LUXEMBOURG INSTITUTE OF SCIENCE AND TECHNOLOGY | LIST

UNIVERSITÉ DU LUXEMBOURG

PhD on "Novel quasiparticles for next-generation computers"

- **Are you a passionate researcher?**
- **Are you motivated to work in a diverse and multidisciplinary team?**
- **Would you like to help this team solve fundamental questions that can lead to more sustainable technologies?**

If so, you may be the person we are seeking for a PhD project supervised by Jorge Íñiguez at the Luxembourg Institute of Science and Technology (LIST), as part of the European training network TOPOCOM (*Topological solitons in ferroics for unconventional computing*).

PROJECT IDEA

Applications of Artificial Intelligence (AI) and Machine Learning (ML) – from chatbots to autonomous driving and medical diagnoses – have the potential to improve our lives in unprecedented ways. But there is a catch: they consume an immense amount of energy. At the current growth rate, by 2040 the total energy produced in the world would be devoted to AI applications (!). Hence, we obviously have an important challenge to address.

Unconventional Computing – which includes subfields such as Neuromorphic, Reservoir or Probabilistic Computing – explores new paradigms to create efficient and ultra-low-power computing components, taking advantage of the dynamical properties of **complex physical systems** to develop radically new approaches. For example, it has been shown that one can use a large variety of systems (from a bucket of water to noisy electronic circuits) to emulate the behaviour of a neural network that can tackle complex problems such as pattern recognition. Most excitingly, it has been recently shown that one can use the **topological quasiparticles** called "**skyrmions**" (search the web for amazing images!) to implement similar concepts, with the added advantage that skyrmion-based components can be powered by the naturally occurring Brownian motion of such quasiparticles. In other words: we can take advantage of the diffusion of skyrmions caused by (unavoidable) thermal fluctuations, so they act as the main (free!) power source of the device. Truly incredible.

The use of skyrmions for unconventional computing is a rapidly expanding field with amazing results being published on a monthly basis. So far, work has focused on magnetic skyrmions, which have been known for about 20 years now. By contrast, in this project we will investigate the use of electric skyrmions for Unconventional Computing, which is a brand-new possibility presenting many fundamental **Physics challenges and opportunities**. In electric skyrmions the magnetic spins are replaced by electric dipoles that originate from the off-set of positive and negative ions in insulators. They were predicted and experimentally demonstrated only a few years ago (see e.g. https://als.lbl.gov/electric-dipoles-form-chiral-skyrmions/), with key contributions from simulations done at LIST. In this project we will use the same advanced simulation methods to better understand the physics of Brownian electric skyrmions and explore their use in selected Unconventional Computing applications.

POSITION CONTEXT – BE PART OF AN EXCITING TEAM OF PHD STUDENTS!

The PhD student will be part of team of 11 doctoral candidates associated to the Marie S. Curie Doctoral Network TOPOCOM (https://www.topocom.eu), which gathers some of the top European groups working on topological phases in condensed-matter systems. The students will benefit from a unique programme designed to train a group of experts on the physics of topological quasiparticles and Unconventional Computing, covering all aspects of the problem – from experiment to theory, from fundamental to applied, from magnetic to electric. The team effort and broad international exposure will rely on secondments (extended visits) of the doctoral candidates to other groups of the network, as well as on periodic TOPOCOM events that will often be linked to relevant international schools and conferences. Besides the science itself, other key aspects of today's work as a scientist – from management to communication skills – will be covered, and to a large extent tailored to the specific interest of the students.

The PhD student will be supervised by Prof. Jorge Íñiguez (https://sites.google.com/site/jorgeiniguezresearch), an expert on the theory and simulation of nano-ferroelectrics. The student will be part of the "Ferroic Materials for Transducers" group (25-30 members) and, in particular, the theory team led by Prof. Íñiguez (6-8 members). The student will be enrolled in the doctoral programme on Physics and Materials Sciences of the University of

Luxembourg (https://www.uni.lu/research-en/doctoral-education/dsse/physics-and-materials-science/), which offers a wide range of training activities as well as a vibrant and diverse environment to young scientists.

REQUIRED PROFILE

We are looking for candidates who are **passionate** about research and excited about being part of a **team** of PhD students who will work a lot together. In particular, candidates with a taste for **theory or computer simulation** are most welcome to apply. A master's degree in Physics, Materials Science, Applied Mathematics or a related discipline is required.

Interested candidates are invited to submit their application via the LIST web:
https://app.skeeled.com/offer/6513ce2d3d8c98814c33e3af?utm_id=60fed4c509c80d16d1bbe536&utm_medium=OFFERS_PORTAL&language=en&show_description=true

For additional information, please contact Jorge Íñiguez (jorge.iniguez@list.lu).