

# Grain Charges and Lightning in Protoplanetary Disks

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## 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  $\sim 10$  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.* (2019, *A&A* 632, 44), 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 Skłodowska-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 Skłodowska-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, laboratory astrochemistry, 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 student is expected to obtain a double degree in St Andrews/UK and Copenhagen/DK. Training secondment for this position is foreseen for 12 month at the Niels-Bohr Institute in Copenhagen.

### **Requirements**

We seek an excellent student with a strong background in astrochemistry. 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 Skłodowska-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.

### **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 understood the requirements of the joint degree and the Marie Skłodowska-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](https://www.st-andrews.ac.uk/physics/prosp_pg/phd/index.php) to upload your application documents. The application deadline is 25/05/2020, however, applications that arrive after this date may also be considered until all ITN positions are filled. The foreseen start date is September 2020.