UNIVERSIDAD DE GRANADA

FACULTAD DE CIENCIAS

Propuesta TFG. Curso 2024/2025

GRADO: Grado en Física

CÓDIGO DEL TFG: 267-132-2024/2025

1. DATOS BÁSICOS DEL TFG:

Título: Quantum effects in Magnetoreception

Descripción general (resumen y metodología):

How do migratory birds know to fly north? It turns out that birds have an internal biochemical compass based on magnetically sensitive free radical reactions [1,2]. Astonishingly such chemical Magnetoreception appears to be extremely sensitive since as the Earths magnetic field is of the order of tens of micro Tesla, far smaller than ambient magnetic noise due to electromagnetic waves used for telecommunication and radar. To explain this increased sensitivity it has been proposed that biochemical Magnetoreception must exploit quantum mechanical effects—such as quantum entanglement—which are known to yield ultra high sensitivity in magnetic field sensing [3].

Yet exactly how such quantum effects can come about—particularly in a hot and noisy environment such as a birds brain —is still not well understood. Several phenomenological models have been proposed [4,5]. In this work you will employ a simplified model of the most prominent models for the dynamics of the radical pair mechanism and study their quantum coherence and entanglement generating properties within the context of quantum statistical inference and quantum resource theories

Metodología:

The project will make use of both analytical and computational techniques. The analytical techniques involve

1. Open Quantum Systems
2. Quantum Resource theory of asymmetry and coherence

Numerical techniques involve implementing the open system dynamics of Magnetoreception (either MATLAB or Python)

Tipología: Estudio de casos, teóricos o prácticos, relacionados con la temática del Grado.

Objetivos planteados:

1. Develop analytical and numerical techniques for obtaining the dynamical super map (also known as the quantum channel) describing two phenomenological models for the radical pair mechanism
2. Apply tools and techniques from quantum statistical inference (Quantum Fisher Information) and the resource theory of quantum reference frames to quantify the quantum coherence generating power of these phenomenological models

Bibliografía básica:

[1] I. K. Kominis. Modern Physics Letters B, 29 (Supplement 1), 1530013 (2015)
[2] P. J. Hore, and H. Mouritsen. Annual Review of Biophysics, 45, 299-344 (2016)
[3] W. Wasilewski, et al., Physical Review Letters, 104, 133601 (2010)
[4] O. Efimova, & P. J. Hore. Biophysical Journal, 94, 1565-1574, (2008)
[5] I. K. Kominis. arXiv:1009.2809 (2010)

Recomendaciones y orientaciones para el estudiante:

Plazas: 1

2. DATOS DEL TUTOR/A:

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