Faculty of Science and Engineering

Profile report: Tenure Track Assistant Professor with education profile in computational physics in particle physics and gravity (Computationele fysica in deeltjesfysica en zwaartekracht)

- Discipline: Computational physics
- Level: Tenure-track assistant professor
- Fte: 0,8-1,0 fte

1. Scientific discipline

The focal area of this position is computational physics, with connection and applications to particle physics and/or gravity, in particular algorithm development and the development of novel or advanced computational methods such as machine learning or artificial intelligence, exploiting technological developments in distributed, parallel, and quantum computing.

This position adds expertise in the development of novel computational strategies to the existing research activities at the Van Swinderen Institute (VSI) in particle physics, gravity and cosmology, and contributes in an essential way to computational aspects of the Physics Bachelor and Master programmes. The candidate's educational and scientific contributions will also strengthen the collaboration of VSI with the Bernoulli Institute for Mathematics, Computer Science and Artificial Intelligence (BI) and the Kapteyn Astronomical Institute, within the faculty theme Fundamentals of the Universe (FotU). It will also contribute to and benefit from the VSI participation in the Nikhef consortium (Nikhef samenwerkingsverband), where VSI is currently the largest university partner in the Netherlands.

2. Vacancy

This position is opened by the Board of the Faculty (PT/gl/00230) and will be embedded in the Van Swinderen Institute for Particle Physics and Gravity, in one of its three base units (the High-Energy, Cosmic, or Precision Frontier) to be assigned when selection is completed. The criteria and conditions pertaining to the position are described in the document 'Assistant professor with an education profile'.

3. Selection committee (BAC)

Prof. Elisabetta Pallante (chair, scientific director VSI)
Prof. Diederik Roest (education director VSI)
Prof. Julia Even (associate professor, VSI)
Prof. Roel Verstappen (program director, mathematics)
Dr.Ir. Gerco Onderwater (associate professor, VSI; member with special attention for teaching)
Prof. Wim Beenakker (external member; RU)
Lisa Bobrova Blyumin (student member)

Advisors to the selection committee
Friso Salwerda (HR advisor for VSI)
Daan Meerburg (assistant professor, VSI and FotU)

4. Area of expertise

The area of expertise is computational physics, with connection and applications to particle physics and/or gravity and/or cosmology.

Computational methods play an increasingly important role in all areas of science, not least in physics. Historically, breakthroughs in computational methods and software development were driven by the need to answer fundamental physics questions, or to analyze and share large amounts of experimental data; one celebrated by-product being the World Wide Web, which was developed in 1989 at CERN at what is now considered the start of the Information Age.

The rise in prominence of computational physics in the research landscape, especially in particle physics and gravity, is not yet accurately reflected in the current curriculum. While the latter does include a number of numerical/computational courses, providing students with a basic understanding of computational techniques and the ability to apply them, there are no physics-oriented courses dedicated to the development of such techniques and the relevant concepts underlying them. The candidate is expected to fill this gap, by teaching courses in computational physics as well as by playing an essential role in designing cutting-edge courses in computational methods, with ample space for innovation and dialogue with other educational programmes at the Faculty of Science and Engineering (FSE).

Particular areas that have recently seen rapid development and that have proven the value of computational physics as a link between theoretical and experimental approaches, but that are not yet adequately covered in the current curriculum or by the expertise of current staff, are development of novel or advanced computational methods such as machine learning and artificial intelligence, and methods that exploit technological developments in distributed, parallel, and quantum computing.

The candidate should have a PhD in theoretical or computational physics, and should be able to fill that gap with her or his expertise, so as to strengthen many aspects of the existing research at VSI, and to add a new profile that focuses on innovative and advanced computational strategies. As an example of the relevance of new computational methods and algorithmic development in the context of VSI research, we mention the recent application of machine learning in the theoretical interpretation and analysis of an abundance of experimental data from the LHC experiments, the need for advanced solutions for precision calculations in the context of perturbative quantum field theory and in the theoretical study of genuinely nonperturbative properties at different stages of the evolution of the Universe, or the use of topological data analysis and likelihood-free inference within cosmology.

5. Embedding: institute (and base unit)

The mission of the VSI is to investigate the fundamental forces of Nature and their implications for the Universe, by connecting the physics at the Planck scale (quantum gravity) via subatomic scales (particle physics) to cosmic dimensions. Research is conducted at three specific Frontiers: the Cosmic, High-Energy and Precision Frontiers. In all Frontiers we aim to exploit experimental and theoretical approaches, to benefit from their synergy. The advertised position will be at the intersection of the theoretical and experimental approaches, linking these with computational techniques. Given the general background of computational techniques development, we expect the candidate to interact with and contribute to one or more research lines at VSI. Ideally, he/she would be able to connect to and collaborate with researchers from multiple VSI Frontiers. Depending on his/her specific physics background, the candidate will be embedded in one of the three base units corresponding to the three VSI Frontiers.

Several of the existing research directions at VSI involve computational aspects: (big-)data analysis optimization at the LHCb experiment, from development of trigger algorithms to tracking algorithms and machine-learning for off-line analysis (de Bruyn, Onderwater, Pellegrino), computational atomic and molecular physics (Borschevsky), cosmological simulations and data analysis (Dimastrogiovanni, Meerburg) and lattice field theory (Pallante).

The profile of this position fits nicely within the recently initiated faculty theme Fundamentals of the Universe (FotU), where VSI collaborates with BI and Kapteyn on common research themes and aims at establishing new common goals. Computational aspects are present in all three institutes (VSI, BI, Kapteyn). VSI offers an optimal embedding for the new position, given the variety of research directions and possibilities for collaboration within the same institute, and the significant involvement of VSI staff members in the Physics curriculum and the educational activities of the university at large.

VSI researchers have access to the University of Groningen's Peregrine high-performance computing cluster. Through participation in the Nikhef consortium, VSI researchers also have access to the computing facilities at Nikhef, Surf-SARA, and CERN. Members of VSI also serve in the NWO national committee for supercomputing, which also plays an advisory role for future investments in computational infrastructure.

6. Local and (inter)national position

Within the Faculty of Science and Engineering, the VSI collaborates with the Bernoulli and Kapteyn institutes in the framework of the FotU faculty theme. VSI researchers are also actively involved in the educational activities of the faculty as well as university-wide, e.g., the Honours College and the Einstein's Physics university minor.

VSI researchers are committed to contribute to development, organization and innovation of educational activities, taking up tasks such as director of the School of Science and Engineering, director of the Physics Bachelor programme, FSE vice-dean, and FSE (adjunct) director of the Honours College.

Through VSI, the University of Groningen is currently the largest university partner in the Nikhef consortium. Long-term collaborations exist between the theorists in the High-Energy Frontier and the Nikhef Theory Group, while the experimental group in the same Frontier is active in the international LHCb collaboration (750+ scientists) at CERN, and is part of the national B-Physics research effort (Nikhef, UvA/VU, RUG, Maastricht). Researchers in the Precision Frontier collaborate with researchers at VU on the eEDM experiment being built at VSI. In the Cosmic Frontier, VSI researchers are members of LISA, Planck and/or the Simons Observatory.

7. Expected contributions to teaching

The Physics and Applied Physics curricula include a wide range of courses, preparing students for the various research directions at FSE. One area that is currently underrepresented in the curriculum is computational physics. The candidate is expected to fill this gap, by contributing teaching in three main directions. The first one is the strengthening of the existing applied computational courses (for example *Python for physicists*, and/or *Computational Methods in Science and Technology*) by including modern developments and ties with current research -- based on the expertise and background of the researcher. The second direction consists of the extension and strengthening of the computational learning line with courses that outline the development of modern computational techniques, such as machine learning, with a possible link to Computer Science and Artificial Intelligence. In addition, we foresee the candidate to play an important role in more introductory courses for a large audience, from general physics topics in the first year of the physics curriculum to general computational topics for students of other curricula within FSE.

We also expect the candidate to have a strong interest and either ample experience or high potential in teaching innovation and curriculum development. He/she will have a clear vision of how to implement an effective course set-up, including modern viewpoints on, e.g. student activation and flipped learning techniques. He/she is also expected to play a leading role in the implementation of such practices, both in the specific courses that he/she will be teaching as well as in the general curriculum.

In addition to training our students for research, a strong computational expertise will also serve them outstandingly should they continue their career outside the academy. We therefore expect the candidate to actively contribute to the connection between our curriculum and future career paths of our students, and include this element in the design, focus and goals of advanced courses, where possible.

8. Expected contributions to research

We expect the candidate to have a strong track-record in computational physics, and to continue to perform cutting-edge research that involves algorithm development and the development of novel or advanced computational methods such as machine learning or artificial intelligence, exploiting technological developments in distributed, parallel, and quantum computing. The candidate will have a profile that is linked to at least one of the existing research directions at VSI, thus specifically to the fields of particle physics and gravity. We envision that the research in computational physics and novel or advanced computational strategies of the candidate will strengthen and extend one or more existing research lines in the Cosmic, High-Energy or Precision Frontiers.

9. Expected contributions to the organization

The candidate is expected to have an active interest and to provide a positive contribution to the management and organizational tasks of the institute. At the level of FSE, the candidate will contribute to the organization of the faculty, for example by participating in working groups and committees in the area of education. The candidate will participate in relevant national and international organizations.