Bilbao Dirac Eguna 2026

BCAM: 14th January 2026

basque center for applied mathematics

EHU

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About

Bilbao Dirac Eguna 2026 is devoted to the Dirac equation, a cornerstone of modern physics connecting quantum mechanics and relativity. The conference will bring together researchers to explore both foundational aspects and contemporary applications, including mathematical structures and solution techniques. The event will feature plenary talks and discussions, fostering interaction and collaboration between established scientists and early-career researchers, with the goal of advancing understanding and inspiring new directions in Dirac-related research.

Organizing committee

Lucrezia Cossetti	*Ikerbasque & Universidad del País Vasco/Euskal Herriko Unibertsitatea*
Fabio Pizzichillo	*Universidad Politécnica de Madrid, ETSI Caminos Canales y Puertos*
Luis Vega	*Universidad del País Vasco/Euskal Herriko Unibertsitatea & BCAM*

Timetable

10:30–11:30	**C. S. Lestayo**	UAM
11:30–12:00	**Coffee break**	
12:00–13:00	**E. Séré**	Paris-Dauphine
13:00–15:00	**Lunch break**	
15:00–16:00	**J. Duran**	CRM
16:00–16:30	**Coffee break**	
16:30–17:30	**L. Cossetti**	Ikerbasque & EHU

Book of Abstract

Quantum simulation of Dirac and Majorana equations

Carlos Sabín Lestayo *(Autonomous University of Madrid)*

In this talk we will review several examples of relativistic quantum mechanical equations that can be simulated with modern quantum technologies. In particular, we will discuss the relation between single-particle one-dimensional Dirac and Majorana equations in the context of time reversal and charge conjugation operations. This will lead us to the possibility of simulate relativistic potentials and curved spacetimes with free flat-spacetime Dirac dynamics.

References:

- Quantum simulation of the Majorana equation and unphysical operations Casanova et al. Phys. Rev. X 1, 021018 (2011).
- Encoding relativistic potential dynamics into free evolution C. S., J. Casanova, J. J. García-Ripoll, L. Lamata, E. Solano, J. León Phys Rev. A 85, 052301 (2012).
- C. S., Mapping curved spacetimes into Dirac spinors Sci. Rep 7 40346 (2017).
- Javier Faba, C.S. Dirac equation in exotic spacetimes Phys. Rev. D 99 025008 (2019).

Peierls instability in the tight-binding approximation for polyacetylene and graphene

Eric Séré *(University Paris-Dauphine)*

We investigate a conventional tight-binding model for one and two dimensional graphene, where distortion of the honeycomb lattice is allowed, but penalized by a quadratic energy. We prove that the optimal 3-periodic lattice configuration has Kekulé O-type symmetry, and that for a sufficiently small elasticity parameter, the minimizer is not translation-invariant. Conversely, we prove that for a large elasticity parameter the translation-invariant configuration is the unique minimizer.

Quantum dot Dirac operators and $\overline{\partial}$-Robin Laplacians connected in shape optimization problems

Joaquim Duran *(Centre de Recerca Matemàtica)*

This talk addresses Faber-Krahn type inequalities for quantum dot Dirac operators on domains in $\mathbb{R}^2$. We show that this family of inequalities is equivalent to a family of Faber-Krahn type inequalities for $\overline{\partial}$-Robin Laplacians. Thanks to this, we prove them in the case of simply connected domains for quantum dot boundary conditions asymptotically close to zigzag boundary conditions.

On the point spectrum of Dirac Hamiltonians via a new development of the method of multipliers.

Lucrezia Cossetti *(Ikerbasque & University of Basque Country)*

Originally developed to understand characterising properties related to dispersive phenomena, in the last decades the method of multipliers has been recognized as a powerful tool in Spectral Theory, in particular in connection with proofs of absence of point spectrum for a wide class of operators.

When the method of multipliers is applied to the toy model given by the self-adjoint Schrödinger operator

$$H = -\Delta + V,$$

one obtains the so-called virial identity

$$2\langle\psi, -\Delta\psi\rangle = \langle\psi, x\cdot\nabla V\,\psi\rangle,$$

valid for any ψ solution of the eigenvalue problem $H\psi = \lambda\psi$, with $\lambda \in \mathbb{R}$.

This identity immediately yields sufficient conditions for the absence of such solutions: the most natural one being the repulsivity condition

$$x\cdot\nabla V \leq 0.$$

In the context of Dirac operators

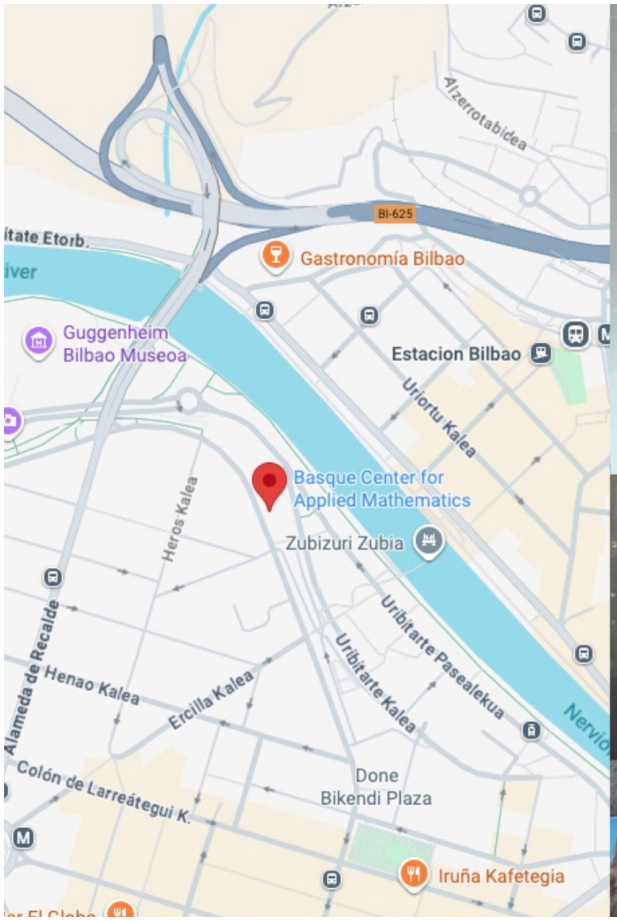
$$H = H_D + V, \qquad H_D = -i\alpha\cdot\nabla + m\beta,$$

the corresponding relativistic analogue of the virial identity reads

$$2\langle\psi, -i\alpha\cdot\nabla\psi\rangle = \langle\psi, x\cdot\nabla V\,\psi\rangle.$$

Unlike in the Schrödinger case, the term involving the kinetic part is no longer positive, and this lack of positivity prevents a direct derivation of conditions excluding the existence of eigenvalues.

In this seminar, we will show that this difficulty can be overcome in two different ways. The first approach exploits the supersymmetric structure of the Dirac operator, reducing the analysis to a more involved Schrödinger-type operator. The second approach consists in introducing new virial identities based on a completely new development of the method of multipliers. These two strategies correspond to two recent works: the first in collaboration with N. Arrizabalaga and M. Morales, and the second, still in preparation, with L. Fanelli and F. Pizzichillo.

Useful Information

The meeting will take place in the **Maryam Mirzakhani Seminar Room** at **BCAM - Basque Center for Applied Mathematics**, located at **Alameda de Mazarredo, 14, 48009, Bilbao, Spain**.