A COVER PAGE AND PERSONAL LETTER

Application at the Faculty of Science, Lund University

The Registrar
Lund University
P O Box 117
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Sweden

Application for ☐ **position**
☒ **promotion to position**

Title and subject field Professor in Astronomy	
Reference number if announced	Earliest possible date of appointment

Applicant information

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Present position and employer Senior Lecturer (universitetslektor), Lund University		

Place and date 2015-06-04	Signature

B CURRICULUM VITAE

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Education

2007	PhD in Astrophysics from Heidelberg University / Max Planck Institute for Astronomy Thesis: "Computer simulations of the early stages of planet formation" Supervisors: Dr. Hubert Klahr and Prof. Thomas Henning
2004	Master's degree in Astrophysics from Copenhagen University Thesis: "Ice condensation, dust coagulation and vortex activity in protoplanetary discs" Supervisors: Prof. Axel Brandenburg, Dr. Anja Andersen and Prof. Åke Nordlund
2001	Bachelor's degree in Physics/Astronomy from Copenhagen University

Employment, current position at the top

2013-	Senior Lecturer at Lund University (20% teaching)
2010-2013	Associate Senior Lecturer at Lund University (20% teaching)

Postdoc stays

2010-2010	"Veni" fellow at Leiden University
2008-2009	Postdoctoral fellow Leiden University
2007-2007	Postdoc at Max Planck Institute for Astronomy

Qualifications for readership, or equivalent

2013	Docent degree obtained at Lund University

Important appointments

2012-	Steering group member/study director of COMPUTE research school (Lund University)
2010-	Master's programme coordinator (Lund University)

Awards and distinctions

2013	"Harold C. Urey Prize in Planetary Science" from the Division for Planetary Sciences of the American Astronomical Society (for outstanding achievement in planetary research)
2008	"Otto Hahn Medal" from the Max Planck Society (for outstanding PhD thesis)
2007	"Summa cum laude" mark for PhD thesis at Heidelberg University
2007	"The Patzer Prize" from the Max Planck Institute for Astronomy (for best paper by young scientist)
2005	"The Patzer Prize" from the Max Planck Institute for Astronomy (for best paper by young scientist)

International research and teaching experience

- Isaac Newton Institute Cambridge (2009, three weeks)
- Kobe University (2009, three weeks)
- American Museum of Natural History (2006, six weeks)

Assignments as editor, referee

- Referee for Astronomy & Astrophysics, Monthly Notices of the Royal Astronomical Society, The Astrophysical Journal, Nature, Icarus, Science
- External referee for research grants submitted to ETH Zürich Research Grant (2013), DiRAC supercomputing grants (2012), Deutsche Forschungsgemeinschaft (2012), Research Foundation Flanders (2012), The Netherlands Organisation for Scientific Research (2011), Swedish Research

Council (2011), ERC Starting Grant (2010), NASA Origins of Solar Systems grants (20092014), Aurora Fellowship (United Kingdom, 2008)

Scholarly/academic societies

- Member of International Astronomical Union (IAU)
- Member of Swedish National Committee of Astronomy (since 2013)

Supervision of PhD students

2010-2015	Michiel Lambrechts (Lund University, licentiate 2012)
2012-	Daniel Carrera (Lund University, licentiate 2014)
2012-	Karl Wahlberg Jansson (Lund University, licentiate 2014)
2012-	Katrin Ros (Lund University, licentiate 2014)

Supervision of postdocs

2012-	Chao-Chin Yang (Postdoc / Senior Research Fellow, Lund University)
2014-	Alexander Mustill (Senior Research Fellow, Lund University)
2014-	Bertram Bitsch (Senior Research Fellow, Lund University)

References

- Senior Lecturer at Lund University:
  Reference: Professor Melvyn B. Davies, Lund University (mbd@astro.lu.se)
- "Veni" Fellow and Postdoctoral Fellow at Leiden University:
  Reference: Dr. Yuri Levin, Monash University (Yuri.Levin@monash.edu)
- PhD student at Heidelberg University and Max Planck Institute for Astronomy:
  References: Professor Thomas Henning, Max Planck Institute for Astronomy (henning@mpia.de), Dr. Hubert Klahr, Max Planck Institute for Astronomy (klahr@mpia.de)

Other relevant information of significance for the application

External funding (principal investigator)

2015-2018	Swedish Research Council grant (3,200,000 SEK) - *ranked 7/7 (outstanding)*
2013-2017	Wallenberg Academy Fellow grant (5,000,000 SEK) - *ranked 4/4 (outstanding)*
2012-2016	ERC Starting Grant (1,300,000 EUR) - *ranked 3.75/4*
2011-2014	Swedish Research Council grant (2,400,000 SEK)
2010	Veni grant from the Dutch Research Foundation (250,000 EUR)
2008	Otto Hahn Medal Fellowship from the Max Planck Society (25,000 EUR)

Scientific impact

- 38 refereed scientific publications since 2004, with more than 1900 citations
- 33 invited conference talks 2008-2014
- 27 invited seminars at European, US, and Japanese universities 2006-2014

Conference organisation

- Main organiser of "Workshop on Ice and Planet Formation" (Lund, 2013), "Pencil Code Meeting 2013" (Lund, 2013), minisymposium on "Turbulence and Planet Formation" in "XXXII Dynamics Days Europe" (Gothenburg, September 2012), "Pencil Code Meeting 2008" (Leiden, 2008)

Supercomputing

- Co-developer of the Pencil Code, a versatile and highly modular code for simulating astrophysical fluid dynamics, since 2003 (see http://code.google.com/p/pencil-code)
- Principal Investigator of PRACE project "PLANETESIM-2" (2013; granted 7,500,000 core hours)

- Principal Investigator of PRACE project "PLANETESIM" (2012; granted 6,200,000 core hours)
- Principal Investigator of computing grant for Alarik cluster at Lund University (2012-2014; granted 1,440,000 core hours per year in 2014)
- Principal Investigator of computing grant for Huygens supercomputer at SARA Computing & Networking Services in Amsterdam (2009; granted 89,000 core hours)

C SELECTED PUBLICATIONS

This list of 10 publications was chosen in order to describe the evolution of my research profile since the start of my scientific career in 2004. I have included papers that I wrote as a Master's student at the University of Copenhagen, as a PhD student at Heidelberg University and the Max Planck Institute for Astronomy, as a postdoc at Leiden University, as well as Associate Senior Lecturer and Senior Lecturer at Lund University.

1. **Johansen A.**, Andersen A. C., & Brandenburg A., 2004, Simulations of dust-trapping vortices in protoplanetary discs, Astronomy & Astrophysics, vol. 417, p. 361-374
   I wrote this paper as part of my Master's thesis at Copenhagen University. My Master's thesis supervisors Anja Andersen and Axel Brandenburg introduced me to the field of planet formation. This is still my main topic of research. I ran all the computer simulations, analysed them and wrote the paper.
   http://adsabs.harvard.edu/abs/2004A%26A...417..361J

2. **Johansen A.**, & Klahr H., 2005, Dust diffusion in protoplanetary discs by magnetorotational turbulence, The Astrophysical Journal, vol. 634, p. 1353-1371
   This is the first paper from my PhD. It is the first in a series of papers that I wrote together with my PhD supervisor Hubert Klahr at the Max Planck Institute for Astronomy in Heidelberg. It was also my first paper on astrophysical turbulence. Hubert Klahr came up with the idea to study dust diffusion in turbulence. I ran all the computer simulations, analysed them and wrote the paper.
   http://adsabs.harvard.edu/abs/2005ApJ...634.1353J

3. **Johansen A.**, & Youdin A., 2007, Protoplanetary disc turbulence driven by the streaming instability: Non-linear saturation and particle concentration, The Astrophysical Journal, vol. 662, p. 627-641 *This paper marks my first independent collaboration with someone who was not my supervisor. I met Andrew Youdin at a conference in Hawaii and a few months later we published our first two papers together. Andrew Youdin and I developed the original ideas together, I ran the simulations, and we analysed the data together. I wrote 100% of the resulting paper.*
   http://adsabs.harvard.edu/abs/2007ApJ...662..627J

4. **Johansen A.**, Oishi J., Mac Low M.-M., Klahr H., Henning Th., & Youdin A., 2007, Rapid planetesimal formation in turbulent circumstellar discs, Nature, vol. 448, p. 1022-1025
   The culmination of my PhD work was the publication of a Nature paper on planet formation. In astronomy the first author is the main contributor to a paper. It was a very hard and long process to get the paper accepted, but it was worth it, because it initiated a paradigm shift in our view of how planets form. I developed the original ideas for the paper, improved the computer code, ran the simulations, analysed the data, and wrote 100% of the paper.
   http://adsabs.harvard.edu/abs/2007Natur.448.1022J

5. **Johansen A.**, & Levin Y., 2008, High accretion rates in magnetised Keplerian discs mediated by a Parker instability driven dynamo, Astronomy & Astrophysics, vol. 490, p. 501-514
   This is the first paper from my postdoc time in Leiden. I chose to go to Leiden University in Holland for a postdoctoral fellowship, to work with Yuri Levin on star formation in the galactic centre. This is the publication that came out. Yuri Levin and I formulated the project together. I ran all the computer simulations, analysed the data and wrote the paper.
   http://adsabs.harvard.edu/abs/2008A%26A...490..501J

6. **Johansen A.**, & Lacerda P., 2010, Prograde rotation of protoplanets by accretion of pebbles in a gaseous environment, Monthly Notices of the Royal Astronomical Society, vol. 404, p. 475-485
   The asteroids and the planets of the solar system have a tendency to rotate in the same direction as their orbit. This is called prograde rotation. In this paper I worked with Pedro Lacerda, an expert on asteroids and Kuiper belt objects, on simulations that showed that accretion of small cm-sized pebbles leads to prograde spin. Pedro and I developed the idea to study asteroid rotations together. I ran the computer simulations, analysed the data and wrote the paper.
   http://adsabs.harvard.edu/abs/2010MNRAS.404..475J

7. **Johansen A.**, Davies M. B., Church R. P., & Holmelin V., 2012, Can planetary instability explain the Kepler dichotomy?, The Astrophysical Journal, vol. 758, id. 39 (15 p.)
In 2011 NASA's Kepler satellite announced the discovery of a high number of planets. In this paper we analysed the Kepler data and found that nature seems to produce two kinds of planetary systems. One kind of system has several small planets in orbits with low mutual inclinations and the other kind of system has a single gas giant close to the star, but no small planets. These results can be used to predict the frequency of habitable planets in the galaxy. Melvyn Davies and I got the original idea for the paper, Ross Church and Viktor Holmelin ran the computer simulations, and I wrote the paper.
http://adsabs.harvard.edu/abs/2012ApJ...758...39J

8. Lambrechts M., & **Johansen A.**, 2012, Rapid growth of gas-giant cores by pebble accretion, Astronomy & Astrophysics, vol. 544, id. A32 (13 p.)
This is the first paper by a PhD student under my direct supervision. Michiel Lambrechts wrote the paper based on my original ideas. We discovered that the solid cores of gas giants can form up to 10,000 times faster than normally thought, if they grow primarily by accreting small pebbles. The results of the paper were featured in the eulogy for the Urey prize that I won in 2013.
http://adsabs.harvard.edu/abs/2012A%26A...544A..32L

9. Ros K., & **Johansen A.**, 2013, Ice condensation as a planet formation mechanism, Astronomy & Astrophysics, vol. 552, id. A137 (14 p.)
Katrin Ros was a Master's student with me in Lund and continued as a PhD student under my supervision. She won the innovation prize from Sparbanksstiftelsen Skåne in 2013 for her Master's thesis on pebble formation. This first paper from her PhD studies concerns the growth of pebbles by ice condensation, in a process similar to how hail stones grow in thunder clouds in the Earth's atmosphere. I got the original idea and Katrin Ros developed the computer code, analysed the results and wrote the paper.
http://adsabs.harvard.edu/abs/2013A%26A...552A.137R

10. **Johansen A.**, Mac Low M.-M., Lacerda P., & Bizzarro M., 2015, Growth of asteroids, planetary embryos and Kuiper belt objects by chondrule accretion, Science Advances, vol. 1, id. e1500109
Fragments of asteroids land on Earth as meteorites. The most primitive meteorites – that have remained unchanged since the formation of the Solar System – contain a high mass fraction in millimeter-sized chondrules. I obtained a large supercomputing grant through the European PRACE network and ran very-high-resolution simulations of planetesimal formation. We found that these planetesimals could grow to form large asteroids and Mars-sized planetary embryos by accreting chondrules floating around in the protoplanetary disc. The results enjoyed significant press attention, including articles in forskning.se, Space.com and Süddeutsche Zeitung. I got the original idea, ran the simulations, analysed the results and wrote the paper in collaboration with my co-authors.
http://advances.sciencemag.org/content/1/3/e1500109

D RESEARCH QUALIFICATIONS PORTFOLIO

1. Summary of research / research profile

My main research area is the formation of planets. I develop computer codes and numerical algorithms for the simulation of the planet formation process, from dust grains to fully-fledged planets. These hydrodynamical simulations are run on supercomputers in Sweden and in the rest of Europe. My research has resulted in several high-impact papers on the formation of planetesimals and exoplanets. These papers have been written with a wide range of international collaborators. My scientific results have attracted significant media attention, among others in National Geograhic News and Sydsvenskan. As an Associate Senior Lecturer and Senior Lecturer at Lund University I have obtained major research grants from the Swedish Research Council, the European Research Council and the Knut and Alice Wallenberg Foundation. These grants have allowed me to build up a group of 3 PhD students and 3 postdocs / Senior Researchers who work under my supervision. I have organised or co-organised several international meetings on exoplanets and planet formation during my time in Lund. I get invited to present my work at a large number of international conferences each year. I also participate in the international community through refereeing for peer-reviewed journals, including Nature and Science.

2. Research activity

a) Previous research activity

My scientific work is driven by a desire to understand the formation of planets. Planets form in protoplanetary discs of gas and dust orbiting young stars as dust grains collide and grow to ever larger bodies. The growth from dust particle to fully-fledged planet involves 13 orders of magnitude in radius (and thus a staggering 39 orders of magnitude in mass). This process is not only responsible for forming terrestrial planets like the Earth, but also gas-giant planets like Jupiter, since planet "embryos" that reach ten times the mass of the Earth can attract several hundred Earth masses of gaseous atmosphere. There is however a major obstacle in growing particles larger than a few cm in size. Collisions between such pebbles, rocks and boulders lead to bouncing and shattering rather than sticking. This problem is often referred to as the "meter barrier" of planet formation.

I was introduced to the problem of the "meter barrier" already during my Master's project at Copenhagen University. Together with two of my Master's thesis supervisors, Dr. Anja Andersen and Prof. Axel Brandenburg, I wrote a paper to explore whether giant gaseous vortices, similar to high-pressure regions in the Earth's weather systems, can collect enough meter-sized dust boulders to allow gravity to squeeze the particles into planetesimals (Johansen et al. 2004). In this picture planet formation proceeds first by dust grains sticking to form cm-sized pebbles and m-sized boulders. These large particles are then concentrated in the turbulent gas flow, and the overdense regions contract under the mutual gravity of the particles to form km-scale planetesimals. During my Master's project I learned to use the so-called "Pencil Code" to simulate the motion of gas and dust. This code is an open source project and I have been one of the core developers since then, working mainly on implementing new modules for handling simultaneously the turbulent dynamics of gas and dust particles.

After my Master's studies I moved to Heidelberg in Germany for PhD studies at the Max Planck Institute for Astronomy and Heidelberg University. I had two PhD supervisors, Dr. Hubert Klahr and Prof. Thomas Henning, both leading experts on dust in protoplanetary discs. I brought with me the knowledge about the Pencil Code. The first project I worked on was on turbulent diffusion of small dust grains in protoplanetary discs. Most young stars are orbited by flat discs consisting of 99% gas (hydrogen and helium) and 1% dust and ice particles. These discs are believed to be turbulent because it can be observed how gas from the disc plunges onto the central star – this mass accretion is best explained as an effect of turbulent gas motion in the disc. Finding the source of the turbulent motion of protoplanetary discs is an important task in theoretical astrophysics. It has been shown that a laminar flow of gas orbiting a star will not spontaneously break into turbulence, unless the disc is threaded by a magnetic field. In the first project of my PhD studies I simulated the motion of dust particles in turbulence driven by magnetic fields and found that the diffusion is surprisingly strong (Johansen & Klahr 2005). This can explain how comets formed in the outer regions of the solar system can contain crystalline dust particles that formed in the inner hot region of the solar nebula. I later expanded the measurements of turbulent diffusion to turbulence driven by magnetic fields of various strengths (Johansen

et al. 2006c).

The turbulent motion of larger particles, up to meters in size, behaved in a very surprising way in the computer simulations. Instead of moving around randomly like small dust particles, large rocks and boulders instead concentrated in dense bands. In order to model such large particles correctly I developed a new numerical method in which the dust particles are evolved as individual particles while the gas is defined on a fixed mesh. Using this hybrid method I could probe much higher particle densities than before. I wrote a paper proposing that the "meter barrier" can be circumvented when particles concentrate in large-scale high-pressure regions that arise spontaneously in a turbulent flow. The concentrations can become high enough that large regions of boulders become gravitationally unstable and contract to form planetesimals (Johansen et al. 2006a). This idea was related to my Master's thesis paper on vortices (Johansen et al. 2004), but was more satisfactory in that it explained the spontaneous appearance of particle-trapping gas structures in the gas flow from first principles.

However, it is not clear that magnetic fields can drive turbulence everywhere in protoplanetary discs. The degree of ionisation must be high enough that the gas couples to the magnetic field. Cosmic rays and X-rays from the central star ionise the gas, but do not penetrate to the dense and cold regions where planets form. Using the hybrid-method that I had developed, where solid particles are followed in the code as numerical "superparticles" that represent a large number of physical particles, I therefore decided to study the motion of cm-sized particles in a gas not affected by the magnetic field. The initial absence of turbulence makes it possible for particles to fall to the mid-plane of the disc, like rocks thrown into a lake sink to the bottom. This mid-plane layer is nevertheless unstable to Kelvin-Helmholtz instabilities that thrive in the velocity difference between the gas in the dense mid-plane layer and the gas in the particle-free upper regions of the disc. It had already been predicted analytically that turbulence could arise from Kelvin-Helmholtz instabilities in the dusty mid-plane layer, but this had never before been modelled in computer simulations. I found that the strength of the turbulence agreed well with analytical predictions (Johansen et al. 2006b). Surprisingly, the particle layer was nevertheless not uniform but instead consisted of dense clumps of particles interacting in complex ways.

One of my closest collaborators throughout my career is Dr. Andrew Youdin (who is now at the University of Arizona). I met Andrew Youdin at a conference in Hawaii in 2005 and we quickly agreed that the clumps that I saw in my simulations of particle sedimentation (Johansen et al. 2006b) were caused by a phenomenon called the "streaming instability" which had been discovered analytically by Youdin & Goodman (2005). This particle clumping mechanism is related to how bicycle riders and migrating geese travel in groups to reduce their common air resistance. Andrew and I wrote two papers about particle clumping in the non-linear phase of the streaming instability (Youdin & Johansen 2007; Johansen & Youdin 2007).

The culmination of my PhD work was a six-weeks research stay at the American Museum of Natural History. I was awarded the Annette Kade Scholarship for working six weeks in New York at the American Museum of Natural History. Here I developed together with Prof. Mordecai-Mark Mac Low and his PhD student Jeff Oishi a module to find the gravitational potential of a collection of solid particles. This way we could include now the mutual gravity of the dust particles in the simulations. Surprisingly, the simulations showed that the overdense regions appearing in the turbulent flow would fragment gravitationally to 1000-km-scale planetesimals, rather than the km-sized planetesimals predicted in classical planet formation theory. The results were published in the journal Nature (Johansen et al. 2007), including an online supplement of 52 pages.

During my PhD I also started a collaboration with Wladimir Lyra, then a PhD student at Uppsala University supervised by Prof. Nikolai Piskunov. Wlad Lyra used the Pencil Code, including some of the modules that I had developed, to simulate the motion of gas and particles in global simulations where the entire protoplanetary disc is considered. I normally use a local approximation where I simulate only a small region inside the disc. Wlad Lyra's papers confirmed some of the simulations that I had done and added many new aspects to the theory of planet formation in turbulence (Lyra, Johansen, et al. 2008a,b; 2009a,b).

After my PhD I initially had a six months postdoc position at the Max Planck Institute for Astronomy. During that time I finished a paper that I had begun with another PhD student at the Max Planck Institute for Astronomy, Frithjof Brauer, to explain the growth of dust particles from a coagulation-fragmentation view (Johansen et al. 2008). The idea is that as large particles collide they fragment each other. However, the few lucky particles that do not collide grow by sweeping up the fragments of their unfortunate siblings. This way

the mean particle size can continue to increase even if collisions between large particles lead to destruction. However, we found that the growth is very slow and that this sweep-up mode does not provide a viable path to planetesimal formation.

After my short postdoc stay at the Max Planck Institute for Astronomy I moved to Leiden University in the Netherlands for a three-year position as postdoctoral fellow. I was attracted to the position with Dr. Yuri Levin because of the opportunity to work on subjects not related to planet formation. We decided to study the effects of a strong magnetic field on star formation in the centre of our galaxy. In this new research topic I studied a number of physical effects – e.g. magnetic Parker instabilities and accretion disc dynamos – that I had never considered before (Johansen & Levin 2008). Shortly afterwards I returned to topics in planet formation. I wrote a paper on large-scale zonal flows in protoplanetary discs (Johansen et al. 2009a), similar to the large-scale wind structures in the giant planets of the solar system, and a paper on how the formation of planetesimals depends on the abundance of heavy elements of the protoplanetary disc (Johansen et al. 2009b).

In 2010 I started a collaboration with Dr. Pedro Lacerda, an expert on Kuiper belt objects. The Kuiper belt is a collection of minor icy bodies beyond the orbit of Neptune (Pluto is one of the largest Kuiper belt objects). Pedro Lacerda approached me during a visit in Leiden and asked if I had ever measured the rotation frequency and direction of newly born planetesimals in the computer simulations. The largest asteroids in the asteroid belt have a tendency to rotate in the same direction as they orbit. This preference is not explained in standard planet formation theory where asteroids form by accretion of small planetesimals. We modelled how asteroids grow by accreting small pebbles and found that this leads to rotation similar to what is seen in large asteroids (Johansen & Lacerda 2010). We also used this to predict that Kuiper belt objects rotate in a similar fashion.

In May 2010 I started as Associate Senior Lecturer in the Department of Astronomy and Theoretical Physics at Lund University ("biträdande universitetslektor", a tenure track position). In Lund I continued to work on the dynamics of gas and dust in accretion discs and on the implications for planet formation. In 2010 I was co-investigator of a computing grant to simulate planet formation at the largest supercomputer in the world at that time – the "Jugene" system at Research Centre Jülich in Germany. I spent two months improving the Pencil Code to be able to run on 4096 processors simultaneously. This led to an interesting publication where we modelled planetesimal formation in very high resolution (Johansen et al. 2011). A criticism of my work had come from a group at Cambridge University. They claimed that particles would not collapse to form planetesimals if we would include collisions between particles. Together with Dr. Yoram Lithwick (Northwestern University) and Andrew Youdin I developed a new algorithm to treat collisions between dust particles. The results turned out to be independent of whether we included collisions or not, but more importantly we found scalings in the simulations that show why Kuiper belt objects are larger than asteroids (Johansen et al. 2012).

b) Current research

At Lund University my research role changed as I started to supervise PhD students and postdoctoral researchers. My first PhD student, Michiel Lambrechts, was funded by the department and started in the late autumn of 2010, half a year after I arrived in Lund. Michiel's PhD project concerned the formation of the cores of gas-giant planets, like Jupiter and Saturn in our Solar System that consist of several hundred Earth masses of gaseous envelope on top of their cores of approximately 10 Earth masses of solids. The formation of the core is believed to take place in the same way as terrestrial planets form, namely by accretion of countless planetesimals. However, the time-scale to form a core of 10 Earth masses is longer than 10 million years in the region where Jupiter and Saturn formed in our Solar System. This time-scale is much longer than the observed life-time of protoplanetary discs around young stars of a few million years.

In Michiel Lambrechts' PhD project we therefore investigated the rapid formation of cores by accreting millimeter and centimeter sized pebbles. Such pebbles are accreted much more readily by the core because they experience strong friction with the gas. The gas friction slows down a pebble as it is gravitationally scattered by the core, and the resulting energy loss traps the pebble in the gravitational field of the core and forces it to spiral in to be accreted on a very short time-scale. The time-scale for core formation can be reduced by a factor of 1,000 or more and this way the cores of the giant planets can form well within the life-time of the protoplanetary disc. The PhD thesis of Michiel Lambrechts resulted in four papers in total, three of them about pebble accretion (Lambrechts & Johansen 2012; Lambrechts et al. 2014; Lambrechts & Johansen 2014).

In 2010 I received a 4-year grant from the Swedish Research Council that funds another PhD student. Daniel Carrera started as a PhD student at Lund Observatory in 2012. His first paper concerned the concentration of small pebbles, down to mm sizes, by the streaming instability. Previous simulations had only probed down to approximately cm-sized particles. However, Daniel's work shows that streaming instabilities can concentrate much smaller particles than previously thought. His results are in press for Astronomy & Astrophysics now (Carrera et al., 2015).

In 2011 I was awarded an ERC Starting Grant of 1.3 million euro from the European Research Council. The call had 4080 applicants from all fields of research and a success rate of only 12%. Within the ERC-funded project PEBBLE2PLANET I focus on the formulation of a new theoretical framework for understanding the important stages involved in the growth from mm-sized pebbles to fully-fledged gas giant planets. The ERC Starting Grant funds two PhD students and a postdoc.

The two PhD students funded by the ERC Starting Grant are Katrin Ros and Karl Wahlberg Jansson. Katrin Ros did a Master's project under my supervision at the astrophysics Master's programme and continued with this project as a PhD student. Her project concerns a new mechanism to grow from dust to pebbles, namely by condensation of water vapour. The inner regions of a protoplanetary disc are hot enough that the water molecule can only exist as vapour. Outside a transition point approximately 2-3 astronomical units from the star, called the ice line or the snow line, the temperature has dropped enough that the water vapour can condense out as icy rims on the particles that reside there. This condensation growth is typically ignored in particle growth models, but Katrin found that the continuous diffusion of water vapour across the ice line can lead to very efficient particle growth there. Growth nevertheless stops as the icy pebbles reach sizes of 10 cm, because these pebbles drift rapidly into the hot region due to gas drag. These decimeter-sized ice balls are nevertheless of a sufficient size to trigger strong particle concentration and planetesimal formation (Ros & Johansen 2013). Katrin was awarded innovation prize from "Sparbankstiftelsen Skåne" in 2013 for her Master's project on the formation of icy pebbles around young stars.

The other PhD student funded by the ERC Starting Grant, Karl Wahlberg Jansson, studies the gravitational collapse of the pebble clumps that form in the hydrodynamical simulations of the streaming instability. The hydrodynamical simulations have a finite resolution and hence we are not able to follow the collapse all the way to planetesimal sizes. Karl has written a computer code to simulate this collapse phase, including particle collisions and realistic collision outcomes based on simulations. Karl showed in his first paper that the primordial pebbles in the protoplanetary disc survive the gravitational collapse phase during the formation of comets. Comets are km-sized, icy planetesimal that formed in the outer Solar System which are scattered into very eccentric orbits that bring them regularly into the inner Solar System. We were able to make the prediction that the come 67P/Churyumov-Gerasimenko, the target of the European Rosetta mission that successfully went into orbit around the comet in 2014, should be a pebble-pile planetesimal consisting of primordial pebbles from the solar protoplanetary disc (Wahlberg Jansson & Johansen 2014). This model received major media attention when the Rosetta orbiter discovered bumpy features that could represent these primordial pebbles (e.g. http://www.bbc.com/news/science-environment-30931445). Karl Wahlberg Jansson is currently at a long-term visit to the Technical University Braunschweig to work with the dust experiment group of professor Jürgen Blum on implementing more realistic pebble fragmentation pebbles based on their experiments.

The ERC Starting Grant also funds a postdoctoral researcher, Dr. Chao-Chin Yang. I already knew Chao-Chin from the Pencil Code project and was very happy when he accepted the position. He works now with developing the Pencil Code to include better algorithms for dust dynamics. His first paper with me in Lund concerned simulations of the streaming instability in very large simulation domains, up to 256 times larger volume than previously concerned (Yang & Johansen 2014). We found that the characteristic distance between neighbouring filaments formed by the streaming instability is much larger than what was inferred from previous simulations of small domain boxes. Chao-Chin is a core developer of the Pencil Code and is now working with me on improving the dust dynamics algorithms in the code, to the benefit also to the PhD students in Lund who use the Pencil Code for their projects.

In 2012 I was contacted by Dr. Lars Buchhave, a researcher at the University of Copenhagen and member of the Kepler team, about some observations that he had done. He had obtained high-quality spectra of a lot of the planet-hosting stars in the Kepler sample. These spectra confirmed that gas-giant planets orbit mainly

around stars that are richer in heavy elements than the Sun. Surprisingly, such a correlation appears to vanish for the smaller-mass planets discovered by Kepler. In fact, these planets seem to be able to form around stars with a wide range of metallicities, from sub-solar to super-solar. Lars Buchhave came over to Lund on several occassions and discussed these results with me. Together with Martin Bizzarro (University of Copenhagen) and David Latham (Harvard University) we wrote a paper that was published in Nature (Buchhave, Latham, Johansen, Bizzarro, et al., 2012). This paper had an enormous impact in the community, getting more than 50 citations per year since then. Lund University wrote a national press release on the paper (see XXX), which was picked up by many Swedish newspapers, including Dagens Nyheter, Svenska Dagbladet, Sydsvenskan, Expressen, Aftonbladet and Metro.

My interest in the results of the Kepler mission was also directed towards a more theoretical paper. Together with Prof. Melvyn B. Davies, Dr. Ross Church and Bachelor's project student Viktor Holmelin we wrote a paper for The Astrophysical Journal where we analysed the statistics of the planetary systems discovered by the Kepler satellite (Johansen et al. 2012). Due to the relatively high number of systems with three transiting planets, we were able to statistically conclude that the orbits of the planets in extrasolar planetary systems are very well-aligned, just like the orbits of the planets in our own Solar System lie in a distinct plane. Alexander Mustill joined us as a Senior Researcher in 2013 (supervised by myself and Melvyn B. Davies). He is currently undertaking more studies of the dynamics of planetary systems discovered by the Kepler satellite. His first paper, where he shows that the migration of a gas-giant planets to a very close orbit will typically destroy any smaller planets that reside there already, is currently in press (Mustill et al. 2015).

Another important interest of mine is meteorites. These rocks are fragments of asteroids that land on the Earth. Meteorites are the oldest objects in the Solar System, since the asteroids have not changed since their formation 4.5 billion years ago and hence preserve a pristine record of conditions during planetesimal formation. The most primitive of meteorites contain a large mass fraction in millimeter-sized spherules called chondrules. However, the incorporation of large amounts of chondrules into the asteroids is not well understood, as most particle concentration mechanisms operate on much larger rocks and boulders (decimeter sizes and larger). Together with Prof. Martin Bizzarro, an expert on meteorites at the University of Copenhagen, I developed a model where asteroid seeds of a characteristic size of 100 km, formed by the streaming instability, grow to their current sizes (up to 1000 km in diameter) by accreting chondrules that were floating around in the solar protoplanetary disc. Surprisingly, we also found that some asteroids would continue to grow to the sizes of planetary embryos (around 10% of the mass of the Earth), providing the seeds for a giant-impact stage that will lead to the formation of terrestrial planets. Our paper was published in Science Advances (Johansen et al. 2015). Lund University wrote both a national and an international press release about the paper. This press release enjoyed significant media attention, including articles in forskning.se, Space.com and Süddeutsche Zeitung.

c) Future plans

Comets. The Kuiper belt contains a pristine collection of icy planetesimals that formed in the outer regions of the Solar System. When stirred by the gravity of the giant planets, these planetesimals can enter the inner Solar System as comets. Comets contain both simple carbon bearing ices as well as organical molecules, and cometary bombardment early in the history of the Earth may have seeded our planet with the building blocks of life. Funded by a Wallenberg Academy Fellow grant, I will investigate the birth size distribution of Kuiper belt objects using high-resolution computer simulations. I will also measure the rate at which such comets could have been transported to the inner Solar System early in the history of the Earth.

Asteroids. Asteroids in the asteroid belt are planetesimals left over from the planet formation epoch. The gravitational influence of Jupiter likely prevented the formation of a fifth terrestrial planet there. Asteroid fragments do not only arrive on Earth as small meteorites; occasionally larger bodies collide with our Earth, with dramatic consequences for our planet, such as mass extinctions. We have recently obtained a grant from the Knut and Alice Wallenberg Foundation to study the impact history of asteroids on Earth. My contribution to the project will be to use our state-of-the-art asteroid formation models to simulate the collisional grinding and gravitational stirring of the early asteroid belt. This will give important information about how the size distribution of asteroids evolved with time, and hence we can use this to estimate a history of the frequency of asteroid impacts with Earth and their sizes. A PhD student is currently being hired, with the project focused

on the formation and evolution of the asteroid belt.

Dust experiments. I have started a collaboration with experimentalists and the Max Planck Institute for Dynamics and Self-organisation in Göttingen on simulating particle concentration in the laboratory. The group of Prof. Eberhard Bodenschatz are specialists in laboratory experiments of hydrodynamical flows. They have developed an experiment in which dust particles are suspended by a wind in a glass tube containing a dilute gas. This way they can probe whether the particles will form spontaneous clumps that fall to the bottom of the glass tube. My former PhD student Michiel Lambrechts verified in a computer simulation that a clumping instability occurs in this set up (Lambrechts et al. 2015). I am a co-Investigator of a grant from the Knut and Alice Wallenberg foundation on bottlenecks in the growth of turbulent aerosols (this PI is Prof. Bernhard Mehlig from Gothenburg University). This grant funds a PhD student based in Lund who will work in collaboration with the Göttingen group on computational modelling of their experimental set up.

Exoplanets. The pebble accretion framework that was developed in Lambrechts & Johansen (2012) has been successful at explaining the rapid formation of the cores of giant planets before the gas disc dissipates. In the next step we will form entire planetary populations with the pebble accretion framework, using statistical Monte Carlo models for the distribution of planetary birth locations as well as protoplanetary disc parameters. The result is a plot of the mass of the planetary population versus the semi-major axis of the planet. Such a plot can be directly compared to observed exoplanet populations, and any discrepancies can be used to sharpen and improve the formation models. Population synthesis can also be used by observational astronomers to plan exoplanet surveys, e.g. by ESA's forthcoming PLATO mission (Rauer et al. 2014) in which I co-lead a Work Package on population synthesis. Bertram Bitsch, a postdoctoral researcher funded by the Wallenberg Academy Fellow grant, is leading our population synthesis work under my supervision. A first paper with realistic protoplanetary disc models is already published (Bitsch et al. 2015a) and a second paper with planetary growth tracks is submitted to Astronomy & Astrophysics (Bitsch et al. 2015b).

Towards more realistic planetesimal formation models. Our planetesimal formation models have so far focused on simulations without magnetic fields present in the protoplanetary disc. The presence of a magnetic field will cause the gas to become turbulent, through the so-called magnetorotational instability. However, only the surface layers of the protoplanetary disc are ionised enough for the gas to couple to the magnetic field. The turbulent gas motion at the disc surface will penetrate down to the mid-plane of the protoplanetary disc where the pebbles reside. These residual density waves will stir the mid-plane mildly and thus affect the ability for the particles to make dense filaments by the streaming instability. My postdoc Chao-Chin Yang, funded by my ERC Starting Grant, is leading a project to include the effect of the turbulent surface layers on the streaming instability. This requires simulations of very large domains and high resolution. We are currently in the process of procuring enough CPU hours to calculate such models, through pending applications with the Swedish National Infrastructure for Computing (SNIC) and the European PRACE partnership. Chao-Chin has also done major code development to improve the code to be able to handle a sufficient range in length scales. The results of these models will yield a much more realistic picture of planetesimal formation in protoplanetary discs.

3. Research experience and qualifications

a) Research environment and scholarly networks

- *Research group.* My research group within the Department of Astronomy and Theoretical Physics currently hosts 3 PhD students and 3 Senior Researchers. An additional 3 PhD students to work under my supervision will be hired in 2015. In my group we work on a wide range of topics within accretion discs and planet formation. We have a weekly group meeting where Master's project students and Bachelor's project students also participate. At these group meetings we discuss the latest research papers as well as progress in the research projects of the team members. More senior team members (postdocs and senior researchers) are also involved in supervision of Master's students and Bachelor's students. Our activies are funded by grants from the Swedish Research Council, the European Research Council and the Knut and Alice Wallenberg Foundation.

- *Visiting researchers*. Each year I host a number of visiting researchers to Lund, funded by my external grants. These visits allow us to work on collaborative projects and to involve the PhD students in a

broader collaboration outside of their home department. Examples of researchers who visited me in the past include Prof. Jürgen Blum from Technical University Braunschweig, Prof. Alessandro Morbidelli from Nice Observatory, Prof. Cornelis Dullemond from Heidelberg University, Dr. Pedro Lacerda from the Max Planck Institute for Solar System Research and Dr. Lars Buchhave from the University of Copenhagen. I have involved PhD students in many of these collaborations – Michiel Lambrechts later went on a long-term visit to Prof. Alessandro Morbidelli at Nice Observatory (where he is now a post-doc) and Karl Wahlberg Jansson went on long-term visit to Prof. Jürgen Blum at Technical University Braunschweig.

- *Observational and Theoretical Astrophysics.* The topic Observational and Theoretical Astrophysics (OTA) within the Department of Astronomy and Theoretical Astrophysics involves 7 Professors / Senior Lecturers, 10 Postdocs / Senior Researchers and 10 PhD students. The research area of OTA spans atomic astrophysics, extreme astrophysics, formation and structure of our galaxy, planetary systems and stellar atmospheres. We have OTA group meetings every two weeks. The Theoretical Astrophysics topic within OTA involves myself, Melvyn B. Davies and Ross Church, as well as 7 PhD students and 3 senior researchers. We have group weekings in Theoretical Astrophysics every two weeks.

- *Lund-Copenhagen disc meetings.* The University of Copenhagen hosts a number of researchers who work on theoretical models of protoplanetary discs and accretion discs. In order to support the contact between our two groups that share so much overlap in our scientific interests, we organise two annual meetings, alternating between Lund and Copenhagen. These meetings are organised by Dr. Chao-Chin Yang from my group in Lund and Dr. Colin McNally in Copenhagen. Meetings typically have 15-25 participants and consist of a mixture of talks and discussion sessions. The meetings are a good opportunity for early stage researchers, such as PhD students and beginning postdocs, to practice giving presentations and getting feedback and questions about their research projects.

- *Cross-disciplinary environment in the impact history on Earth.* Together with Melvyn B. Davies and Ross Church we have formed a cross-disciplinary research environment with geologists and physicists at Lund University, centered on understanding the impact history of Earth. Three facilities at Lund University play important roles in the environment. (i) The Medicon Village Astrogeobiological Laboratory (MV-AGB) is led by Birger Schmitz and is used for locating fossil meteorites within large amounts of sediments. (ii) Per Kristiansson at the Department of Physics, is responsible for the development and operation of the Luis-W.-Alvarez-Iridium-Coincidence Spectrometer recently developed at the Faculty of Science and central to the search for traces of ancient comet and asteroid impacts on Earth. (iii) Lund University's supercomputing centre Lunarc is used by the the theoretical astrophysics group for computations of asteroid formation and dynamics, to assess the impact rate of meteorites on Earth. We have contributed to the financing of the Alarik system through grants obtained from the Royal Physiographical Society in Lund. The environment is funded by a Breakthrough Research grant from the Swedish Research Council (PI: Birger Schmitz, co-Is: Anders Johansen and Melvyn B. Davies) and a Project Grant from the Knut and Alice Wallenberg Foundation (PI: Melvyn B. Davies, co-PIs: Anders Johansen and Birger Schmitz).

- *Cross-disciplinary environment in particle growth in turbulence.* The growth of particles in turbulence is an important aspect of precipitation in terrestrial clouds as well as in the formation of planets. I am a co-Investigator of a grant from the Knut and Alice Wallenberg Foundation (PI: Bernhard Mehlig of Gothenburg University) on bottlenecks in the growth of turbulent aerosols. The grant funds 20% of my time and a PhD student to work with me in Lund on connecting particle concentration in protoplanetary discs to laboratory experiments performed at the Max Planck Institute for Dynamics and Self-organisation in Göttingen. We have planned several meetings and summer schools under the auspices of the KAW grant to bring better together the astrophysics and cloud physics communities, two communities who actually work on very similar problems.

- *Cross-disciplinary environment in particle growth in astrobiology.* I participated in scientific programme on "Astrobiology: past, present, and future" at the Pufendorf Institute for Advanced Studies at Lund University (2011–2012). This cross-disciplinary programme brought researchers from many fields of

research together – for example astronomy, chemistry, biology and idea history – on the topic of astrobiology. See http://www.pi.lu .se/archive/former-themes/astrobiology.

b) Supervision experience

Supervision of PhD students (main supervisor):

2010 – 2015	Michiel Lambrechts (Lund University) Thesis title: "Formation of gas-giant plants" PhD defense: April 2015 Licentiate defense: December 2012 Current position: postdoc at Nice Observatory
2012 – 2017	Katrin Ros (Lund University, ongoing) Thesis title: "Ice condensation as a planet formation mechanism" Licentiate defense: September 2014
2012 – 2017	Daniel Carrera (Lund University, ongoing) Thesis title: "Asteroids and terrestrial planet formation" Licentiate defense: November 2014
2012 – 2017	Karl Wahlberg Jansson (Lund University, ongoing) Thesis title: "Towards an initial mass function of planetesimals" Licentiate defense: December 2014
2015 – 2020	NN (Lund University, hiring in progres) Thesis topic: "Formation of super-Earths and gas-giant planets"
2015 – 2020	NN (Lund University, hiring in progress) Thesis topic: "Asteroid formation, orbital evolution and impact history on Earth"
2015 – 2020	NN (Lund University, hiring in progress) Thesis topic: "Clumping of particles in computer simulations and in the laboratory"

Supervision of postdocs and senior researchers (main supervisor or shared supervision):

2012 –	Dr. Chao-Chin Yang (Lund University) Research area: hydrodynamical models of planet formation Funding: ERC Starting Grant PEBBLE2PLANET
2014 –	Dr. Bertram Bitsch (Lund University) Research area: protoplanetary discs and pebble accretion Funding: Wallenberg Academy Fellow Grant
2014 –	Dr. Alex Mustill (Lund University, w. Melvyn B. Davies) Research area: planetary dynamics Funding: Wallenberg Academy Fellow Grant

c) Participation in the organisation of scholarly symposia and conferences

- Main organiser of "Pencil Code Meeting 2013" (Lund, 2013)
- Main organiser of international workshop "Ice and Planet Formation" (Lund, 2013)
- Main organiser of minisymposium on "Turbulence and Planet Formation" in "XXXII Dynamics Days Europe" (Gothenburg, 2012)
- Main organiser of "Pencil Code Meeting 2008" (Leiden, 2008)
- Co-organiser of meetings "Exoplanets in Lund 2015" (Lund, 2015), "The Transient Universe for All" (Lund, 2015), "Star and Planet Formation for All" (Lund, 2014), "Cosmology for All" (Lund, 2013), "Stars for All" (Lund, 2012), "Building Galaxies for All" (Lund, 2011), "Computational Physics with GPUs" (Lund, 2010) and "MHD Days 2006" (Heidelberg, 2006)

- Member of Scientific Organising Committee for "New Directions in Planet Formation" (Leiden or Amsterdam, 2016), "Disc Dynamics & Planet Formation" (Cyprus, 2015), "Exoplanets in Lund 2015" (Lund, 2015), "Nordic Science with ALMA" (Gothenburg, 2013)

d) Assignments as editor of a journal or other publication

N/A

e) Important research collaborations: state the scope of the research, key people and funding if applicable

I have many ongoing national and international collaborations:

Martin Bizzarro (University of Copenhagen): Martin Bizzarro is a geologist with specialisation in meteoritics and cosmochemistry. I work with Martin Bizzarro on understanding the connection between planetesimal formation and the observed properties of asteroids and meteorites.

Jürgen Blum (Braunschweig University of Technology): I wrote a review paper on planetesimal formation, for the Protostars and Planets VI conference, with among others Jürgen Blum, Martin Bizzarro, and Hans Rickman. My PhD student Karl Wahlberg Jansson is currently visiting the lab of Jürgen Blum as part of our ongoing collaboration to understand the formation of comets.

Eberhard Bodenschatz (Max Planck Institute for Dynamics and Self-Organization): I work with Eberhard Bodenschatz and members of his research group on understanding particle concentration in protoplanetary discs and its connection to laboratory experiments performed at the MPIDS. Our collaboration is now funded through a grant from the Knut and Alice Wallenberg foundation on bottlenecks for particle growth in turbulence.

Axel Brandenburg (NORDITA, Stockholm): Axel Brandenburg was the main supervisor of my Master's project at the University of Copenhagen. We work actively together on the Pencil Code project. We have organised many annual Pencil Code meetings together.

Lars Buchhave (Center for Astrophysics, Harvard University): Lars Buchhave is an expert on exoplanet observations and member of the Kepler satelite team. I collaborate with him on understanding the metallicities of exoplanet host stars and how this connects to planet formation.

Ross P. Church (Lund University): Ross Church is a Senior Researcher at Lund Observatory with expertise in planetary dynamics. He worked with me on a paper from 2012 where we studies the architectures of planetary systems discovered by the Kepler satellite.

Melvyn B. Davies (Lund University): Melvyn B. Davies is an expert on planetary dynamics and planetary instability. We work together on understanding the architectures of exoplanet systems observed with the Kepler satellite.

Thomas Henning (Max Planck Institute for Astronomy, Heidelberg): Thomas Henning is the director of the Max Planck Institute for Astronomy in Heidelberg. I work with Thomas Henning on dust dynamics in protoplanetary discs and observational consequences of dust transport.

Hubert Klahr (Max Planck Institute for Astronomy, Heidelberg): Hubert Klahr is an expert on hydrodynamics and planetesimal formation. We collaborate on modelling planetesimal formation in magnetorotational turbulence.

Pedro Lacerda (Max Planck Institute for Solar System Research): Pedro Lacerda is an expert on Kuiper belt objects in the Solar System. We work together on modelling the formation, growth and rotation of asteroids and Kuiper belt objects.

Yuri Levin (Monash University): Yuri Levin was my postdoc supervisor at Leiden Observatory. I collaborate with him on magnetohydrodynamical models of how strongly magnetised accretion discs can lead to rapid accretion of super-massive black holes.

Wladimir Lyra (Jet Propulsion Laboratory): Wladimir Lyra and I work on global simulations of protoplanetary discs, MHD turbulence, vortices, particle concentration and planet formation.

Mordecai-Mark Mac Low (American Museum of Natural History, New York): Mordecai-Mark Mac Low is a curator at the American Museum of Natural History. I visited his group for six weeks when I was a PhD student. I continue to work with Mordecai-Mark Mac Low on particle-driven turbulence and on the initial mass function of planetesimals.

Alessandro Morbidelli (Nice Observatory): Alessandro Morbidelli is a collaborator on the formation of gas-giant planets by pebble accretion. My PhD student Michiel Lambrechts visited Alessandro Morbidelli in 2013 and this resulted in a collaborative paper.

Hans Rickman (Uppsala University): Hans Rickman is a co-author of my review paper on planetesimal formation for Protostars and Planets VI. We work together on understanding the connection between comets and planetesimal formation. In 2012 we organised a small comet meeting in Lund.

Birger Schmitz (Lund University): We have recently obtained a grant from the Knut and Alice Wallenberg Foundation for a cross-disciplinary collaboration in Lund between astronomers, geologists and physicists on understanding the impact history on Earth. Birger Schmitz is co-PI on the proposal and is an expert on fossil meteorites. We recently published our first collaborative paper.

Andrew Youdin (University of Arizona): I have a long-term collaboration with Andrew Youdin, which started when I was a PhD student, on the modelling the non-linear evolution of streaming instabilities and planetesimal formation in protoplanetary discs.

f) Assessment of others work: grading committee assignments, expert assignments, referee assignments, peer review, assignments as faculty examiner, reviewer

- External referee for research grants submitted to: German Research Foundation Emmy Noether Grant (Germany, 2014), HARPS North telescope (international, 2014), Austrian Science Fund (Austria, 2013), ETH Zurich Research Grant (Switzerland, 2013), DiRAC supercomputing grants (United Kingdom, 2012), Deutsche Forschungsgemeinschaft (Germany, 2012), Research Foundation Flanders (Belgium, 2012), The Netherlands Organisation for Scientific Research (Netherlands, 2011), Swedish Research Council (Sweden, 2011), ERC Starting Grant (Europe, 2010), NASA Origins of Solar Systems grants (USA, 2009–2012), Aurora Fellowship (United Kingdom, 2008)
- Referee for international journals Astronomy & Astrophysics, Monthly Notices of the Royal Astronomical Society, The Astrophysical Journal, Icarus, Nature, Science
- Committee member in PhD defenses of Ricky Nilsson (Stockholm University, 2012) and Koen Kemel (Nordita, 2012)
- External examiner for PhD defense ("viva") of Peter Gibbons (University of Edinburgh, 2013)
- Reviewer of thesis of Mohamad Ali-Dib (Besancon Observatory, 2015)

g) Awards and distinctions in research activity

- "Harold C. Urey Prize in Planetary Science" from the Division for Planetary Sciences of the American Astronomical Society (2013)
  For outstanding achievement in planetary research
- "Otto Hahn Medal" from the Max Planck Society (2008; 5000 € and one year fellowship)
  For outstanding PhD thesis (given to ≈5% best PhD theses in the ≈80 Max Planck institutes)
- "The Patzer Prize" (2007; 2,000 €)
  For best refereed paper by young scientist at Max Planck Institute for Astronomy
- "The Patzer Prize" (2005; 1,000 €)
  For best refereed paper by young scientist at Max Planck Institute for Astronomy

4. List of publications - comprehensive

a) Published original articles in referee-assessed international journals

35. **Johansen A.**, Mac Low M.-M., Lacerda P., & Bizzarro M., 2015, Growth of asteroids, planetary embryos and Kuiper belt objects by chondrule accretion, Science Advances, vol. 1, id. e1500109 (11 p.), **1 citations**
DOI: 10.1126/sciadv.1500109

34. Bitsch B., **Johansen A.**, Lambrechts M., & Morbidelli M., 2015, The structure of protoplanetary discs around evolving young stars, Astronomy & Astrophysics, vol. 575, id. 28 (17 p.), **2 citations**
DOI: 10.1051/0004-6361/201424964

33. Dullemond C. P., Stammler S. M., & **Johansen A.**, 2014, Forming chondrules in impact splashes I. Radiative cooling model, The Astrophysical Journal, vol. 794, id. 91 (12 p.), **1 citations**
DOI: 10.1088/0004-637X/794/1/91

32. Lambrechts M., & **Johansen A.**, 2014, Forming the cores of giant planets from the radial pebble flux in protoplanetary discs, Astronomy & Astrophysics, vol. 572, p. A107 (12 p.), **8 citations**
DOI: 10.1051/0004-6361/201424343

31. Lambrechts M., **Johansen A.**, & Morbidelli A., 2014, Separating gas-giant and ice-giant planets by halting pebble accretion, Astronomy & Astrophysicsvol. 572, id. A35 (12 p.), **6 citations**
DOI: 10.1051/0004-6361/201423814

30. Wahlberg Jansson K., & **Johansen A.**, 2014, Formation of pebble-pile planetesimals, Astronomy & Astrophysics, vol. 570, id. A47 (10 p.), **1 citations**
DOI: 10.1051/0004-6361/201424369

29. Yang C.-C., & **Johansen A.**, 2014, On the feeding zone of planetesimal formation by the streaming instability, The Astrophysical Journal, vol. 792, id. 86 (10 p.), **1 citations**
DOI: 10.1088/0004-637X/792/2/86

28. Rauer H., & et al. (including **Johansen A.**), 2014, The PLATO 2.0 mission, Experimental Astronomy, vol. 38, p. 249-330, **75 citations**
DOI: 10.1007/s10686-014-9383-4

27. Schmitz B., Huss G. R., Meier M. M. M., et al. (including **Johansen A.**), 2014, A fossil winonaite-like meteorite in Ordovician limestone: A piece of the impactor that broke up the L-chondrite parent body?, Earth and Planetary Science Letters, vol. 400, p. 145-152, **0 citations**
DOI: 10.1016/j.epsl.2014.05.034

26. Ros K., & **Johansen A.**, 2013, Ice condensation as a planet formation mechanism, Astronomy & Astrophysics, vol. 552, id. A137 (14 p.), **30 citations**
DOI: 10.1051/0004-6361/201220536

25. Dittrich K., Klahr H., & **Johansen A.**, 2013, Gravoturbulent planetesimal formation: the positive effect of long-lived zonal flows, The Astrophysical Journal, vol. 763, id. 117 (17 p.), **21 citations**
DOI: 10.1088/0004-637X/763/2/117

24. Gaburov E., **Johansen A.**, & Levin Y., 2012, Magnetically-levitating accretion disks around supermassive black holes, Astronomy & Astrophysics, vol. 758, id. 103 (11 p.), **10 citations**
DOI: 10.1088/0004-637X/758/2/103

23. **Johansen A.**, Davies M. B., Church R. P., & Holmelin V., 2012, Can planetary instability explain the Kepler dichotomy?, The Astrophysical Journal, vol. 758, id. 39 (15 p.), **22 citations**
DOI: 10.1088/0004-637X/758/1/39

22. Lambrechts M., & **Johansen A.**, 2012, Rapid growth of gas-giant cores by pebble accretion, Astronomy & Astrophysics, vol. 544, id. A32 (13 p.), **70 citations**
DOI: 10.1051/0004-6361/201219127

21. Buchhave L. A., Latham D. W., **Johansen A.**, et al., 2012, An abundance of small exoplanets around stars with a wide range of metallicities, Nature, vol. 486, p. 375-377, **145 citations**
DOI: 10.1038/nature11121

20. **Johansen A.**, Youdin A., & Lithwick Y., 2012, Adding particle collisions to the formation of asteroids and Kuiper belt objects via streaming instabilities, Astronomy & Astrophysics, vol. 537, id. A125 (17 p.), **30 citations**
DOI: 10.1051/0004-6361/201117701

19. **Johansen A.**, Klahr H., & Henning Th., 2011, High-resolution simulations of planetesimal formation in turbulent protoplanetary discs, Astronomy & Astrophysics, vol. 529, id. A62 (16 p.), **32 citations**
DOI: 10.1051/0004-6361/201015979

18. **Johansen A.**, & Lacerda P., 2010, Prograde rotation of protoplanets by accretion of pebbles in a gaseous environment, Monthly Notices of the Royal Astronomical Society, vol. 404, p. 475-485, **41 citations**
DOI: 10.1111/j.1365-2966.2010.16309.x

17. **Johansen A.**, Youdin A., & Mac Low M.-M., 2009, Particle clumping and planetesimal formation depend strongly on metallicity, The Astrophysical Journal, vol. 704, L75-L79, **93 citations**
DOI: 10.1088/0004-637X/704/2/L75

16. **Johansen A.**, Youdin A., & Klahr H., 2009, Zonal flows and long-lived axisymmetric pressure bumps in magnetorotational turbulence, The Astrophysical Journal, vol. 697, p. 1269-1289, **103 citations**
DOI: 10.1088/0004-637X/697/2/1269

15. Lyra W., **Johansen A.**, Zsom A., Klahr H., & Piskunov N., 2009, Planet formation bursts in the edges of the dead zone, Astronomy & Astrophysics, vol. 497, p. 869-888, **70 citations**
DOI: 10.1051/0004-6361/200811265

14. Lyra W., **Johansen A.**, Klahr H., & Piskunov N., 2009, Standing on the shoulders of giants. Trojan Earths and vortex trapping in low mass self-gravitating protoplanetary disks of gas and solids, Astronomy & Astrophysics, vol. 493, p. 1125-1139, **43 citations**
DOI: 10.1051/0004-6361:200810797

13. Lyra W., **Johansen A.**, Klahr H., & Piskunov N., 2008, Embryos grown in the dead zone. Assembling the first protoplanetary cores in low mass self-gravitating circumstellar disks of gas and solids, Astronomy & Astrophysics, vol. 491, p. L41-L44, **45 citations**
DOI: 10.1051/0004-6361:200810626

12. **Johansen A.**, & Levin Y., 2008, High accretion rates in magnetised Keplerian discs mediated by a Parker instability driven dynamo, Astronomy & Astrophysics, vol. 490, p. 501-514, **29 citations**
DOI: 10.1051/0004-6361:200810385

11. **Johansen A.**, Brauer F., Dullemond C.P., Klahr H., & Henning Th., 2008, A coagulation-fragmentation model for the turbulent growth and destruction of preplanetesimals, Astronomy & Astrophysics, vol. 486, p. 597-611, **32 citations**
DOI: 10.1051/0004-6361:20079232

10. Lyra W., **Johansen A.**, Klahr H., & Piskunov N., 2008, Global models of turbulence in protoplanetary disks I. A cylindrical potential on a Cartesian grid and transport of solids, Astronomy & Astrophysics, vol. 479, p. 883-901, **44 citations**
DOI: 10.1051/0004-6361:20077948

9. **Johansen A.**, Oishi J., Mac Low M.-M., Klahr H., Henning Th., & Youdin A., 2007, Rapid planetesimal formation in turbulent circumstellar discs, Nature, vol. 448, p. 1022-1025, **357 citations**
DOI: 10.1038/nature06086

8. Brauer F., Dullemond C. P., **Johansen A.**, Henning Th., Klahr H., & Natta A., 2007, Survival of the mm-cm size grain population observed in protoplanetary discs, Astronomy & Astrophysics, vol. 469, p. 1169-1182, **53 citations**
DOI: 10.1051/0004-6361:20066865

7. **Johansen A.**, & Youdin A., 2007, Protoplanetary disc turbulence driven by the streaming instability: Non-linear saturation and particle concentration, The Astrophysical Journal, vol. 662, p. 627-641, **99 citations**
DOI: 10.1086/516730

6. Youdin A., & **Johansen A.**, 2007, Protoplanetary disc turbulence driven by the streaming instability: Linear evolution and numerical methods, The Astrophysical Journal, vol. 662, p. 613-626, **79 citations**
DOI: 10.1086/516729

5. **Johansen A.**, Klahr H., & Mee A. J., 2006, Turbulent diffusion in protoplanetary discs: The effect of an imposed magnetic field, Monthly Notices of the Royal Astronomical Society, vol. 370, p. L71-L75, **42 citations**
DOI: 10.1111/j.1745-3933.2006.00191.x

4. **Johansen A.**, Henning Th., & Klahr H., 2006, Dust sedimentation and self-sustained Kelvin-Helmholtz turbulence in protoplanetary disc mid-planes, The Astrophysical Journal, vol. 643, p. 1219-1232, **61 citations**
DOI: 10.1086/502968

3. **Johansen A.**, Klahr H., & Henning Th., 2006, Gravoturbulent formation of planetesimals, The Astrophysical Journal, vol. 636, p. 1121-1134, **86 citations**
DOI: 10.1086/498078

2. **Johansen A.**, & Klahr H., 2005, Dust diffusion in protoplanetary discs by magnetorotational turbulence, The Astrophysical Journal, vol. 634, p. 1353-1371, **91 citations**
DOI: 10.1086/497118

1. **Johansen A.**, Andersen A. C., & Brandenburg A., 2004, Simulations of dust-trapping vortices in protoplanetary discs, Astronomy & Astrophysics, vol. 417, p. 361-374, **73 citations**
DOI: 10.1051/0004-6361:20034417

b) Overview articles and other invited articles in international journals

5. **Johansen A.**, Jacquet E., Cuzzi J. N., Morbidelli A., & Gounelle M., 2015, New paradigms for asteroid formation, In Asteroids IV, University of Arizona Press, **0 citations**

4. Pfalzner S., Davies M. B., Gounelle M., **Johansen A.**, Münker C., Lacerda P., Portegies Zwart S., Testi L., Trieloff M., & Veras D., 2015, The formation of the solar system, Physica Scripta, vol. 90, id. 068001 (18 p.), **0 citations**
DOI: 10.1088/0031-8949/90/6/068001

3. Chabrier G., **Johansen A.**, Janson M., & Rafikov R., 2014, Giant planet and brown dwarf formation, In Protostars and Planets VI, University of Arizona Press, **12 citations**
DOI: 10.2458/azu_uapress_9780816531240-ch027

2. **Johansen A.**, Blum J., Tanaka H., Ormel C., Bizzarro M., & Rickman H., 2014, The multifaceted planetesimal formation process, In Protostars and Planets VI, University of Arizona Press, **18 citations**
DOI: 10.2458/azu_uapress_9780816531240-ch024

1. Klahr H., & **Johansen A.**, 2008, Gravoturbulent planetesimal formation, Physica Scripta, vol. T130, p. 014018, **2 citations**
DOI: 10.1088/0031-8949/2008/T130/014018

c) Books, book chapters

N/A

d) Other articles and reports published in international journals

N/A

e) Scholarly articles and reports published in Swedish

N/A

f) Popular science articles/presentations

Popular science articles:

- **Johansen A.**, & Feltzing F., 2013, "Stjärnor och planeter", to appear in "Extrema världar", edited by David Dunér
- Scientific consultant on Peter Linde's "Jakten på liv i universum", 2013, Caravan, Lund

Popular science presentations:

- Popular science talk to "Sällskapet Seniorgeograferna i Lund" (Lund, 2015)
- Popular science talk at "Lund Kloster Rotary" (Lund, 2014)
- Popular science talk at "Lundbeckfond lectures" at Experimentarium City (Copenhagen, 2014)
- Popular science talk at "Kulturnatten" at Lund Observatory (Lund, 2012, 2013, 2014)
- Three public lectures at "Folkuniversitet" in Sweden (Halmstad, Lund, Växjö, 2012)
- Two public lectures at "Folkeuniversitet" in Denmark (Copenhagen, Århus, 2010)
- Lectures to high school students at "NMT dagar" (Lund, 2011, 2012)

Press releases:

- "Millimetre-sized stones formed our planet" (2015)
  Lund University's international press release about the paper "Growth of asteroids, planetary embryos and Kuiper belt objects by chondrule accretion" (written by Lotte Billing)
  http://www.lunduniversity.lu.se/article/watch-millimetre-sized-stones-formed-our-planet
- "Millimetersmåstenar skapade vår planet" (2015)
  Lund University's national press release about the paper "Growth of asteroids, planetary embryos and Kuiper belt objects by chondrule accretion" (written by Lena Björk Blixt)
  http://www.forskning.se/nyheterfakta/nyheter/pressmeddelanden/millimetersmastenarskapadevarplanet.html
- "Överraskande upptäckt om jordlika planeter" (2012)
  Lund University's press release about "An abundance of small exoplanets around stars with a wide range of metallicities" (written by Lena Björk Blixt)
  http://www.lu.se/o.o.i.s?id=708&news_item=8310
- "Dirty stars make good solar system hosts" (2009)
  American Museum of Natural History's press release about the paper "Particle clumping and planetesimal formation depend strongly on metallicity" (written by Kristin Phillips)
  http://www.eurekalert.org/pub_releases/2009-10/amon-dsm100609.php
- "Turbulente Geburt in der Urwolke" (2007)
  Max Planck Society's press release about the paper "Rapid planetesimal formation in turbulent circumstellar discs"

Press coverage:

- I am interviewed for typically 3-6 articles in popular science journals and newspapers every year. A full list of press coverage of my own research papers, and interviews on other people's research papers, can be found on my webpage: http://www.astro.lu.se/~anders/research.php#press

g) Conference papers

6. **Johansen A.**, Klahr H., & Henning Th., 2011, High-resolution simulations of planetesimal formation in turbulent protoplanetary discs, Proceedings of "IAU Symposium 276: The Astrophysics of Planetary Systems: Formation, Structure, and Dynamical Evolution", Torino, 2011, **1 citations**
DOI: 10.1017/S1743921311019995

5. **Johansen A.**, Kato M., & Sano T., 2011, A new viscous instability in weakly ionised protoplanetary discs protoplanetary discs, Proceedings of "IAU Symposium 274: Advances in Plasma Astrophysics", Giardini-Naxos, 2010, **1 citations**
DOI: 10.1017/S1743921311006569

4. **Johansen A.**, 2009, The role of magnetic fields for planetary formation, Proceedings of "IAU Symposium 259: Cosmic Magnetic Fields: From Planets, to Stars and Galaxies" Puerto Santiago, Tenerife, 2008, **1 citations**
DOI: 10.1017/S1743921309030592

3. **Johansen A.**, & Klahr H., 2008, Planetesimal formation through streaming and gravitational instabilities, Proceedings of "Origin and Evolution of Planets 2008", Ascona, 2008, **1 citations**
DOI: 10.1007/s11038-010-9370-3

2. Youdin A., & **Johansen A.**, 2007, Planetesimal formation with particle feedback, Proceedings of "Extreme Solar Systems", Santorini, 2007, **0 citations**
http://www.aspbooks.org/a/volumes/article_details/?paper_id=29230

1. Klahr H., Rozyczka M., Dziourkevitch N., Wünsch R., & **Johansen A.**, 2006, Turbulence in protoplanetary accretion disks: driving mechanisms and role in planet formation, in "Planet Formation", edited by Hubert Klahr and Wolfgang Brandner (Cambridge University Press), **3 citations**
ISBN: 0-521-86015-6 and 978-0-521-86015-4

h) Manuscripts (submitted manuscripts are to be listed first, followed by works in progress)

4. Bitsch B., Lambrechts M., & **Johansen A.**, The growth of planets by pebble accretion in evolving protoplanetary discs, submitted to Astronomy & Astrophysics

3. Lambrechts M., **Johansen A.**, Capelo H., Blum J., & Bodenschatz E., Spontaneous concentrations of solids through two-way gas drag on sedimenting particles, submitted to Astronomy & Astrophysics

2. Mustill A., Davies M. B., & **Johansen A.**, The destruction of inner planetary systems during high-eccentricity migration of gas giants, submitted to The Astrophysical Journal

1. Carrera D., **Johansen A.**, & Davies M. B., How to form asteroids from mm-sized chondrules and chondrule aggregates, accepted for publication in Astronomy & Astrophysics

5. Research grants

The two following tables document my grant income over the last 5 years, respectively as Principal Investigator and as co-Principal Investigator and co-Investigator.

Notes to tables: Monetary amounts are given in kSEK, rounded off to the nearest 100 kSEK for amounts above 200 kSEK. The EUR-SEK exchange rate was taken as 9.39. The own share of grants where I am not the PI are estimated values that include own salary as well as salary to PhD students and postdocs under my supervision. The two KAW Project Grants start in July 2015 and hence their annual monetary value is 1/2 of their nominal value in 2015.

Anders Johansen as PI	2011	2012	2013	2014	2015	Finance source
Project name and PI	Total / own share	Total / own share	Total / own share	Total / own share	Total / own share	
VR Project Grant / Anders Johansen	600 / 600	600 / 600	600 / 600	600 / 600	0	Swedish Research Council
Royal Physiographical Society Grant / Anders Johansen	115 /115	0	0	0	200 / 200	Royal Physiographical Society
ERC Starting Grant / Anders Johansen	0	2300 / 2300	2900 / 2900	2100 / 2100	3000 / 3000	European Research Council
Wallenberg Academy Fellow / Anders Johansen	0	0	500 / 500 (0.5 year)	1000 / 1000	1000 / 1000	Knut and Alice Wallenberg Foundation
VR Project Grant Young Researchers / Anders Johansen	0	0	0	0	800 / 800	Swedish Research Council
Total per year	715 / 715	2900 / 2900	4000 / 4000	3700 / 3700	5000 / 5000	

Anders Johansen as co-PI or co-I	2011	2012	2013	2014	2015	Finance source
Project name and PI	Total / own share	Total / own share	Total / own share	Total / own share	Total / own share	
VR Breakthrough Research Grant / Birger Schmitz (AJ co-I)	0	0	1000 / 100	1000 / 100	1000 / 100	Swedish Research Council
KAW Project Grant I / Melvyn B. Davies (AJ co-PI)	0	0	0	0	2200 / 600 (0.5 year)	Knut and Alice Wallenberg Foundation
KAW Project Grant II / Bernhard Mehlig (AJ co-I)	0	0	0	0	4500 / 400 (0.5 year)	Knut and Alice Wallenberg Foundation
Total per year	0	0	1000 / 100	1000 / 100	7700 / 1100	

List of grants and fellowships obtained since 2009:

- Swedish Research Council Project Grant for Young Researchers (2015–2018; PI; 3,200,000 SEK)
  To fund a PhD position in the topic of planet formation
- Knut and Alice Wallenberg Foundation Project Grant (2015–2020; co-I; 44,700,000 SEK)
  For project to study the bottlenecks in the growth of particles in turbulence, with applications both to terrestrial clouds and planet formation. The PI is Bernhard Mehlig of Gothenburg University.
- Knut and Alice Wallenberg Foundation Project Grant (2015–2020; co-PI; 23,200,000 SEK)
  For IMPACT project to study the impact history of the Earth. The PIs of the project are Melvyn B. Davies, Anders Johansen and Birger Schmitz.
- Wallenberg Academy Fellow grant (2013–2017; PI; 5,000,000 SEK)
  For project on the formation of icy planetesimals and their delivery of volatiles to Earth
- ERC Starting Grant (2012–2016; PI; 1,300,000 €)
  For PEBBLE2PLANET project on formulating a new planet formation theory framework
- Swedish Research Council Project Grant (2011–2014; PI; 2,400,000 SEK)
  To fund a PhD position in the topic of planet formation

- Veni Grant (2009; PI; 250,000 €)
  Three year fellowship given by the Dutch science foundation NWO
- Otto Hahn Medal Fellowship (2008; PI; 25,000 €)
  One year fellowship given by the Max Planck Society (declined)
- The Annette Kade Student Fellowship Program (2006; PI)
  Six weeks scientific visit to the American Museum of Natural History in New York

E TEACHING QUALIFICATIONS PORTFOLIO

1. Summary of teaching activities

I have strived to develop my teaching and supervision skills throughout my career. The grounds were laid as a university student, PhD student and postdoctoral fellow, where I was an assistant teacher on courses at both University of Copenhagen and University of Heidelberg and also gave lectures at winter schools. As a Senior Lecturer at Lund University I have had the opportunity to become course responsible, for both a course at the Bachelor's level and a course at the Master's level. Direct feedback from students and evaluations have allowed me to continuously improve those courses. My teaching practices have also been sharpened in pedagogical courses given at Lund University, by reading literature and discussion with the course teachers and the other participants. I have supervised the projects of a number of Bachelor's students and Master's students. My first PhD student graduated recently. I currently supervise three PhD students who all successfully defended their licentiate degrees in 2014. Three more PhD students are in the hiring process. I am involved in teaching administration and leadership through my roles as coordinator of the Master's programme in Astrophysics at Lund University and as study director (and steering group member) of the COMPUTE research school that organises many activities for the more than 60 enrolled PhD students, including PhD level courses.

2. Personal reflection on teaching

Teaching university students is as important a task as research. Throughout my career I have taken every opportunity available to teach students and to improve my teaching skills, both in topics close to my own research and in general topics in mathematics, physics and astronomy.

Teaching experience as university student, PhD student and postdoctoral researcher

As a Master's student at Copenhagen University I had a job as an assistant teacher on a first-year mathematics course "Mathematics A". The students (around 20 each semester) were mostly nanotechnology students with a moderate interest in mathematics. I was responsible for correcting the coursework and for teaching the exercise classes. The students solved problems on the blackboard, handed in home work assignments, and asked questions about the contents of the lectures and about the problems. It quickly became clear to me that the students would understand the topics much better if the *relevance* was clear to them. So I tried to explain when and why they would use the various mathematics tools in their later studies. This experience was very rewarding for me. Often a group of students would stay for a while after the classes and ask further questions about the implications of what they had learned.

Teaching was unfortunately not a mandatory part of the PhD studies at the University of Heidelberg (except for minor laboratory supervision). I was therefore happy when the chance came to organise the exercise classes for the course "Hydrodynamics II - numerical methods and applications" lectured by Dr. Cornelis Dullemond (who is now a professor at the University of Heidelberg's Institute for Theoretical Astrophysics). I volunteered immediately. I was responsible for planning the coursework for the computer exercise classes. There were six students at the exercises, solving coursework problems in the computer lab. This was a non-mandatory Master's level course, and the students were highly motivated. We designed a coursework where the students worked with simple numerical solvers for hydrodynamics and diffusion problems, illustrating the contents of the lectures and the lecture notes. Based on my experience from "Mathematics A" in Copenhagen, I tried to show the students the relevance of the coursework with examples (such as movies of computer simulations) from my own research as well as the research of other numerical astrophysicists.

My stay as a postdoc at Leiden Observatory at Leiden University was very fruitful scientifically, but sadly there were no opportunities to teach any courses. Fortunately I could instead teach as an invited teacher at winter schools and at other universities. I lectured at the winter school "Supercomputing and numerical techniques in astrophysics fluid flow modelling" in Evora in Portugal in 2008. The approximately 50 students were at various career stages, from Master's students and PhD students to young postdocs. I gave a two-hour lecture on numerical algorithms for computational modelling of planet formation and supervised the corresponding exercise classes (three times two hours). The teaching material that I developed is now available on my web site (http://www.astro.lu.se/∼anders/research.php#teaching). For the exercise classes the students solved simple

numerical problems with the Pencil Code. Because of my previous experience that the programming abilities of students can vary quite strongly, I made sure that there were both simple exercises for the less experienced students, as well as more advanced exercises for the more experienced students. I was later invited to Kobe University for a special meeting on planet formation in 2009. During my six weeks stay there I gave a two-hour lecture on the physics of accretion discs to approximately 50 students. This was an interesting new experience because of the cultural differences in teaching Japanese students. I had been given the advice that Japanese students are very strict in their methodology and expect a lecturer to make mathematical proofs of all claims. Therefore I used the blackboard in combination with projector slides, to give rigorous proofs of various aspects of the lectures. The lectures were well received by the students.

Teaching experience as Associate Senior Lecturer and Senior Lecturer

I came to Lund University in 2010 as Associate Senior Lecturer ("biträdande universitetslektor"). The director of studies Professor Sofia Feltzing approached me shortly after my start in Lund and we had a long talk about the course structure at the astronomy Bachelor's and Master's level. She thought it would be a good idea if I would teach the course on planetary systems that had entered the course plan the previous year. The course was at that consisting of a few lectures on exoplanets. I therefore decided to develop the course from scratch. Developing nine two-hour lectures and hand-in material was a major challenge. I decided to focus the course on three main topics – the solar system, planet formation, and exoplanets – so the first task was to read up on all the background material. I found a good text book that covered all these topics and I read a number of additional books and review articles to strengthen my background knowledge.

The course had eight students in the first year (seven Master's students and one PhD student). The students were highly active during the lecture and asked many advanced questions. I often had to defer difficult questions to the following lecture, in order to read up on the background literature. I developed a new concept that I called *question sheets*. For each lecture I handed out a sheet with three questions to be answered in writing by the students until the next lecture. The questions focused on a deep understanding of the lectured material, based in part on the book chapters, in part on the lectures and in part on analytical thinking. These question sheets were very well received by the students and got positive reviews in the evaluation at the end of the course.

The final exam was a report and presentation of a chosen subject. I compiled a booklet of 20 suggestions for topics, including for each topic three scientific papers to read and three questions to be answered in the report. The overall workload for the students was approximately three weeks, including preparation of the presentation. I had two meetings with each student to monitor progress and to guide and to answer questions. The students presented their work to each other in a day of student lectures. I had in advance prepared a number of simple and one difficult question for each student, to probe their level of knowledge acquired during the preparation of the lectures. The other students were also encouraged to ask questions.

The course had generally positive evaluations (5/6 average in "How was the course overall?")[1]. One point of criticism was that the discussion classes were too short and too qualitative. I had planned to use the discussion classes to expand on the lectured topic with additional information such as short movies of future missions to planets in the solar system. However, some students thought the benefit of the discussion classes was too little compared to the time spent. Therefore I changed the discussion classes the year after to what I called *post-lecture exercises* where the students work in groups on small exercises related to the lecture. The intention is to let the material that has just been lectured sink in deeper. The post lecture exercises worked well and activated also some more introverted students that were not usually active during the lectures and discussions.

Since 2012 I am the course responsible also for the Bachelor's level course "ASTB01 – Introduction to Astrophysics". This course has typically 15–20 students, mainly students on the third year of the physics education and exchange students. Teaching a Bachelor's level course is very different to teaching a Master's level course. I follow here a text book rather strictly and teach almost purely using the whiteboard, with only a few slides on the computer to illustrate biographies of important astronomers and to show complicated plots. The students are generally very positive about whiteboard lectures, as these force the lecturer to slow down and go through the derivations very carefully. The course has received generally positive feedback (4.5/5 in 2014). My lectures received a score of 4.9/5 in 2014.

[1] See http://www.astro.lu.se/Education/utb/ASTM20/evaluation_results_2010.html.

Teaching philosophy

When I studied at university, a good teacher for me was someone who was dedicated to the topic and knowledgeable of the assumptions, foundations, and implications of the field. I try to live up to those ideals when ever I teach students myself. My principal teaching philosophy is founded on three pillars:

1. *Relevance:* I strive to show the students the relevance of what they are learning, because I know from myself and from experience that learning is very difficult when the relevance is not clear.
2. *Depth:* I never tell students just naked facts. Astronomy has many interesting facts, but I always go at least one step beyond that with the students and explain to them why we believe a certain fact to be true.
3. *Skepticism:* University students should learn to question assumptions and paradigms. I encourage skeptical questions during class and independent thinking in hand-ins and reports.

Relevance. Learning is hard if the relevance is not clear. This is true both for fundamental courses, such as first year mathematics, and for advanced level courses in a specialised field. In lectures and exercises I strive to explain to the students why what they are learning is useful. In a methods course like Mathematics A for Nanotechnology students at Copenhagen University I explained to the students how the lectured mathematics would be useful in more specialised courses in their main topic of studies. *Depth*. One goal of my teaching is to teach the students not just naked facts, but also why we believe that certain facts are true. There are as an example some very simple arguments for why the planets must have formed in a circumstellar disc orbiting the newly born sun (simply put: that all planets orbit in the same plane and that primitive meteorites have the same isotope ratios as gas in the atmosphere of the Sun). These fundamental logical arguments are often easier to remember than more complicated facts (that may be so detached from everyday experiences that learning by heart is the only way to do well at an exam). *Skepticism*. Modern workplaces, both inside or outside of academia, require employees to think independently and make qualified judgements about the quality of a written text or an abstract idea or concept. Such skills can be taught at all levels of university teaching, but are particularly important in Master's level courses. When teaching Master's level courses I present students with all the relevant information, even on controversial subjects. I encourage critical questions during lectures and independent thinking in weekly hand-ins, reports and exam projects. Independent and critical thinking can be encouraged by letting students read and summarise scientific papers with conflicting views of a topic.

Supervision of Bachelor's and Master's students

At Lund University I have supervised four students in 15 ECTS Bachelor's projects (and one ongoing). Bachelor's projects are challenging to supervise because of the limited time, so I write a plan for how the project should progress week by week. In the end this may not be followed strictly, but it is good for myself and the students to have a well-defined guideline. All the projects were finished on time and many of the students continued on the astrophysics Master's programme. As a postdoctoral researcher at Leiden University I supervised two Master's projects. Although I did most of the project definition and supervision, I could not be the main supervisor of Michiel Lambrechts and David Huijser, because university rules dictated that the main supervisor had to be a tenured professor. Michiel Lambrechts continued to work with me in Lund as a PhD student and graduated in 2015. At Lund University I supervised the Master's project of Katrin Ros. She won the "Innovation Prize" from Sparbanksstiftelsen Skåne in 2013 for her Master's thesis on pebble formation. Katrin Ros finished her degree in May 2012 and has continued under my supervision as a PhD student. I currently supervise Matthew Agnew in a project on exoplanet atmospheres, a new direction for my research. Supervising a Master's project on a new scientific topic was a very rewarding experience. The new topic exposed me to methodological challenges and results that I had not foreseen, and hence many more discussions and planning meetings with the student were needed, compared to what is usually the case when I have supervised Master's students.

Supervision of PhD students

My first PhD student, Michiel Lambrechts, did a Master's project with me at Leiden University and afterwards moved to Lund University as a PhD student. He graduated in 2015 and is now a postdoc at Nice Observatory in France. Michiel worked with me on the formation of the cores of giant planets in the Solar System as well as around other stars. Initially his project was about the migration of such cores by gravitational scattering of pebble-sized dust particles, but Michiel's simulations repeatedly showed that the cores migrated very little –

instead the cores grew very rapidly as they accreted the surrounding pebbles. This "pebble accretion" process turned out to be very important for explaining the formation of planets, and the discovery of the process was mentioned in the eulogy for the "Harold C. Urey Prize" that I was awarded by the American Astronomical Society in 2013. The fact that we almost missed this rapid growth process, by focusing initially on the migration of the cores, made me realise what a potential PhD students have in exploring new research areas. I currently supervise three PhD students (who have all successfully defended their licentiate theses in 2014), and I have strived for all of their projects to define new research directions for me.

Pedagogical education

At Lund University I have had the opportunity to follow courses on university-level teaching. I have so far had 8 weeks of training, and another 5 weeks ongoing in a course on pedagogical leadership that I am currently following. These courses have allowed me to compare my teaching practices against the scientific literature that exists on university-level teaching. Importantly, the discussions and exchange of ideas with lecturers and the other course participants in these courses have yielded important new perspectives on teaching and supervision.

3. List of teaching qualifications

a) Formal training in teaching and learning in higher education

- "Ledning av pedagogisk verksamhet" (Lund University, 2014/2015, five weeks, ongoing)
  The course concerns leadership of pedagogical activities, including an actual project to be implemented. My project concerns the introduction of a scientific writing workshop at the Master's programme in Astrophysics.

- "Kommunikation i naturvetenskaplig utbildning (komNU) " (Lund University, 2014, one week)
  The course concerned the introduction of training in scientific writing in the courses at the Bachelor's programme in Physics. See Attachment E1.

- "Den goda föreläsningen" (Lund University, 2013, two weeks)
  The course concerned modern teaching practices, including student activities during lectures. See Attachment E2.

- "Seminariekurs för undervisning på forskarnivå" (Lund University, 2011/2012, two weeks)
  The course concerned a number of topics within PhD level teaching and supervision. See Attachment E3.

- "Docentförberedande kurs" (Lund University, 2011, three weeks)
  The course concerned a number of topics within teaching, supervision and research. See Attachment E4.

b) Educational training relevant to the subject, or other training in teaching and learning

- Participated in "luPOD postdoctoral development programme", with university-level teaching as one of the topics (Lund University, 2011)
  See Attachment E5.

c) Other experience of an educational nature which the applicant considers wholly or partially relevant or complementary to the other points (point of view to be justified)

N/A

d) Teaching experience or equivalent

- Lecturer on "FYTA14 – Fluid Dynamics" (Lund University, annually since 2015)
  This is a Bachelor's level course followed mainly by meteorology, physics and astronomy students. I was part of the group that defined the course contents after it was decided to start a fluid dynamics course at Lund University. The course started in 2013, and since 2015 I have been responsible for approximately 1/3 of the lectures.
  http://home.thep.lu.se/∼patrik/fyta14/

- Course responsible for "ASTB01 – Introduction to Astrophysics" (Lund University, annually since 2012)
  This is a Bachelor's level course (third year) with approximately 15 students each year. Teaching consists of 14 two-hour lectures, exercises and experimental labs. The latter two components are taken care of by PhD students. The course examination combines lab reports and a written exam. See Attachment E10.
  http://www.astro.lu.se/Education/utb/ASTB01/

- Course responsible for "Topics in Theoretical Astrophysics" (Lund University, 2012)
  This is a PhD level course that I developed together with Prof. Melvyn B. Davies. The course had 5 participating PhD students. We developed a system where the PhD students take turns at presenting a research paper. Two other PhD students were given the task to ask questions after the presentation and write down the question and the answer.

- Course responsible for "ASTM20 – Planetary Systems" (Lund University, annually since 2010)
  This is a Master's level course (fifth year) with approximately 10 students each year. Teaching consists of nine two-hour lectures and exercises. The exam consists of various hand-ins during the term plus a project and a presentation by each student at the end of the term. See Attachment E7.
  http://www.astro.lu.se/Education/utb/ASTM20/

- Invited lecturer at winter school "Chronology of solar system formation V: the first solids and the first planetesimals" (Les Houches, 2013)
  I gave two two-hour lectures at this winter school for the approximately 60 students.
  https://www-n.oca.eu/michel/SchoolChronoV/

- Invited lecturer at summer school "IMPRS Summer School 2011: Characterizing exoplanets – from formation to atmospheres" (Heidelberg University, 2011)
  I gave three one-hour lectures at this summer school and designed a two-hours exercise for the approximately 70 students.
  http://www.mpia.de/imprs-hd/SummerSchools/2011/

- Invited lectures on "The magnetorotational instability and accretion disc turbulence: an overview" (Kobe University, 2009)
  I gave a two-hour lecture to approximately 100 students at Kobe University.
  https://www.cps-jp.org/calendar/fy2009/2009-06-01/Lecture_Johansen.txt

- Invited lecturer at winter school "Supercomputing and Numerical Techniques in Astrophysics Fluid Flow Modelling" (Evora University, 2008)
  I gave two two-hour lectures at this winter school and developed a booklet containing a range of small and long projects and exercises for the approximately 50 students.
  http://www.lca.uevora.pt/ip-supercomputing/

- Assistant teacher on "Hydrodynamics II - numerical methods and applications" (Heidelberg University, 2006)
  This was a Master's level course at Heidelberg University. I was responsible for designing and teaching the weekly two-hour exercise classes for approximately 5 students.
  http://www.mpia.de/homes/dullemon/lectures/hydrodynamicsII/

- Assistant teacher on "Mathematics A" (Copenhagen University, 2003–2004)
  This was a Bachelor's level course at Copenhagen University. I was responsible for the weekly two-hour exercise classes for approximately 20 students.

e) Supervision at the Bachelor's and Master's degree levels

- Supervision of Master's students (main supervisor):
  Matthew Agnew (Lund University, 2014–2015), Katrin Ros (Lund University, 2011–2012), David Huijser (Leiden University, 2009–2010), Michiel Lambrechts (Leiden University, 2008–2009)
  See Attachment E8, E9 and XXX.

- Supervision of Bachelor's students (main supervisor):
  Daniel Mikkola (Lund University, 2015), Joakim Eriksson (Lund University, 2014), Erik Jeppsson (Lund University, 2013), Erik Dahlén (Lund University, 2012), Viktor Holmelin (Lund University, 2011)
  See Attachment XXX.

f) Educational leadership

- Study director at COMPUTE research school on scientific discovery using computers (Lund University, from 2012)
  Together with the other study director, Tobias Ambjörnsson, I organise the activities of the COMPUTE research school. COMPUTE connects research group within the science faculty with a focus on scientific discovery using computers. COMPUTE provides courses to the participating PhD students, as well as a seminar series and an annual retreat. I am also in the steering group that makes decisions about courses and other COMPUTE activities. See Attachment E6.

- Coordinator of Astrophysics Master's programme (Lund University, since 2010)
  I have the overall responsibility for the development of the Master's programme and the admission of new students to the programme, in collaboration with the director of studies. I organise 1. the introduction week for new Master's students, 2. the choice of Master's project (based on a booklet of Master's project topics), 3. the three seminars given by the Master's students, and 4. daily matters concerning the Master's students in relation to the programme. See Attachment E11.

g) Educational development work

- Co-developed "FYTA14 – Fluid Dynamics " course (Lund University, 2012)
  I was part of the the group that defined the text book, the curriculum and the study plan of the new fluid dynamics course. The course is mandatory on the Bachelor's programme in Meteorology and optional for physics students. I teach parts of the lectures of FYTA14 since 2015.

- Co-developed "Topics in Theoretical Astrophysics" PhD course (Lund University, 2012)
  XXX

- Developed "ASTM20 – Planetary Systems" course (Lund University, 2010)
  The course had been given once in a different form before I took over as course responsible. I redesigned the course completely, decided the topics and the textbook and developed nine two-hour lectures, as well as weekly hand-ins and the final exam. See Attachment E7 and E10.

h) Production of teaching materials and publications

- "Pencil Code test problems" (with Axel Brandenburg)
  Small and large exercises and projects developed for the "Supercomputing and Numerical Techniques in Astrophysics Fluid Flow Modelling" winter school at Evora University in 2008.
  http://www.astro.lu.se/∼anders/research.php#teaching

i) National and international educational work

N/A

j) Internationalisation work within teaching practice

- Coordinator of collaboration between Lund University and Mbarara University of Technology in Uganda (since 2012)
  Mbarara University of Technology recently started a Master's programme in Astrophysics in order to attract more students into studying science. Funded partially through the ISP (International Science Programme) at Uppsala University, we assisted in the definition of the curriculum. My postdoc Bertram Bitsch went to Uganda in 2014 to teach a course on planetary systems, based on the ASTM20 course that I developed in Lund.

k) Reporting assignments and evaluation assignments

- Wrote self-evaluation report of Master's programme in Astrophysics for "Högskoleverket" (2012)
  Together with deputy prefect Sofia Feltzing, I organised the plan for the self-evaluation report of the Master's programme in Astrophysics for "Högskoleverket". We compiled material from the teaching staff and produced a cohoerent 17-page document.

l) Symposia, conferences, workshops and collaborations

N/A

m) Distinctions and awards for educational activities

N/A

F PORTFOLIO: LEADERSHIP AND ADMINISTRATION

1. Summary of leadership and administration

I have been involved in research and teaching boards as a student politician at the University of Copenhagen. At Lund University I continue by involvement and sit both in the board of the Department of Astronomy and Theoretical Physics and in the Swedish National Committee for Astronomy.

My pedagogical leadership and administration is centred on two tasks. I am the coordinator of the Master's programme in Astrophysics. Here I organise the arrival of the new Master's students and give them support and advice during their two years on the Master's programme. I am also the director of studies and steering group member of the COMPUTE research school, with more than 60 PhD student members from a high number of research groups in the Science Faculty at Lund University.

2. Leadership and administration – personal reflection

I have a keen interest in academic leadership and administration. When I was student at the University of Copenhagen I was active in the student political organisation. I sat two terms as a student representative in the board of the Astronomical Observatory at the University of Copenhagen. I also sat one term as a student member of the Physics Study Council. During this period the physics studies transformed from a two semester system to a four period system, and all courses had to be rescheduled and resized. I was heavily involved in this process.

I have been the coordinator of the Master's programme in Astrophysics since I arrived at Lund University in 2010. As a programme coordinator, I have the overall responsibility for the development of the Master's programme and the admission of new students to the programme, in collaboration with the director of studies. I organise the introduction week for the new Master's students, with inspirational lectures, seminars and a barbecue that I ask the PhD students to arrange. This way the new Master's students get a chance to meet the existing Master's students and PhD students in a social setting with no senior staff present. I also compile Master's project descriptions from the teaching staff, distribute these to the Master's students and advice the students on their choice. I organise the seminars of the Master's students and give them feedback on presentation style and project progress during their two years on the programme.

My interest in pedagogical leadership also extends to PhD courses. I am director of studies and steering group member in the COMPUTE research school that combines many research groups within the Science Faculty of Lund University. More than 60 PhD students are members of COMPUTE. I organise courses for COMPUTE and the annual retreat for PhD students, supervisors and partners.

At the Department of Astronomy and Theoretical Physics I sit in the board as a representative of the academic staff. I am also a member of the Swedish National Committee of Astronomy, an advisory group to the Swedish Royal Academy of Sciences.

I have received leadership training in several courses given at Lund University. The "luPOD" postdoctoral development programme had leadership as one of the cornerstones. I am currently participating in a course on leading pedagogical activities given by the Centre for Education at Lund University. These courses, together with my experience in pedagogical and academic leadership positions, have shaped my view of leadership. Academic leadership flows both from the formal position one has (external mandate), but equally importantly also from the view of one's competences by one's peers (internal mandate). The latter is particularly important in academia where collegial leadership exists at many levels.

Another aspect of my leadership experience comes from leading my research group. My group currently hosts three Senior Researchers, three PhD students (with three more in the hiring process) and a number of Master's and Bachelor's students. As a group leader I distribute work tasks and scientific projects among the members. The feedback from the group members is an important component in defining the best scientific projects and their best distribution among the team members. Therefore I organise weekly group meetings where we discuss recent scientific results, progress and problems in our own projects and plans for future projects.

3. Academic leadership and administration – list of qualifications

a) Formal training in leadership and administration

- Participated in "Ledning av pedagogisk verksamhet" ("Leading pedagogical activity") course given by Centre for Education (Lund University, 2014–2015, 3 weeks)
- Participated in "luPOD postdoctoral development programme" (Lund University, 2011)

b) Leadership positions within academia

- Coordinator of Master's programme in Astrophysics (Lund University, since 2010, 5% working time)
- Study director and member of steering group of COMPUTE research school on scientific discovery using computers (Lund University, 2012, 10% working time)

c) Leadership positions outside academia

N/A

d) Assignments on boards and committees

- Teacher representative in board of Department of Astronomy and Theoretical Physics (Lund University, since 2013)
- Member of Swedish National Committee of Astronomy (since 2013)
- Student member in Physics Study Council (University of Copenhagen, 2003)
- Student member in Astronomical Observatory Board (University of Copenhagen, 2002–2003)

e) Assignments concerning ethics, gender equality, work environment and environmental issues

N/A

f) Management and cooperation expertise within other organisations outside the University such as scholarly or professional organisations

- Member of International Astronomical Union (IAU)

G PORTFOLIO: COOPERATION WITH WIDER SOCIETY, INNOVATION AND ENTREPENEURSHIP

1. Summary of cooperation, innovation and entrepreneurship

My interaction with the surrounding society takes place mainly in the form of press releases, press interviews and popular outreach talks. My research has resulted in four press releases, the latest in 2015, all of which were picked up by national and international media. Each year I am interviewed for a number of popular articles about the latest results in research – most often about exoplanets and exploration of the Solar System. I have given many outreach talks during my time at Lund University, most recently as an invited lecturer at the "Lundbeckfond lectures" at Experimentarium City in Copenhagen. I have obtained innovative research results by developing novel software tools for modelling the formation of planets. The research results I obtained as a PhD student were referred to as "paradigm breaking". My supervision of PhD students at Lund Observatory has resulted in the "Harold C. Urey Prize" for my work on planet formation with Michiel Lambrechts and the "Innovation Prize" from Sparbankstiftelsen Skåne to my Master's student Katrin Ros for her novel Master's project on the formation of icy pebbles around young stars.

2. Cooperation, innovation and entrepreneurship personal reflection

I am dedicated to the popularisation of research on exoplanets and planet formation. During my career I have sent out four press releases about my research results. The latest press release was published in 2015 and concerned our paper published in Science Advances about the formation of asteroids and terrestrial planets. This press release enjoyed significant media attention, including articles in forskning.se, Space.com and Süddeutsche Zeitung.

I am interviewed for typically 3-6 articles in popular science journals and newspapers every year. In the past year I have been interviewed about the arrival of Rosetta satellite at the comet 67P/Churyumov-Gerasimenko, the arrival of the Dawn satellite at the asteroid Ceres and the upcoming arrival of the New Horizons spacecraft to the dwarf planet Pluto. A full list of press coverage of my own research papers, and interviews on other people's research papers, can be found on my webpage: http://www.astro.lu.se/~anders/research.php#press

I have given a number of public outreach talks in Sweden and in Denmark, among others to "Folkeuniversitet" in Denmark (2010) and "Folkuniversitet" in Sweden (2012), at "Kulturnatten" at Lund Observatory (2012, 2013, 2014), as an invited lecturer at "Lundbeckfond lectures" at Experimentarium City in Copenhagen (2014) and at the "Lund Kloster Rotary" (2014). I have furthermore authored a popular science article about astrobiology for the anthology "Extrema världar" (edited by David Dunér), a result of an astrobiology programme at the Pufendorf Institute for Advanced Studies at Lund University.

My research has a high degree of innovation. I develop novel numerical algorithms for modelling the formation of planets on supercomputers. I have been a core developer on the software project "Pencil Code", an open source code to simulate the coupled motion of gas and dust particles, since 2003. Results obtained with this code have been referred to as "paradigm breaking" by Morbidelli et al. (2009, Icarus, 204, 558). I continue to develop novel ideas in planet formation. My work on the rapid formation of planets by accretion of pebbles, together with my PhD student Michiel Lambrechts, was featured in the eulogy for the "Harold C. Urey Prize" for outstanding achievement in planetary research that was awarded to me in 2013 by the American Astronomical Society "for outstanding achievement in planetary research". My Master's student Katrin Ros won the "Innovation Prize" from Sparbanksstiftelsen Skåne in 2013 for her Master's thesis on pebble formation as a planet formation mechanism. In the Master's thesis, and the resulting publication, we modelled for the first time how ice particles in protoplanetary discs around young stars grow by condensation of water vapour in a process similar to how hail forms in a terrestrial thunder cloud.

3. Cooperation, innovation and entrepreneurship - list of qualifications

a) Formal training in media and communication

- Participant in mentor program for Wallenberg Academy Fellows, with media training as one of the topics (since 2012)

b) Information to business/culture sector/associations/industry/public sector

N/A

c) Advice to business/culture sector/associations/industry/public sector

- Scientific consultant on Peter Linde's "Jakten på liv i universum", 2013, Caravan, Lund
  http://www.peterlinde.net/index.php/en/
  See Attachment G for except from the book's preamble

d) Development of information and educational material for the general public, other professional groups, etc.

- Author of popular science article: **Johansen A.**, & Feltzing F., 2013, "Vanliga och ovanliga stjärnor och planeter", in "Extrema världar", edited by David Dunér, ISBN 978-91-979893-2-9
  https://lup.lub.lu.se/search/publication/4196079

e) Participation in various media

Press releases:

- "Millimetre-sized stones formed our planet" (2015)
  Lund University's international press release about "Growth of asteroids, planetary embryos and Kuiper belt objects by chondrule accretion" (written by Lotte Billing)
  http://www.lunduniversity.lu.se/article/watch-millimetre-sized-stones-formed-our-planet

- "Millimetersmåstenar skapade vår planet" (2015)
  Lund University's national press release about "Growth of asteroids, planetary embryos and Kuiper belt objects by chondrule accretion" (written by Lena Björk Blixt)
  http://www.forskning.se/nyheterfakta/nyheter/pressmeddelanden/millimetersmastenarskapadevarplanet.html

- "Överraskande upptäckt om jordlika planeter" (2012)
  Lund University's press release about "An abundance of small exoplanets around stars with a wide range of metallicities" (written by Lena Björk Blixt)
  http://www.lu.se/o.o.i.s?id=708&news_item=8310

- "Dirty stars make good solar system hosts" (2009)
  American Museum of Natural History press release for "Particle clumping and planetesimal formation depend strongly on metallicity" (written by Kristin Phillips)
  http://www.eurekalert.org/pub_releases/2009-10/amon-dsm100609.php

- "Turbulente Geburt in der Urwolke" (2007)
  Max Planck Society's press release on "Rapid planetesimal formation in turbulent circumstellar discs"
  http://www.mpg.de/546916/pressemitteilung20070829

Press coverage:

- I am interviewed for typically 3-6 articles in popular science journals and newspapers every year. A full list of press coverage of my own research papers, and interviews on other people's research papers, can be found on my webpage: http://www.astro.lu.se/~anders/research.php#press

f) Examples showing innovation within e.g. education, research or other area

- In 2013 I was awarded the "Harold C. Urey Prize" by the Division for Planetary Sciences of the American Astronomical Society for outstanding achievement in planetary research. An excerpt from the eulogy shows documents my innovative research: "Dr. Anders Johansen's pioneering work on planetesimal accretion and more recently on giant planet core formation has provoked paradigm shifts in a field which for years had been plagued by long-standing problems. By filling not one but two major gaps in one of the most difficult areas of solar system studies, Dr. Johansen's findings represent one of the most significant contributions to the field."
  http://aas.org/posts/news/2013/07/dps-announces-2013-prize-winners
  http://dps.aas.org/prizes/2013

- My Master's student Katrin Ros won the "Innovation Prize" from Sparbanksstiftelsen Skåne in 2013 for her Master's thesis on pebble formation.
  http://science.prodwebb.lu.se/sites/science.prodwebb.lu.se/files/insidan_131219_eng.pdf
- I am a core developer of the open source software program Pencil Code. I have implemented innovative numerical algorithms into the code. The results obtained with this code have been referred to as "paradigm breaking" by Morbidelli et al. (2009, Icarus, 204, 558).
  http://pencil-code.nordita.org/

g) Examples showing entrepeneurship

N/A

h) List of patents

N/A

ATTACHMENT E1

Certificate of participation in course "Kommunikation i naturvetenskaplig utbildning"

Kursintyg

LUNDS UNIVERSITET

Naturvetenskapliga fakulteten

2014-12-18

Anders Johansen

har godkänts på kursen

Kommunikation i naturvetenskaplig utbildning
2013–2014

Kursen motsvarar en veckas heltidsarbete och kan tillgodoräknas inom den behörighetsgivande högskolepedagogiska utbildningen.

Syfte och mål

Kursens syfte är att ge ökad kunskap om hur skriftlig och muntlig kommunikationsträning kan integreras i den naturvetenskapliga utbildningen. Det övergripande målet är att kursdeltagarna ska få ökad medvetenhet om språkliga verktyg och responsmetoder, och därigenom utveckla sin förmåga att stödja såväl studenters färdighetsutveckling som deras ämnesförståelse.

Efter genomgången kurs ska deltagaren kunna argumentera för värdet av en varierad kommunikationsträning i utbildningen, och av naturvetares förmåga att kommunicera med olika grupper i olika sammanhang, kunna argumentera för hur ämnesintegrerad kommunikationsträning kan bidra till studenters förståelse av ämnet, kunna utveckla kommunikationsmoment med tydligt formulerade mål, konstruktiv och effektiv responsgivning, samt relevanta examinationsformer, och kunna utvärdera vilka effekter ämnesintegrerad kommunikationsträning får på studenters färdigheter och förståelse.

Innehåll och genomförande

Kursen är praktiskt inriktad och deltagarna arbetar i workshop- och seminarieform med att analysera, utveckla och utvärdera kommunikationsmoment i den egna undervisningen. Kursen har tre schemalagda träffar – workshop, responsseminarium och slutseminarium – som bygger på deltagarnas aktiva medverkan och interaktion. Träffarna schemaläggs enligt överenskommelse med respektive institution. Utöver träffarna tillkommer eget arbete med utveckling, reflexion och redovisning. I en avslutande rapport redogör deltagarna, med utgångspunkt i kursmålen, för det kommunikationsmoment som har utvecklats.

Kurskrav

Aktivt deltagande i kursträffarna samt godkänd rapport.

Susanne Pelger
Kursledare

Sara Santesson
Kursledare

Naturvetenkapliga fakulteten; Box 118, SE-221 00 Lund, Tel. +46 46 222 00 00

ATTACHMENT E2

Certificate of participation in course "Den goda föreläsningen"

LUNDS UNIVERSITET
Lunds Tekniska Högskola

Kursintyg

14 maj 2013

Anders Johansen

770218-8256

har fullföljt kursen

Den goda föreläsningen *(GB_S01)*
(The Good Lecture)

Våren 2013

Kursen motsvarar 2 veckors behörighetsgivande högskolepedagogisk utbildning.

Kursens syfte
En stor del av akademisk undervisning bedrivs i form av föreläsningar. Kursen syftar till att deltagarna ska förbereda sina föreläsningar och belysa några av de för- och nackdelar som finns med föreläsningen som undervisningsform.

Innehåll och arbetsform
Kursen behandlar styrkor och svagheter med föreläsningsformen, föreläsningsteknik, föreläsaren, studentstrategier visavi föreläsningsform, kursansvarigrollen, konkreta metoder för hur föreläsningar kan genomföras och utvärderas, röst- och kroppsspråk, auskultationsarbete.

Kursen består av schemalagda kursträffar med en blandning av lärarledd undervisning, deltagarundervisning och diskussioner. Kursdeltagarna gör auskultationsarbete, förberedelse av deltagarundervisning och analysuppgift i grupp mellan kursträffarna.

Kursens mål
För godkänd kurs ska deltagaren med stöd i universitetspedagogisk litteratur kunna redogöra för några av föreläsningsformens styrkor och svagheter i relation till studenters lärande; inom ramen för kursen kunna diskutera universitetsundervisning utifrån ett sociokulturellt perspektiv; kunna analysera föreläsningsformen med hjälp av relevant litteratur; kunna analysera hur en föreläsnings olika delar och former kan samverka inom en kurs för att stödja studenters lärande samt inom ramen för ett kollegialt samtal kritiskt kunna granska en inspelad egen föreläsning.

Roy Andersson
Universitetslektor
Lunds Tekniska Högskola

Katarina Mårtensson
Pedagogisk utvecklare
Lunds universitet

ATTACHMENT E3

Certificate of participation in course "Seminariekurs för undervisning på forskarnivå"

LUNDS UNIVERSITET

Sektion Personal
Avdelning Lednings- och kompetens-
utveckling/CED

KURSINTYG

Härmed intygas att

Anders Johansen

aktivt har deltagit i

Seminariekurs för utbildning på forskarnivå

läsåret 2011/2012

Åsa Lindberg-Sand

För kursbeskrivning, mål och kurskrav se andra sidan.

Postadress Box 118, 221 00 Lund *Besöksadress* Tornav 9 B, Lund *Telefon* 046-222 00 00 *Direkt* 046-222 39 00 *Fax* 046-222 39 49
E-post ced@ced.lu.se *Webbadress* www.ced.lu.se

ATTACHMENT E4

Certificate of participation in course “Docentförberedande kurs”

LUNDS UNIVERSITET

Naturvetenskapliga fakulteten

INTYG

2011-10-12

Anders Johansen

har genomgått

kurs för blivande docenter

anordnad av den naturvetenskapliga fakulteten vårterminen 2011. Kursen omfattar 9 dagars schemalagd utbildning och muntliga presentationer, förberedelser, samt en skriftlig redogörelse och beräknas motsvara tre veckors heltidsstudier. Docentkursen räknas i sin helhet som behörighetsgivande högskolepedagogisk utbildning (tre veckor). Forskarhandledningsmomentet är behörighetsgivande i enlighet med universitetsstyrelsens beslut I G 51 6636/2003. Kursen innehåller delmomenten

- vetenskapsteori
- kreativitet och kvalitet i forskningen
- Populärvetenskaplig forskningspresentation
- Mediehantering
- Forskarhandledning och forskarutbildningens formalia
- Professionell handledningsrelation

Tobias Nilsson
Kurskoordinator, naturvetenskapliga fakulteten

Postadress Box 118, 221 00 LUND *Besöksadress* Sölvegatan 37 *Telefon dir* 046-222 71 82, *växel* 046-222 00 00 *Telefax* 046-222 40 24
E-post Tobias.Nilsson@kanslin.lu.se

Bilaga till kursintyget med information om de ingående kursmomenten

Vetenskapsteori och kreativitet

Kursmomenter syftar till att introducera deltagarna i vetenskapsteoretiskt tänkande kring sin egen forskning och vetenskap i allmänhet, samt stimulera till reflektion över använda forskningsmetoder och deras förutsättningar. Momentet avslutats med ett block om vetenskaplig kreativitet och hur man som handledare kan främja skapandet av kreativa miljöer.

Efter avslutat moment ska kursdeltagaren:

– ha kännedom om centrala vetenskapsteoretiska frågeställningar och diskussioner såsom Vad är vetenskap? Vad är empiriskt stöd? Kan en hypotes falsifieras? Vilken roll spelar experiment och observation i vetenskapen? Är vetenskapliga teorier sanna? Hur fungerar vetenskaplig begreppsbildning?
– konstruktivt kunna analysera sin egen och andras forskning ur ett vetenskapsteoretiskt perspektiv och på ett sätt som gagnar den egna forskningen och forskarutbildningen.

Populärvetenskaplig forskningspresentation

Efter avslutat moment ska kursdeltagaren:

– ha en mera utvecklad förmåga och vilja att presentera sitt ämne och sin forskning för en bredare publik.
– kunna belysa forskningsämnet från olika perspektiv och att anpassa innehåll och framförande till olika målgrupper och sammanhang.
– ha utvecklat en beredskap att använda populärvetenskaplig kommunikation som ett didaktiskt redskap i undervisningen.
– ha utvecklat en förmåga att ge konstruktiv respons på populärvetenskapliga presentationer.

Mediehantering

Efter avslutat moment ska kursdeltagaren:

– ha ökad insikt i hur man på ett konstruktivt sätt möter journalister, hur man förbereder sig inför en intervju och vad man ska tänka på under själva intervjun samt vid efterföljande textgranskning.
– ha en inblick i journalisters arbetsförhållanden och arbetsmetoder.
– ha en ökad insikt i konsten att sålla fram det väsentliga för en tilltänkt målgrupp, att formulera rubriker och bärande nyckelord.

Forskarhandledning och forskarutbildningens formalia

Efter avslutat moment ska kursdeltagaren:

– kunna definiera sin egen roll och sitt ansvar inom ramen för forskarutbildningen.
– kunna relatera kunskaper om doktorandernas lärande till frågor om handledarstöd och utformning av andra inslag i forskarutbildningen.
– kunna relatera forskarutbildningen och handledningen till de regelverk som är relevanta.
– kunna introducera doktoranden till såväl rättigheter som skyldigheter och vilka resurser som står till förfogande då hjälp och stöd utöver handledningen är påkallad.
– tillsammans med doktoranden kunna upprätta den individuella studieplanen, på ett sätt som är väl avvägt och förankrat i målen för forskarutbildningen och de faktiska förutsättningarna.

Professionell handledningsrelation

Efter avslutat moment ska kursdeltagaren:

– ha ökad förståelse för hur grundläggande faktorer såsom förväntningar, ömsesidiga överenskommelser, arbetsallians, målformulering och uppföljning m.m. påverkar handledningsrelation och arbetsresultat
– ha ökad förmåga att identifiera olika typer av svårigheter som kan uppstå i handledning
– ha en bredare repertoar av olika sätt att hantera svårigheter i handledning
– ha ökad medvetenhet rörande olika typer av etiska dilemman i handledningssituationen
– ha ökad insikt om egna förutsättningar för att kunna utveckla en framgångsrik handledningsrelation.

Postadress Box 118, 221 00 LUND *Besöksadress* Sölvegatan 37 *Telefon dir* 046-222 71 82, *växel* 046-222 00 00 *Telefax* 046-222 40 24
E-post Tobias.Nilsson@kanslin.lu.se

ATTACHMENT E5

Certificate of participation in "luPOD postdoctoral development programme"

LUND UNIVERSITY

DIPLOM

Anders Johansen

har under 2011 genomgått utvecklingsprogrammet

luPOD – Lunds universitets postdoktorsprogram

Syftet med programmet har varit att stödja deltagarna i deras personliga och professionella utveckling och därmed främja deras karriär. Programmet har vänt sig till biträdande lektorer och forskarassistenter, eller motsvarande, vid Lunds universitet. Programmet har bestått av elva seminariedagar med mellanliggande arbetsuppgifter och ett mentorsprogram. luPOD har initierats av rektorsämbetet och arrangerats av sektion Personal vid Lunds universitet.

Innehåll:

- Forskning och forskarrollen
- Undervisning och lärarrollen
- Samverkan, innovation och tredje uppgiften
- Akademisk organisation, kultur och miljö
- Att kommunicera forskning
- Ledarskap och kommunikation
- Karriär och framtidsstrategier
- Kompetens, skicklighet, meriter och prioriteringar

Cecilia Agrell Johannes Persson

Programledare

ATTACHMENT E6

Statement of teaching and organisation of COMPUTE research school

LUND UNIVERSITY

Department of Astronomy and
Theoretical Physics
Prof. Melvyn B. Davies, ämnesansvarig

July 31, 2012

Natural Science Faculty
Lund University

CONCERNING ANDERS JOHANSEN'S PEDAGOGICAL EXPERIENCE AND SKILLS

Anders Johansen has significant pedagogical experience and skills. He has been been the course responsible for the masters course: Planetary Systems (ASTM20) since 2010. Anders Johansen is responsible for the development, teaching and examination of the entire course. His teaching for ASTM20 combines lectures with student exercises. I have observed Anders' lectures for this course. I have to say that I have been impressed for a number of reasons: in his lectures he shows a very high degree of preparation and attention to detail, and good ownership of the material combined with a genuine enthusiasm for teaching. I have also discussed the structure of the course with him. He has clearly thought a great deal about how the course is arranged and the learning goals of the various elements.

Anders Johansen has supervised three masters students and two bachelors students on their research projects. I was the examiner for one of the masters students. It was clear from discussions with Anders, and separately with the student concerned, that Anders put considerable effort into the planning and direction of this masters project, providing time for example for regular meetings with the student.

Anders Johansen has thus far been involved in the supervision of four PhD students, all as head supervisor. Anders Johansen invests considerable time and effort in the education of his PhD students. I have seen Anders interact with the PhD and masters students during our regular group meetings. In this setting, he puts in considerable thought about how best to develop the skills of both PhD and masters students.

Anders Johansen has been the coordinator for the Astrophysics Masters Programme in Lund since 2010. In this role, he organises and runs the introduction week for incoming masters students. He is responsible for the assembling of the research projects booklet given to the students, which contains information about available masters research projects, and then organises the process by which students select their projects. He also runs the three seminars given by the masters students during their time in Lund.

Anders Johansen is also co-director of studies for the COMPUTE research school. COMPUTE spans computational research groups across the science faculty. As part of his duties, Anders is in part responsible for the organising of courses, for ensuring that the COMPUTE PhD students are aware of the opportunities open to them through COMPUTE and for the arranging of the annual retreat. COMPUTE represents an important opportunity for the research education for PhD students working in computational fields. It is a particular goal to provide interdisciplinary opportunities for the students, by having students working, for example, in astrophysics, learn more about topics in other areas, for example in computational biology.

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Anders Johansen clearly brings a range of skills and experiences to his teaching. Within the department he has taken a very active role in education at both undergraduate and postgraduate levels. He has also made an important contribution to our public outreach activities, including talks to visiting high-school students and the presentation of computer simulation videos at the open evening during Culture Night.

THREE SUGGESTIONS FOR POSSIBLE EXPERTS

Below I list three suggestions for possible experts:

1. Professor Hans Olofsson, Onsala Space Observatory, Chalmers University of Technology, SE 439 92 Onsala. Email: hans.olofsson@chalmers.se

2. Professor Susanne Höfner, Department of Physics and Astronomy, Uppsala University, SE 751 20 Uppsala. Email: susanne.hoefner@physics.uu.se

3. Professor Goran Olofsson, Department of Astronomy, Stockholm University, SE 106 91 Stockholm. Email: olofsson@astro.su.se

THREE SUGGESTIONS FOR TITLES OF A DOCENT LECTURE

Below I list three suggestions for titles of possible docent lectures:

1. Modelling type II supernovae on a computer

2. Modelling galaxy formation on a computer

3. The observational study of exoplanetary atmospheres

Yours faithfully,

Prof. Melvyn B. Davies

ATTACHMENT E7

Statement of development of course "ASTM20 Planetary Systems"

LUND
UNIVERSITY

Department of Astronomy and
Theoretical Physics
Patrik Edén, Director of Undergraduate Studies

May 16, 2012

To whom it concerns

Summary of course evaluations concerning Anders Johansen

Since his appointment at our department, Anders Johansen has from scratch designed a course on planetary systems, and has so far held it in 2010 and 2011. The course is very well received among the students, who mention appropriate work-load, interesting content, relevant exercises etc. When asked to evaluate Anders as a lecturer, choosing among phrases ranging from "excellent" to "very poor", students persistantly choose the top two marks ("excellent" and "very good").

Sincerely yours,

Patrik Edén

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ATTACHMENT E8

Certificate of supervision of Master's project of Michiel Lambrechts at Leiden Observatory

Melbourne, January 22, 2012

To whom it may concern:

Dear sir/madam,

this letter is to certify that Dr. Anders Johansen was responsible for designing a major masters project and for day-to-day supervision of Michiel Lambrechts, who was officially my masters student at Leiden Observatory in 2008/2009. Anders' supervision was excellent, and the project was a success, resulting in an original piece of research that is being prepared for publication. The collaboration has endured and Michiel is now pursuing a PhD degree under Anders' supervision at Lund.

Please don't hesitate to contact me if you need any further clarification.

Yours sincerely,

Yuri Levin

Yuri Levin
Lecturer
Monash University
E-mail: Yuri.Levin@monash.edu
Phone: +61 (3) 9905 3646

ATTACHMENT E9

Certificate of supervision of Master's project of David Huijsser at Leiden Observatory

Universiteit Leiden
Sterrewacht Leiden
Prof. Dr. Huub Röttgering

Subj.: Supervision of Master's project by Anders Johanson

Leiden, February 7, 2012

To Whom it May Concern:

This letter is to certify that Anders Johansen supervised David Huijser's Master's project "Computer simulations of galactic magnetic fields" at Leiden Observatory in 2009/2010. In close collaboration with dr. Peter Katgert, associate professor at Leiden University, Anders Johansen defined the project and preformed the daily supervision. The project was carried out on schedule.

Sincerely yours,

Huub Röttgering
Professor of Observational Cosmology

Prof. Dr. Huub Röttgering - Sterrewacht Leiden, Postbus 9513, 2300 RA Leiden
Niels Bohrweg 2. 2333 CA Leiden Telefoon: 0715275851 Telefax: 071-5275743
Email: rottgering@strw.leidenuniv.nl Homepage: www.strw.leidenuniv.nl/~rottgering

ATTACHMENT E10

Statement on teaching at Lund Observatory

LUNDS
UNIVERSITET

Institutionen för astronomi och teoretisk fysik
Prof. Sofia Feltzing

Lund
2013-04-26

Anders Johansen's teaching at Lund Observatory

When Anders joined Lund Observatory I was directory of undergraduate studies. It is in this capacity and as the current deputy head of the department that I write this supporting letter.

Anders already from the start showed a keen interest in getting involved in the teaching at the Observatory. He is responsible for two courses at the advanced (master) level: Introduction to Astrophysics and Planetary Systems. He has completely re-developed the course on planetary systems. This was a major piece of work as it required, for example, getting fully acquainted with various aspects of geology. The introductory course is, and will remain, an important part of our undergraduate curriculum. Anders has also been teaching a part of the masters-level course on Dynamical Astronomy.

On the PhD level Anders has led, together with Prof Melvyn Davies, a course on Topics in Theoretical Astrophysics during the last academic year. In addition, Anders has been guiding PhD students through a self-study course on Advanced Simulations using a Hydrodynamical Code.

In all this Anders has shown great enthusiasm and dedication.

Yours sincerely

Professor Sofia Feltzing
Deputy head of the department with responsibility for teaching

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ATTACHMENT E11

Statement of coordination of the Master's programme at Lund Observatory

LUNDS UNIVERSITET

Institutionen för astronomi och teoretisk fysik
Prof. Sofia Feltzing

Lund
2013-04-26

Anders Johansen's work as master program coordinator at Lund Observatory

Anders Johansen has been coordinator of the masters program in astrophysics at Lund Observatory since 2010. I have followed his work in this and also mentored him in his role as coordinator. He is now solely in charge of this program, starting with admission of the students, through the organization of the courses, allocation of projects, careers advice to the students, and the final examination.

He also led the on-going external evaluation of our program and wrote, together with me, our self-evaluation for this process.

Anders has brought much energy and enthusiasm to the program and has shown that he is able to guide the students well through the program as well as through difficult times. His organization of the program, including direct contacts with the head of teaching for some re-structuring, is excellent.

In his role as coordinator, he is doing a very good job for the department, keeping our important master program vibrant and exciting.

Yours sincerely

Professor Sofia Feltzing
Deputy head of the department with responsibility for teaching

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ATTACHMENT G1

Documentation for consultant role on Peter Linde's popular science book "Jakten på liv i universum"

Förord

Alla människor borde få möjligheten att titta på en riktigt mörk stjärnhimmel. I dagens värld bor över hälften av mänskligheten i städer, i Sverige är det mer än åtta av tio. En nattbild av jorden sedd från rymden avslöjar hur stadsljuset sprider sig på planeten. Risken är alltså stor att det finns många som aldrig har sett hur en riktig stjärnhimmel kan se ut. Och ändå är det inte så svårt. Det räcker att ha lite tur med vädret och att en höstkväll bege sig ett par mil utanför stadens ljus. Jag tror aldrig jag träffat en människa som förblivit helt oberörd av den anblicken. Så mycket djup det finns i den, inte bara rent fysiskt utan även intellektuellt, estetiskt och känslomässigt. Man får en nyttig påminnelse om perspektiven i livet. "Så små och obetydliga vi ändå är", reagerar en del. Det tycker inte jag. Däremot får jag en känsla av samhörighet med det oändliga där ute som oavbrutet skickar sitt ljus till jorden.

Fascinerande nog bekräftar modern vetenskap på många sätt att kopplingen mellan oss och universum är mycket stark. De atomer som våra kroppar består av skapades där ute, både vid universums uppkomst och senare när de bearbetats i många generationer av stjärnor. Det gäller i högsta grad även vår hjärna. Det är ingen överdrift att säga att den också är ett resultat av universums utveckling, i enlighet med Darwins evolutionsteori. Detta dryga kilo hjärnsubstans måste betraktas som den högst utvecklade och organiserade form av materia vi känner till. I den bemärkelsen är vi inte små – tvärtom. Åtminstone här på jorden finns det alltså materia som utvecklat intelligens och medvetande, och åtminstone här har det genom människans utveckling blivit möjligt att studera och försöka förstå vårt universum. Jag anser att det är vår skyldighet att ta den chansen och min bok handlar i mångt och mycket om detta.

Tanken är då inte långt borta att det någonstans kan finnas andra intelligenta varelser som på samma sätt står och tittar på en för oss okänd stjärnhimmel. Har de samma känslor, ställer de samma frågor? Att ens fundera på det har länge verkat meningslöst, för hur skulle vi någonsin kunna få veta?

Men 1995 blev dessa frågor betydligt mindre meningslösa. För första gången blev astronomerna säkra på att det finns planeter inte bara i vårt eget solsystem utan även vid andra stjärnor. Upptäckten blev starten på en lavinartad utveckling, där vi inom knappt tjugo års tid redan konstaterat existensen av närmare 1 000 sådana nya

planeter. De fick snart sin egen beteckning – exoplaneter. Upptäckten blev också grunden för en ny och expanderande vetenskapsgren: astrobiologin. När det alltså visat sig att planeter är vanliga och att det mycket väl kan finnas hundratals miljoner bara i vår egen galax, Vintergatan, är det oundvikligt att åter ställa frågan: kan det finnas liv därute?

Ambitionen med denna bok är att i populära termer ge en bakgrund till jakten på liv i universum. Det är en fascinerande forskning att följa. Nästan dagligen rapporteras om nya exoplaneter. Andra forskare ägnar hela sitt liv åt att försöka fånga upp intelligenta meddelanden som de tror kan vara på väg till jorden i detta nu. Och mänskligheten skickar själv ut information som någon gång kanske fångas upp av någon annan.

Jag har försökt att förankra redogörelsen i den modernaste forskningens fakta men samtidigt har jag också givit utrymme för spekulationer om utomjordingar och mänsklighetens framtida öde. En del hamnar nära science fiction-romanens domäner, men nog bör det vara tillåtet att ibland tänka både stort och fritt? Förhoppningsvis kan läsaren i varje fall någonstans också uppleva den häpnad och förundran jag själv ofta känner inför ämnet.

Att skriva denna bok har varit en utmaning på många sätt. Forskningen runt exoplaneter utvecklas blixtsnabbt och det är oundvikligt att några fakta jag ger i boken hinner bli inaktuella ganska fort. Det finns därför en särskild hemsida, www.peterlinde.net, där de senaste uppgifterna kommer att finnas tillgängliga tillsammans med annat extramaterial. En annan sak har varit att försöka undvika alltför många facktermer. I de fall det inte varit möjligt rekommenderar jag en titt i ordförklaringarna längst bak i boken.

Ämnet spänner över många områden och det är omöjligt att vara fackman på alla. Jag har därför tagit hjälp av vänner och experter, som jag särskilt vill tacka. Ulf R. Johansson, tidigare kulturredaktör och ständig astronomientusiast, gav mig många tips och mycken uppmuntran. Mikrobiologen Leif Petersson gav synpunkter på kapitlet om livets utveckling. Anders Johansen, en av de i Sverige få verksamma exoplanetforskarna, gjorde värdefulla förbättringar i kapitlen om planeter och exoplaneter. Astronomen och redaktören Björn Stenholm gjorde samma sak, framför allt med de sex sista kapitlen, bland annat om SETI och Drakes formel. Om det trots deras insatser kan finnas något fel kvar i texten beror det helt och hållet på mig själv.

Till slut vill jag tacka mina två närmaste: Eva Dagnegård som följer mig i livet och hela tiden hjälpt och uppmuntrat mig, samt min dotter Amanda, som när hon fyller 90 år 2080 kommer att uppleva en helt annan – och förhoppningsvis ännu bättre – värld än den vi ser nu.

Peter Linde