

## Machine Learning from Complex Disk Models

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### Project Description

Molecular emission features observed in the near and mid infrared, for example with the VLT and JWST, will allow us to determine the chemical composition of the gas in protoplanetary disks in the planet-forming regions within 10 au around new-born stars. This project will combine our previous expertise in modelling the line radiative transfer, chemistry and heating/cooling balance in disks, see *Woitke et al. (2016, A&A 586, 103)* with new machine learning techniques developed in the exoplanet community, e.g. *Zingales & Waldmann (2018, AJ 156, 268)*. Neutral networks (NNs) will be trained on the predictions by tens of thousands of complex thermo-chemical 2D disk models, where we will apply the radiative transfer code FLiT (Woitke et al. 2018, A&A 618, 57) to post-process the ProDiMo results to identify the spectral signatures. Using an algorithm developed for the ARCiS code (artful modelling of cloudy exoplanet atmospheres, author M. Min), these NNs will enable us to retrieve the chemical composition and the physical disk parameters, including their errorbars, from the observations. We can then use these new machine learning algorithms to quickly predict the emergent near-mid infrared line emission spectra from disks as function of physical parameters like UV irradiation, dust/gas ratio and element abundances, capable to thoroughly fit and analyze JWST data to determine the physical disk parameters and their observational uncertainties, taking into account all degeneracies.

### 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 renowned 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. The Kapteyn Astronomical Institute is part of the Netherlands Research School for Astronomy (NOVA) and is recognised world-wide for the quality of its research in multiple areas of astronomy. With 15 faculty and 50 PhD students, it is the second-largest astronomical institute in the Netherlands. Groningen, a historic town in the northern Netherlands, occupies a strategic place in Dutch astronomy, hosting both the Kapteyn Institute and the low-energy astrophysics division of the Netherlands Institute for Space Research (SRON).

### **The Position**

The PhD position is fully funded for a period of 4 years. The student is expected to obtain a double degree in St Andrews/UK and in Groningen/NL. Training secondment for this position is foreseen for 12 months at SRON in Utrecht, The Netherlands, working with Dr. Michiel Min. In addition, regular research visits of the research group of Prof. Inga Kamp are planned at the Kapteyn Institute in Groningen, The Netherlands.

### **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 machine learning, astrochemistry and/or radiative transfer, 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. 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 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 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.