Faculty of Science and Engineering

Profile Report: Astronomical Data Science / Astronomische Data Wetenschap

- Discipline: Astronomical Data Science
- Level: Tenure-track assistant or associate professor
- Focus domain: research
- FTE: Full time (1,0)

1. Scientific discipline

The discipline is in the field of "Astronomical Data Science." The discipline involves developing and applying advanced data science and machine learning techniques to large, complex datasets from state-of-the-art astronomical instruments and simulations, to maximize their scientific return.

2. Vacancy

The Board of the Faculty opens this position in the context of the "Sectorplannen Astronomy". The position will be embedded in the Kapteyn Astronomical Institute. The position falls within the framework of 'Career Paths in Science and Engineering ('Bèta's in Banen' version 5; June 1, 2023). As the focus domain of the position is research, the criteria of the career path with a focus on research apply. Please see the link for the criteria and conditions.

3. Selection Committee (BAC)

The selection committee consists of:

- Prof. dr. L.V.E. Koopmans (Chair, Scientific Director), RUG
- Prof. dr. M.A.M van de Weijgaert (Education Director, repr. USS), RUG
- Prof. dr. F. Fraternali, RUG
- Prof. dr. A. Helmi [W], RUG
- Dr. L. Wang [W], SRON/RUG
- Prof. dr. T. Heskes, RU [External Member; AI/Computer Science; vice-dean of fac. of science]
- Sten Sipma, RUG [Master student Astronomy]

Advisors:

- o Dr. L. van der Voort (Scientific Coordinator Kapteyn)
- o Henriette van Ingen (HR advisor)

4. Area of expertise

Increasingly larger (multi-messenger) datasets obtained on the one hand with state-of-the-art ground and space-based instruments and, on the other hand, coming from large numerical simulations, rapidly push the boundaries of our understanding of the Universe back in time and across increasingly wider fields of view and depths. Most advances in astronomy are now data-driven. Increased sensitivity and a higher dynamic range in spectral and temporal coverage, moreover, allow increasingly fainter objects to be studied in ever greater detail and to be compared to increasingly more complex numerical

simulations from high-performance computers. With petabytes of data per year coming from instruments in which the Kapteyn Institute and NOVA are involved and from state-of-the-art numerical simulations, the need for advanced (astronomical) data-science and machine-learning techniques is crucial to maximise scientific return. This need has evolved into a new discipline: *astronomical data science.* Examples include searching for and categorising billions of targets automatically without human intervention, accelerating (statistical) data analyses through deep-learning emulation models, finding complex patterns in (meta)data, generating artificial datasets for training and simulations, etc. Developing and applying such advanced algorithms and methods to these large and complex datasets has become an indispensable part of the analysis of astronomical data (observed or simulated).

The candidate's profile should strengthen the development and application of astronomical data science methods at the Kapteyn Astronomical Institute, where related to its observational or theoretical research (including that of the candidate) and instrumentation programs (e.g. through NOVA, SRON and ASTRON). The candidate's profile should strengthen the institute's interdisciplinary research program with the department of computers science. By creating this new position, Kapteyn plans to exploit data/results coming from current (e.g. JWST, Gaia, VLT, LOFAR, ALMA, WEAVE, Euclid) and upcoming facilities (e.g., 4MOST, ELT, SKA, CTA) and large numerical simulations. Kapteyn has invested in these facilities over the past decades through the development of instrumentation and science programs, together with the nearby NOVA (optical/IR and sub-mm) labs and with the Dutch Research Council Institutes ASTRON and SRON, with which Kapteyn shares nearly a dozen affiliated staff members. The position should be focused on applied astronomical data science, through the development or application of novel algorithms and open-access codes. We aim for a profile that strengthens the ongoing research at the Kapteyn Institute, and at the other NOVA institutes, ASTRON and SRON. The focus of the new staff member will be on rapidly emerging data-science research areas with a long-term perspective. The new staff member should preferably use or interpret data from the facilities with a significant investment by the Institute and be able to build collaborations within the Institute, NOVA, ASTRON and SRON, and elsewhere.

5. Embedding: institute (and base unit)

The Kapteyn Astronomical Institute consists of a single base unit, and therefore the candidate reports directly to the Scientific Director of the Institute. The institute has a vibrant and currently growing number of 20 scientific staff, including two new staff members joining in 2024, and a joint staff member with ASTRON (18.8 FTE in total), plus 11 affiliated staff (incl. 3 Honorary Professors) with ASTRON and SRON. The number of PhD students is approximately 60, and the number of postdocs is approximately 25.

The institute focuses on several research domains:

- Galaxy Structure, Formation and Evolution.
- ISM, Star and Planet formation.
- Cosmology and Large-Scale Structure.
- High-Energy (Particle) Astrophysics.

Beyond these domains/themes, substantial staff effort is being put into Advanced instrumentation and software, simulations, data science and virtual observatories.

The mission of the Kapteyn Astronomical Institute is to perform front-line research in astronomy, astrophysics, and related fields, aided by the presence of NWO-institutes ASTRON and SRON, and to provide an excellent educational environment for both graduate and undergraduate studies. The Institute's mission and its policy and strategy are closely linked to and partly define the mission of the Netherlands Research School for Astronomy, NOVA. Research is mainly concentrated on two of three themes of NOVA, namely "formation and evolution of galaxies: from high redshift to the present" and "formation and evolution of stars and planetary systems". In the process of doing this research, scientific staff members are building several instruments for large-scale facilities, both on the ground and in space. They aim to maximally exploit the existing and upcoming instruments scientifically, reaping the rewards of years of dedicated preparation, and to position themselves in scientific and instrument leadership roles in current (e.g. JWST, Gaia, VLT, LOFAR, ALMA, WEAVE, Euclid) and future instrumentation (e.g., 4MOST, ELT, SKA, CTA) and to prepare the next generation of young scientists for a future in science and society through high-quality education at the bachelor, master and PhD levels, closely connected to the research done at the institute.

The excellent reputation of the Kapteyn Astronomical Institute has made it possible to attract promising, high-quality astronomers to the University of Groningen. The facilities that the Institute offers, such as world-class observing facilities (e.g., ESO, La Palma, LOFAR), involvement in space missions (e.g. Gaia, Euclid, JWST), data reduction and computing facilities, instrumentation infrastructure, and scientific environment, make the Kapteyn Astronomical Institute a very attractive institute for astronomical research in the world. The institute also offers free access to both national and local high-performance computing facilities at the SURF and CIT, respectively. The institute operates several dozen compute/storage clusters, hosts an optical/infrared Astronomical Science Data Centre (currently focused on Euclid data) and is closely connected to the nearby ASTRON radio-astronomy institute, which develops a Science Data Centre for radio astronomical, and SRON which is involved in X-ray (Athena) and gravitational wave missions (e.g. LISA)

The position strengthens our ties to the NOVA Instrumentation Labs, SRON, ASTRON and JIVE, to Computer Science and the CIT, and opens new national/international funding opportunities.

6. Local and (inter)national position

The Kapteyn Astronomical Institute at the University of Groningen currently covers expertise on a wide range of sciences related to planetary sciences, galaxy structure, formation, and evolution, and high-energy. In this, researchers at the Kapteyn Institute collaborate internally, with researchers in theoretical physics (VSI), computer and mathematical sciences (BI), engineering (ENTEG) and with groups in Leiden, Amsterdam, Nijmegen (NOVA Institutes), and at SRON and ASTRON, and internationally. Over the past decades, NOVA has strongly invested in the Euclid, ELT, JWST, ALMA, WEAVE/4MOST, LOFAR/SKA and CTA missions and instruments, related to the research of the Kapteyn Institute. With this new position, the institute envisions strengthening its exploitation of these upcoming instruments and deepening existing collaborations with the NOVA, SRON and ASTRON institutes, and locally with computer science. Kapteyn/NOVA will have prime access to the first data from the above instruments/facilities.

7. Expected contributions to research

The candidate is expected to develop and apply state-of-the-arts algorithms and (open-access) codes to astronomical data and develop into a recognised expert in the field of astronomical data science. The candidate is expected to become a key player in exploiting data from, e.g. the Euclid, WEAVE/4MOST, JWST, ALMA, LOFAR/SKA, ELT (upcoming) instruments/facilities and/or in numerical simulations and modelling to interpret such data and develop an astronomical research line complementing the research at the Kapteyn institute and NOVA. The expertise of the candidate is expected to complement other staff and leverage the general use and application of advanced data-science methods in research and education at the Kapteyn Institute. The candidate's expertise helps develop the current Euclid Science Data Centre into a general optical/infrared Astronomical Science Data Centre, hosting, and processing and analysing data from upcoming facilities (e.g. ELT/NOVA) using data-science methods. The candidate is expected to develop an independent research group, obtain substantial external funding to contribute to the research at the Kapteyn Institute and NOVA and sustain an active and competitive research group of PhDs and postdocs.

8. Expected contributions to teaching

The BSc/MSc program Astronomy comprises roughly 300 students. The candidate will be expected to teach (primarily) courses such as the Astronomy Bachelors and Master's programs. These concern, in particular, the BSc course Introduction to Programming and Image Processing and the MSc course Astronomical Data Science, as well as the courses Statistics for Astronomy, Numerical Methods, and Statistical Signal Processing, and develop them further. Other appropriate courses may be taught as needed by the programs. The candidate will also be actively involved in developing new and ongoing courses.

9. Expected contributions to the organisation

The candidate is expected to have an active interest in the running and well-being of the institute and to provide a positive contribution to its management and organisational tasks. At the level of FSE, the candidate will contribute to the organisation of the faculty, for example, by participating in working groups and committees in the fields of teaching, research, and management. The candidate will participate in relevant national and international organisations.