Project Title: Early universe cosmology beyond the Standard Model

Project description: This project will develop the theory and techniques required to probe near term and planned cosmological observations for the physics underlying the cosmological standard model – to better understand its particle physics origins, and how it might be embedded in fundamental theory. These observations could include galaxy surveys, CMB anisotropy and spectral distortion measurements, gravitational wave astronomy and 21 cm tomography. After developing the requisite theoretical tools – primarily quantum field theory on curved space, effective field theory techniques, cosmological perturbation theory, and non-equilibrium field theory, we will focus on ways in which we can probe any of the current and future observations described above for signatures of high energy physics beyond what can be probed in collider experiments.

Supervisor: Dr. Subodh Patil

Selection criteria: Students with a strong background in theoretical high energy physics (broadly defined) are particularly encouraged to apply.

Applications:
To apply for this vacancy, please send an email to patil@lorentz.leidenuniv.nl. Please ensure that you upload the following additional documents quoting the project title:

- Curriculum vitae;
- Bachelor's and master's transcripts;
- (Draft of) MSc thesis.

Deadline: Dec. 1, 2020

Project Title: Tuneable strong coupling in an optical microcavity

Project description: In this project, you will build a tuneable optical microcavity to enhance the light-matter interaction of single molecules, increase their efficiency as single-photon sources, and enable their use in quantum gates. Our expertise in vibration isolation and low-temperature physics makes Leiden an ideal place to develop this technologically challenging system. We will use it to study the quantum physics of 2D van-der-Waals materials and organic molecules in thin layers.

Supervisor: prof. dr. M.P. van Exter, Leiden University

Selection criteria:

- MSc Physics degree
- Ample experience with experiment physics, preferably in optics or solid state physics
- Sufficiently fluent in English

Applications:
To apply for this vacancy, please send an email to exter@physics.leidenuniv.nl. Please ensure that you upload the following additional documents quoting the project title:

- Curriculum vitae;
- Bachelor's and master's transcripts;
- (Draft of) MSc thesis.

Deadline: Dec. 1, 2020

Project Title: Quantum metrology of two-dimensional superconducting single photon detectors

Project description:

Nanowire superconducting single photon detectors can detect single photons at telecommunication and infrared wavelengths with near unity quantum efficiency, high speed and low dark count rates. As such they are the preferred detector technology for future quantum information and quantum communication protocols. The physical detection mechanism is actively researched and it is not yet known how the detection mechanism depends on the geometry (width, length and thickness) of the nanowire and the properties of the superconducting material. This limits the progress in the development of future detectors.

One of the most important challenges is that the effects of the geometry of the nanowire cannot be separated from the physical properties of the material; for instance, because the crystalline structure depends on layer thickness. This limitation can be overcome by studying nanowires of amorphous superconducting materials (MoGe and MoSi) and by using exfoliated superconductors (NbSe and twisted bilayer graphene).

To unravel the detection mechanism with the goal to understand the fundamental limitations of these detectors we will make use of quantum metrology techniques. In particular, we will study single photon detection in nanofabricated point contacts or bridges with techniques of detector tomography developed at Leiden university [1].

[1] Q. Wang, J.J. Renema, A. Engel and M.J.A. de Dood *Design of NbN superconducting nanowire single photon detectors with enhanced infrared photon detection efficiency* Phys. Rev. Applied. **8** 034004 (2017)

Supervisor: dr. Michiel J.A. de Dood

Selection criteria: Applicants should hold a Master of Science degree (or equivalent) fulfilling the entry requirements for doctoral education at Leiden University. The ideal candidate has a strong interest in superconductivity, optics and/or materials science. Candidates must be proficient in English and have good problem-solving skills, creativity, strong motivation for doctoral studies and the ability to work independently.

Applications:
To apply for this vacancy, please send an email to Michiel de Dood, dood@physics.leidenuniv.nl. Please ensure that you upload the following additional documents quoting the project title:

- Curriculum vitae;
- Bachelor's and master's transcripts;
- (Draft of) MSc thesis.

Deadline: Dec. 1, 2020

Project Title: Advanced electron paramagnetic resonance for intrinsically disordered proteins

Project description: Intrinsically disordered proteins (IDP's) are a novel and important class of biologically relevant proteins and their biophysical behavour is poorly understood. Modern electron paramagnetic resonance (EPR) techniques enable new insights into these proteins: They provide ensemble parameters via distance distributions, nano-second dynamic data and can be applied under conditions that are prohibitive for standard biophysical methods. In this project the student should apply the laboratory derived instrumentation available at the Leiden EPR group to investigate intrinsically disordered proteins related to neurodegenerative disease and functional IDP's.

In contrast to many other spectroscopic techniques, for EPR instrumental development and fundamental understanding of the measurement process are still essential to obtain meaningful data and progress into new areas. Therefore, the Leiden EPR group focusses on instrumental development in including microwave technology and the development of pulse-EPR techniques. Supervisor: Prof. Martina Huber

Selection criteria: Solid background in experimental physics, preferentially with a spectroscopy background and master degree in physics or engineering. A master in physical chemistry is also possible, if the candidate had a very good background in the experimental side of instrumentation and spectroscopy. Candidates with EPR experience will be preferred. Interest in the instrumentation, practical experience with measurement technology is essential.

Applications:
To apply for this vacancy, please send an email to

huber@physics.leidenuniv.nl.

Please ensure that you upload the following additional documents quoting the project title:

- Curriculum vitae;
- Bachelor's and master's transcripts;
- (Draft of) MSc thesis.

Deadline: Dec. 1, 2020

Project Title: Detecting neutrino oscillations with the KM3NeT telescope

Project description:

KM3NeT/ORCA is a new neutrino telescope which will observe neutrino oscillations at unprecedented precision. The neutrino observations require excellent pattern identification in an overwhelming background. In this project the PhD student will help in the development of the signal evaluation exploiting modern machine learning techniques. The reconstruction of event signatures enables then to measure the neutrino oscillations and with that also determine the neutrino mass ordering. At the same time also several non-standard scenarios can be probed, which have been proposed as viable extensions of the current Standard Model of Particle Physics. Computing experience and skills are essential in this project.

Supervisor: Dr. Dorothea Samtleben (Leiden / NIKHEF)

Selection criteria: Applicants should hold a Master of Science degree (or equivalent) fulfilling the entry requirements for doctoral education at Leiden University. The ideal candidate has a strong background in the subject matter. Candidates must be proficient in English and have good problem-solving skills, creativity, strong motivation for doctoral studies and the ability to work independently.

Applications:
To apply for this vacancy, please send an email to Dorothea Samtleben (dosamt@nikhef.nl). Please ensure that you upload the following additional documents quoting the project title:

- Curriculum vitae;
- Bachelor's and master's transcripts;
- (Draft of) MSc thesis.

Deadline: Dec. 1, 2020

Project Title: **Quantitative Superresolution Studies of the Regulation of Stoichiometry in Matrix-Adhesions**

Project description: It has been recently found that cellular behavior is critically controlled by mechanical cues set by the local environment of every cell. It is believed that the translation of any mechanical signal into an internal biochemical signal of the cell occurs at cell-matrix adhesions. In cell-matrix adhesions, integrin receptors and associated proteins provide a dynamic coupling of the extracellular matrix (ECM) to the cytoskeleton. This allows bidirectional transmission of forces between the ECM and the cytoskeleton, which tunes intracellular signaling cascades that control survival, proliferation, differentiation, and motility. The quantitative relationships between recruitment of distinct cell matrix adhesion proteins and local cellular traction forces are not known. We propose to apply dSTORM to cell matrix adhesions formed on fibronectin-stamped PDMS pillars and develop a quantitative approach to relate the number of talin, vinculin, paxillin, and focal adhesion kinase (FAK) molecules to local cellular traction force. We hypothesize that a substrate stiffness-dependent modulation of the stoichiometry in cell-matrix adhesions will lead to the observed modulation of cellular traction forces and will allow us to decipher the process of cellular mechnosensation.

Supervisor: Prof dr Thomas Schmidt, Leiden Institute of Physics, Leiden University

Selection criteria: You have a solid background in optical techniques and quantitative analysis combined with the interest of how cells work. Some prior exposure to optical super-resolution microscopy, and cell biology would be a pre. Further, you will need strong communication skills as the project will be within a collaboration with groups from other disciplines.

Applications: To apply for this vacancy, please send an email to schmidt@physics.leidenuniv.nl. Please ensure that you upload the following additional documents quoting the project title:

- Curriculum vitae;
- Bachelor's and master's transcripts;
- (Draft of) MSc thesis.

Deadline: Dec 1, 2020