this work. Therefore, although the content in this piece was materialized during the last four years, the conception and emergence of ideas and knowledge date back to the time I began to pursue my dreams and aspirations in science. Here, I would like to thank the people involved by giving a brief account for their influence to my scientific background.

My first encounter with professional Astronomy dates back to the summer of 1999 during my participation in the CUREA program held in Mt. Wilson Observatory. Joe Snider gave me the opportunity to undertake for the first time hands-on research activities in a professional facility. I am deeply thankful to Joe for sharing his love for solar physics and Astronomy. Joe has not been only a great mentor, but also someone with a warm and quality persona from who I’m still learning up to this day.

A milestone in my aspirations in science was my interaction with the astronomer of the Astronomical National Observatory (OAN) in Baja California, México, Roberto Vázquez. After meeting him for the first time in an OAN summer school in 2000, I invited him to my University in Monterrey to explore possible ways of student research collaboration that involved also a group of enthusiastic undergraduates. Roberto shared his passion for the ultimate fate of stars ranging from 0.8 to around 8 solar masses; the spectacular multi-form objects known as planetary nebulae. My academic relationship with Roberto has been one of the most fruitful research learning experiences that prepared me for the coming projects. For this, I want to thank Roberto for sharing his knowledge and enthusiasm for Astronomy, as well as for his friendship and longstanding mentoring.

Two influential people to my scientific education are also Nolan Walborn and Jesus Maíz, who in the short 10-week intership at the Space Telescope Science Institute, shared their vision on science and their longstanding school of research on observational spectroscopy in connection with massive stars. Meeting Nolan and Jesús in the intership, and after communication, gave a good shape to my scientific aspirations. For their support to propel my career in science and for sharing their knowledge and their great scientific spirit, I want to express my endlessly gratitude to Nolan and Jesús.

All my efforts to build an amateur SETI station during my freshman years found a good course when I met the astronomer of the Centro de Radio Astronomía in Morelia México, Stan Kurtz. He shared his passion for radio Astronomy, which tool he uses to study regions of massive-star formation and underlying atomic and molecular processes. With his great expertise, we set up various home made dipole, Yagi and dish antennas to listen to Jupiter–Io radio emissions and solar bursts (calling E.T. was left for other time). I want to thank Stan because during summer schools, workshops, meetings and so on he was a source of inspiration, as well as a mentor from who I enjoyed the advices, teachings and great sense of humor.

Luis Lauro Cantú is a professor in my University in Monterrey and his immense support at the end of my undergraduate physics years is endlessly thanked. During the research project of my
master thesis in 2006 and 2007, I worked in the Swedish Institute of Space Physics up in Kiruna with Uwe Raffalski to whom I’d like to express my gratitude for allowing me to experiment with his novel atmospheric radiometer KIMRA for many months, and which led to my master diploma. I learned important lessons and skills during this time.

In 2008 I began the last four years of this enterprise. Besides the astrophysical aspect, one of the reasons for which I decided to pick this line of research was the interdisciplinary component of the project, and the fact that laboratory spectroscopy is on the heart of modern Astronomy; which consists in finding the constituents of the Universe based on the spectral signatures that are first measured here on Earth with novel techniques. Once an atomic or molecular species is identified, the connection between the underlying physical/chemical processes taking place in the space environment and the given observed signature, can be bridged through laboratory studies. In this new era of great technological progress, Laboratory Astrophysics, and spectroscopy in this case, is helping to unravel interstellar spectroscopic phenomena that was impossible to study before since candidate species were either difficult to produce, isolate, or both, in the laboratory.

Working in the group of Gerard Meijer (then leading the in-house Molecular Dynamics group of the FELIX facility), Jos Oomens set out in 2000 at the Rijnhuizen institute, a new technological scheme to record laboratory infrared spectra of molecular ions based on free electron laser IR light, mass spectrometry and ion trapping methods. Eight years later, and after novel work done by Olivier Pirali, Nick Polfer, and Jos Oomens, I was offered to continue the application of this instrumental setup to investigate ionic species of astrophysical interest. Here I would like to take the opportunity to thank Jos Oomens for allowing me to take part in this experimental endeavour, for supporting it and for being my promotor. It has been a great experience. Thank you.

Due to the open-facility character of the Rijnhuizen institute, my experience was enriched by the frequent visit of FELIX users. These visitors regularly brought news from the ‘outside world’ and freshened up my perspective. I would like to thank those professors that allowed me to share with them and their “delegations” my view and current town Utrecht. Even more, I also thank them because within their professorship nature, I was touched by the long arm of their solidarity, knowledge and mentoring. For all this I would like to thank Martin Vala, Peter Armentrout, Rob Dunbar, Mary Rodgers, Tom Morton, Mike Van Stipdonk and Bruno Martínez. In addition, I’d also like to thank Nick Polfer, Marcus Tirado, Warren Mino, Peter Kupser, Frauke Bierau, César Contreras, David Nei, and Andrew Sweeney for their invaluable friendship, good sense of humor and fraternity.

I can finally thank Jeff and Amy Steill. Amy was a priceless friend who always appeared there to bring the good spirit. Jeff is a colleague and friend, but also, an invaluable source of inspiration and encouragement. Things would not have been this easy without the mentoring of Jeff. Thank you. In the same way, with her optimistic approach, I found invaluable support and influence in Johanne van Maurik. Besides, she also helped me on the Dutch translation of the summary and read parts of this Thesis. Also, Alvaro Avéliz was the first person that welcomed me in Holland and another priceless friend and I thank him for that. My warm thanks to Marion Poeth and Damir Popovic who spent many hours sharing with me their expertise on graphic design that led to the creation of the cover.

When I took part in a research project on molecular diamondoids in the SOLEIL facility in France, Olivier Pirali gave me a very warm and joyful welcome and I thank him for it. I also thank Olivier for sharing his experiences, knowledge, enthusiasm for science and the memorable bike tour around Paris. Sergio Ioppolo from Sackler Lab in Leiden gave me important advices and shared his experiences and I’m deeply grateful to him.

I want to acknowledge the work of the staff of the FELIX facility who kept the IR photons knocking the door: Lex van der Meer, Britta Redlich, Giel Berden, Rene van Buuren, Michel
Riet, Wybe Roodhuyzen, Cor Tito, and Jules van Leusden. With gusto, I thank Jules and Michel who made my beamtime campaigns stress-free and smooth. My thanks also go to Edwin Goes and Gerben Kaas from the ICT department for their prompt support and their high spirit. I want to thank Andre Yaksins who was my official mentor during this four years and his support was invaluable. I am very appreciative for the help on several aspects of the ion trap that I recievied from Jan Pluygers, engineer of the Moldyn group. Also from Moldyn, Anouk Rijs and Joost Bakker for assisting me in the lab during my first times employing the light of FELIX, for the advices and challenges that enriched my experience. Thanks to Annemieke Petrigiani for her quality company during trip conferences and for being a good officemate. Also thanks to Vivike Lapoutre for being a good colleague as well to Gydo van Zundert and Sander Jaeqx. Denis Kiawi and Juehan Gao from Moldyn are thanked for their good spirit and good sense of humor. Hajnal Voros takes care of the Rijnhuizen library and her good vibe and kind gestures are also thanked. I charmingly thank Loes van de Ven, An Uwland and Jose Kragten who always recievied me in the door of Rijnhuizen with a smile and they will be very much missed.

The quality of the information contained in this Thesis was improved considerably thanks to the people that read it. The members of the doctorate committee played a crucial role in this and I thank them for that: Wybren Jan Buma, Giel Berden, Aart Kleyn, Evert Meijer, Martin Vala and Xander Tielens. I appreciate the very good and punctual comments of Giel. Also, his transparence, interest on sharing his views with people, and words of encouragement are appreciated. Wybren and Jos were also impeccable in reading the Thesis and providing feedback. I appreciate greatly the comments and contributions of Martin, both on experiments and Astrophysics. Also, for his enthusiastic approach, words of encouragement and guidance. Also, Jos enormously enhanced and contributed to the quality of the information presented. Finally the comments of Xander were extremely important to give the final touch to the Thesis. Especially his contributions to the Astrophysics were really invaluable. I thank him for sharing with me his enthusiasm, knowledge and elevated spirit that translated in great words of encouragement and inspiration.

Héctor Alvaro Galué
Utrecht, 2012.