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Uncovering the ingredients for planet formation

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Citation

Bosman, A. D. (2019, October 8). *Uncovering the ingredients for planet formation*. Retrieved from <https://hdl.handle.net/1887/79194>

Version: Publisher's Version

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Author: Bosman, A.D.

Title: Uncovering the ingredients for planet formation

Issue Date: 2019-10-08

LIST OF PUBLICATIONS

Refereed publications

1. *Probing planet formation and disk substructures in the inner disk of Herbig Ae stars with CO rovibrational emission*
Bosman, A. D., Banzatti, A., Bruderer, S., Tielens, A. G. G. M., Blake, G. A., van Dishoeck, E. F. *Astronomy and Astrophysics* in press
2. *CO destruction in protoplanetary disk midplanes: Inside versus outside the CO snow surface*
Bosman, A. D., Walsh, C., van Dishoeck, E. F., (2018), *Astronomy and Astrophysics* 618, 182
3. *Efficiency of radial transport of ices in protoplanetary disks probed with infrared observations: the case of CO₂*
Bosman, A. D., Tielens, A. G. G. M., van Dishoeck, E. F., (2018), *Astronomy and Astrophysics* 611, 80
4. *Photodissociation and photoionisation of atoms and molecules of astrophysical interest*
Heays, A. N., **Bosman, A. D.**, van Dishoeck, E. F., (2017), *Astronomy and Astrophysics* 602, 105
5. *CO₂ infrared emission as a diagnostic of planet-forming regions of disks*
Bosman, A. D., Bruderer, S., van Dishoeck, E. F., (2017), *Astronomy and Astrophysics* 601, 36

Submitted publications

1. HCN/HNC luminosity ratio: a new chemical thermometer for the molecular ISM
Hacar, A., **Bosman, A. D.**, van Dishoeck, E. F., (2017), *Astronomy and Astrophysics* submitted

CURRICULUM VITAE

I was born on March 21nd in The Hague to Theo Bosman and Thea Hagemeyer. With a father working as a naval engineer and a mother teaching English at a secondary school, it should not have been a big surprise when the pediatrician remarked that my development seemed to be more cognitively focussed than physically focussed. This clearly indicated that a career in sports was not for me. Even so my parents kept investing in my physical development, and decided that korfbal would be a good sport for me, which I have been playing for most of the past 20 years. During primary school, I had a video game fuelled interest in ancient, classical and medieval history. Clearly pointing me to a career in archaeology.

This started to shift around the time I went to the Dalton Den Haag, for my secondary education. My interests started to shift from the relics themselves to the ground these relics are in: Geology. I still picked up Latin and Greek in my second and third year as my interest in classical history was still strong. I've always had a knack and a interest for math, physics and chemistry and the more the focus of these courses shifted for memorizing to figuring out and understanding, the more my interest was piqued. At the end of the third year I thus chose to follow this path and picked a program with math, physics, chemistry, biology and Latin. Although the latter was partially motivated by the fact that it allowed me not having to continue German or French.

During the next two years, chemistry became my primary interest. I decided to partake in the "Scheikunde Olympiade", where I did well enough to join 19 other students for a one week master class and the national final. It was only in my last year that my interest in astronomy was solidified after taking part in the "Sterrenkunde Olympiade" and joining the master class in Amsterdam.

Partially unsure of my choice, partially looking for a challenge, I enrolled in the dual program of astronomy and mathematics in Leiden in the fall of 2010. As the big expanse was pulling on me, I decided to focus on Astronomy after the first year taking a few interesting math courses on the side. During my Bachelor project I worked with Sierk van Terwisga, under the supervision of David Sobral and Huub Röttgering. Together we dove into the joys of optical data reduction, looking for the brightest and largest blobs of gas in the universe.

I was torn between my ever resurfacing interest in chemistry and the physics of the early universe. As a compromise, I took the cosmology stream of the Leiden astronomy master program but started my first research project in astrochemistry. My project was on the photo-dissociation on molecules under various UV radiation fields in space in the group of Ewine van Dishoeck under Alan Heays and Catherine Walsh. For my second project I worked under Marijn Franx on the evolution of galaxies and how this influences the total observed population of galaxies at a set

age. During the five years of my bachelors and masters I have done various teaching related activities, including training secondary school students for their final economics exams at “Stichting Studiebegeleiding Leiden” and working as a teaching assistant for calculus.

When the time came for the PhD interviews in Leiden, I had mostly made my choice so when Ewine offered me a position within the astrochemistry group I did not think long before I took it.

During the four years of my PhD thesis I have worked on many of the theoretical aspects of astrochemistry, especially those important within proto-planetary disks. I have looked at molecular physics, the energy states of molecules and transitions between them to predict emission line strengths. I have studied the chemistry in warm gas as well as on cold grains surface with the help of kinetic chemical models. I have also considered the impact of physical processes, especially the transport of gas and dust through the disk on the chemical composition. All to explain the current observations of different chemical tracers and make predictions for the next big generation of instruments. The results of the work can be found in this thesis. During these four years I helped organise the “Sterrenkunde Olympiade”, the contest that got me into astronomy years ago, as well as taught master students as teaching assistant for the course Star and Planet formation. In November 2019 I will start a post-doc position at the University of Michigan.

ACKNOWLEDGMENTS

The writing of any PhD thesis is a far cry from the “ff een boekie doen”, or “just doing a booklet”, that my dad jokingly refers to, and this one was no different. This thesis contains the results of four years of work, including many deadline crunches, coding frustrations, exhausting meetings and the occasional sleepless night. Luckily, it also contains the results of four years of lively discussions, the attitude that there is always time to help a colleague, laughter and an awful lot of horrible puns without which this thesis would not have been finished. Thanks to all who have made this possible.

I would like to start by thanking the boss, Ewine, for giving me the opportunity to take this journey and all the support during it. You have always been able to get a bit more out of me than I thought was possible. Then there is Xander, who, besides handing out great advice, acted as counter balance by telling me to stick with good enough. Furthermore, Tim, thanks for teaching the life lessons of the less talkative. Here I would also like to thank Andrea Banzatti, who challenged my theoretical mind with the scientific reality of observations.

While the group’s composition has been in constant flux during the past four years, it has always been a great environment to work in. A big thanks to all of you who have made it this way. I would like to thank Anna, Mihkel, Catherine and Alan for getting me started on this journey and teaching me many of the things I needed to finish it. A special shout out to the two that have sat at the other side of my screen, Leon, for being there to share all the technical difficulties with, and Alex, for sharing your truly stellar (or rather planetary) optimism and enthusiasm. Sierk, thanks for all the help, from statistics to imaging. Alvaro, thanks for broadening my scientific horizons. Nadia, thanks for all the great baked goods that I could actually eat. Benoît, Giovanni, I’ve always enjoyed our intense discussions. Martijn, it has been good to have a fellow Hagenaar in the group, best of luck the next years. Niels, Ko-Ju, Kirstin, Vincent, Jeroen, Donna and Michał, I’ve always greatly enjoyed the more down to earth discussions. Niels and Jeroen, thanks for your great contribution to the atmosphere in our corridor. Paolo and Stefano, thanks for always making me feel at home when I came to visit Garching. The biggest thanks to my (travel) buddies that have always been at my side. Łukasz, your relaxed and open attitude is something I can still learn a lot from, thanks for all the good times, and I hope there will be more great coffee in the future. Merel, you’ve always been there when I needed you, from the organisational stuff (that you had already figured out) to the big questions (where your insights are always useful), thank you for everything.

I would also like to thank all my friends outside of work, for your support, keeping me connected to the rest of the world and of course, all the boardgames. Special thanks to Kai and Bram for making sure my summary is readable and Anouk for the great cover illustration. Finally, I would like to thank my parents for their unwavering support.