CALL FOR APPLICATIONS - October 2022

Research Assistant Position

Donostia International Physics Center (DIPC) is currently accepting applications for Research Assistant positions. This is a unique opportunity for highly motivated students, recently graduated from the University in Physics or related fields, to gain research experience in one of DIPC's high-profile research teams. A description of each of the available openings, contact information and deadlines can be found on the following pages.

Although candidates are welcome to contact the project supervisors to know further details about the proposed research activity, please be aware that the application will be evaluated only if it is submitted directly to the email address listed as "application email".

Applications received by the deadline will be evaluated by a Committee designed by the DIPC board on the basis of the following criteria:

- CV of the candidate (60%)
- Adequacy of the candidate's background to the project (20%)
- Reference letters (10%)
- Other: Diversity in gender, race, nationality, etc. (10%)

Evaluation results will be communicated to the candidates soon after. Positions will only be filled if qualified candidates are found.

The DIPC may revoke its decision if the candidate fails to join by the appointed time, in which case the position will be awarded to the candidate with the next highest score, provided it is above 50 (out of 100).

However, the selected candidate may keep the position if, in the opinion of the Selection Committee, the candidate duly justifies the reasons why he or she cannot join before the specified deadline, and as long as the project allows it.

Ref. 2022/60
Non-Hermitian quantum mechanics for bosons and fermions, application to quantum sensing

Supervisor(s):
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Duration*: *1 year*

Application Deadline: *05/10/2022* ***Application Email:*** *jobs.research@dipc.org*

The canonical formulation of quantum mechanics prescribes that Hermitian operators represent physical observables. This is a requirement to ensure the reality of the expectation values of these operators. This implies that the Hamiltonian operator representing a physical system is always expressed as a Hermitian operator.

However, in the last thirty years, it has been understood that the condition of Hermiticity can be relaxed [1]. It means that a larger class of operators exists that shows a real spectrum within specific symmetry constraints. A particular class of quasi-Hermitian operators [2] is the non- Hermitian one fulfilling the $\mathscr{PT}$-symmetry [1], where $\mathscr{P}$ is a parity operator and $\mathscr{T}$ time-reversal symmetry. The peculiarity of systems described by this class of non-Hermitian operators is that when $\mathscr{PT}$ symmetry is broken, the spectrum of the system becomes complex. This peculiarity of the spectrum can be used to represent gains and losses ubiquitous in open quantum systems.

This non-Hermitian quantum mechanical approach is convenient when investigating photonic systems for lasing [3]. Additionally, it has crucial implications for topological systems and the description of quasi-particles in the fermionic context [4].

Last but not least, the enhanced sensitivity of topological non-Hermitian systems can pave the way to introducing highly sensitive quantum sensors [5].

In this project, we will explore some features of simple topological quantum systems and try to find a direct application in the context of photonic systems. We will mainly focus on polaritons lattices that allow for simple engineering of the gains and losses of the photonic system. We will collaborate with front-line researchers in the theoretical field as Dr. Flore Kunst (MPI Erlangen — Germany) and in the experimental field as Prof. Hai Son Ngyen (Ecole Centrale de Lyon — France).

Bibliography:

[1] Bender & Boettcher, Phys. Rev. Lett. 70, 947 (1998).
[2] Mostafazadeh, Int. J. Geom. Meth. Mod. Phys. 7, 1191 (2010). [3] Harari et al., Science 358, 636 (2017).
[4] Bergholtz, Budich, & Kunst, Rev. Mod. Phys. 93, 01500 (2021). [5] Koch & Budich, Phys. Rev. Research 4, 013113 (2022).

Interested candidates should submit an updated CV and a brief statement of interest to the application email listed above. Reference letters are welcome but not indispensable. The reference of the specific opening to which the candidate is applying should also be stated in the subject line.