Faculty of Science and Engineering

Profile report: Tenure track assistant professor in table-top tests of fundamental symmetries

- Discipline: *Experimental physics*
- Level: *tenure-track assistant professor*
- Fte: *Full time (1,0)*

1. Scientific discipline

The research field is centered on experimental precision measurements that tests aspects of the Standard Model of particle physics at low energies. This is done by using techniques from atomic, molecular and optical physics with a strong focus on the application of these techniques to study the underlying fundamental interactions and symmetries.

2. Vacancy

This position is opened by the Board of the Faculty in the context of the sector plans and will be embedded in the Van Swinderen Institute, basic unit the Precision Frontier. The position falls within the framework of 'Career Paths in Science 4' ('Bèta's in Banen 4'). Please see link for criteria and conditions.

3. Selection committee (BAC)

The selection committee consists of the following members:
- Prof. Elisabetta Pallante (chair, full professor, director of the VSI)
- Prof. Meike Stöhr (full professor of nanophysics, RUG)
- Prof. Patrick Decowski (full professor dark matter physics, UvA and Nikhef)
- Jan Rol (master student quantum universe, RUG)
- Prof. Diederik Roest (full professor, Education director VSI, RUG)
- Prof. Steven Hoekstra (associate professor, atomic and molecular physics, RUG)
- Prof. Anastasia Borschevsky (associate professor, quantum chemistry, RUG)

In addition, we add the following advisors to the committee:
- Dr. Lorenz Willmann (UHD, atomic, molecular and particle and fields physics, RUG)
- Henk Haagsma (HR Advisor for the VSI)

4. Research area

The research area of this position concerns the experimental exploration of fundamental physics using quantum systems on the atomic scale and ultra-sensitive detection methods. The research, at the boundary of particle physics and atomic, molecular and optical physics, provides stringent tests of pillars of the Standard Model of particle physics. Precision measurements of well-chosen quantum systems provide extraordinary sensitivity through enhancement of small effects. In particular, tests of the validity of fundamental discrete symmetries (parity, charge conjugation

and time reversal) open possibilities in experiments such as searches for permanent electric dipole moments, parity violation in atomic systems, magnetic moments of fundamental particles, study of anti-matter, or the investigation of the properties of gravity. The researchers in this field use precision measurements to probe such effects and employ sophisticated theoretical techniques for their interpretations. This combination of experimental and theoretical methods allows for testing of the validity of the laws of physics in a way that is complementary to investigations at the highest energy scale available at particle accelerators. Research based on the preparation of cold and intense beams or trapped samples, ranging from atoms and ions to molecules and nanoparticles, has a strong connection with quantum optics/computation. With this position we aim to add a complementary but strongly connected activity to ongoing research at the Van Swinderen Institute.

5. Embedding: institute (and base unit)

The aim of the Van Swinderen Institute for Particle Physics and Gravity is to study the fundamental forces of Nature in the Universe, by connecting the physics at the Planck-scale (quantum gravity) via sub-atomic scales (particle physics) to cosmic dimensions. Research in experimental as well as theoretical framework is conducted at three frontiers: the cosmic, high-energy and precision frontier. The advertised research position will be embedded in the precision frontier. Local experimental research is conducted in precision atomic/molecular physics experiments at low energies and at LHCb/CERN to study lepton-flavour violation and lepton universality. The in-house experimental infrastructure comprises a wide range of frequency stabilized laser systems, data acquisition/control systems and the UHV systems. This is employed in manipulation and control of atoms, ions and molecules. The main current activities focus on atomic parity violation measurements in single trapped ions to extract the Weinberg angle and on the measurement of the permanent electric dipole moment of the electron. Current research employs atomic/molecular beam sources, ion trapping, Stark deceleration, laser cooling, quantum state control with lasers and precision control of electric and magnetic fields.

6. Local and (inter)national position

The special focus of the experimental base unit in our institute, that we aim to extend and strengthen with this new position, is the experimental exploration of fundamental physics using quantum systems on the atomic scale and ultra-sensitive detection methods. The Van Swinderen Institute, with the Bernoulli Institute (mathematics) and the Kapteyn Institute (astronomy), coordinates the research theme 'Fundamentals of the Universe' of the Faculty of Science and Engineering. At the national level, the advertised position in the field of low-energy precision research is embedded in the Dutch National research institute for (astro)particle physics Nikhef. At the international level, the research in tests of the Standard Model by precision measurements on atomic and molecular systems is highly active, competitive and rapidly growing. For example, excellent research teams at MIT & Harvard, JILA (Boulder, Colorado) and Imperial College London are active in this field.

With this new position we aim to build on the strong position of the Van Swinderen Institute and the University of Groningen in that context.

7. Expected contributions to research

The candidate is expected to develop a research line that is complementary but has strong connections to the ongoing activities on the manipulation, control and precision spectroscopy of small quantum systems and particles. The candidate is expected to focus on the use of such techniques in the experimental approach to test the Standard Model of particle physics and possible physics beyond the Standard Model. The candidate will supervise bachelor, master and PhD students in their research projects. Obtaining external funding to fund PhD or postdoc positions is crucial.

8. Expected contributions to teaching

The candidate will contribute to teaching within his/her expertise in the bachelor and/or master programme of physics, and strengthen the existing programmes with for example courses on fundamental physics and experimental techniques. The candidate is expected to obtain the University Teaching Qualification (UTQ). The teaching task is specified in the 'Career Paths in Science 4' ('Bèta's in Banen 4').

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 the FSE, the candidate will contribute to the organization 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 organizations and contribute to the visibility of the institute and the university.