Grain Charges and Lightning in Protoplanetary Disks

Peter Woitke
School of Physics & Astronomy
Centre for Exoplanet Science
University of St Andrews, UK
pw31@st-and.ac.uk
star-www.st-andrews.ac.uk/~pw31

Uffe G. Jørgensen
Niels-Bohr Institute
StarPlan Centre
University of Copenhagen, DK
uffegj@nbi.dk
www.astro.ku.dk/~uffegj

Project Description

The thermo-chemical state of circumstellar disks determines the composition of planets that form in them, and is hence the key to understand exoplanet diversity. Yet, the temperature and chemical composition of the gas in these disks is not known, in particular the properties of the gas in the midplane inside of ~10 au *(Woitke et al. 2018, A&A 618, 57)*, where most of the planets form. In this project, we want to study grain charging processes in protoplanetary disks and their feedback on gas ionisation and observation of line emission by molecular ions. Based on a moment method developed in *Thi et al. (2018, arXiv 1811.08663)*, we want to compute the size-dependent charge distribution function of grains *f(a,Z)* in the disk, where *a* is the grain radius and *Z* its charge, based on our state-of-the-art disk modelling software ProDiMo *(Woitke et al. 2016, A&A 586, 103)*. In particular, we want to include the so-called tribo-electric effect, where grains undergo frictional charging when they collide with each other in a turbulent environment. In combination with dust settling, this effect is known to cause electrification of volcano plumes and, more general, lightning in the Earth atmosphere *(Helling et al. 2016, Survey in Geophysics 37, 705)*. It is hence the aim of this project to find out in how far this mechanism also applies to protoplanetary disks, and could change the chemical composition and ionisation in disks.

Innovative Training Network (ITN)

This project is part of the Marie Sklodowska-Curie Innovative Training Network (ITN) *CHAMELEON* "*Virtual Laboratories for Exoplanets and Planet Forming Disks*" (http://chameleon.wp.st-andrews.ac.uk/). The ITN combines the expertise of eight European research institutes (Universities of St Andrews, Groningen, Copenhagen, Edinburgh, Leuven and Antwerp, the Max-Planck Institute in Heidelberg and the Netherlands Institute for Space Research) to cover all relevant aspects for this complex modelling task, joining the expertise in planetary atmospheres and protoplanetary disks, including observation and interpretation. As Marie Sklodowska-Curie fellows, you will receive generous benefits, including a fixed salary with additional mobility and family allowances. The network will consist of 15 Early Stage Researchers (PhD students) and the respective supervisors/local research groups. For a complete list of all open PhD positions within this training network, including those of our European partners, please see http://chameleon.wp.st-andrews.ac.uk/recruitment/.

The Host Institutes

The School of Physics & Astronomy at the University of St Andrews is an active member of the St Andrews Centre for Exoplanet Science (https://www.st-andrews.ac.uk/exoplanets/) which leads an interdisciplinary agenda on exoplanet research. St Andrews is renown for exoplanet research ranging from exoplanet discovery and characterisation, atmosphere chemistry and thermo-chemical disk modelling, to the impact of the host star on exoplanet systems. In Copenhagen, the student will be part of the active environment in the Niels Bohr

Institute's section for Astrophysics and Planetary Science, which covers aspects of exoplanet research, proto-planetary disk formation, formation of our solar system, meteorites and exploration of Mars.

The Position

The PhD position is fully funded for a period of 3.5 years. The PhD position is fully funded for a period of 3.5 years. The student is expected to obtain a double degree in St Andrews/UK and Copenhagen/DK. Training secondment for this position is foreseen for six months at the Niels-Bohr Institute in Copenhagen.

Requirements

We seek an excellent student with a strong background in physics or astrophysics. Successful candidates must hold a Masters degree or equivalent by the starting date of the position. Previous research experience on planet forming disks and/or astrochemistry, and a track record of team work/mobility will be important criteria for the selection. This is a computational project: some prior knowledge of coding would be useful (e.g., Python and Fortran). Note that the general eligibility and mobility rules of Marie Sklodowka-Curie Actions apply, i.e. applicants must not have resided or carried out their main activity (work, studies, etc.) in the country of the main host institution (in this case the UK) for more than 12 months in the 3 years immediately before the recruitment date. If you have been residing in the UK, please consider to apply to the open positions of our European partners (http://chameleon.wp.st-andrews.ac.uk/recruitment/).

Application documents

Your application package should contain (i) a CV including publication list if applicable, (ii) a statement of interest (max. one page, including a brief description of research interests and relevant experience), (iii) copies of university grades, certificates and/or diplomas, (iv) two letters of reference to be sent by the application deadline, (v) a statement that confirms that you undestood the requirements of the joint degree and the Marie Sklodowska-Curie mobility criteria as outlined at https://chameleon.wp.st-andrews.ac.uk/recruitment/.

Use the portal of the School of Physics & Astronomy in St Andrews University https://www.st-andrews.ac.uk/physics/prosp_pg/phd/index.php to upload your application documents. The application deadline is 03/02/2020, however, applications that arrive after this date may also be considered until all ITN positions are filled. The foreseen start date is September 2020.