Title: **Decoding Protein Dynamics of Magneto and Photon Perception with Single-Molecule Optical Techniques**

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Project:

In this PhD studentship, you will tackle one of biology's great challenges: decoding the protein dynamics underlying magneto- and photoperception. You may be familiar with AlphaFold [1], the Nobel Prize–winning breakthrough that predicts protein structures from sequences. While revolutionary, AlphaFold is limited to static protein structures. To truly understand protein function, we must also resolve the dynamic motions of signalling proteins and enzymes.

To address this, we have developed a single-molecule optical method that probes protein dynamics directly in real time [2]. This technique captures optical signals as proteins undergo structural motions during photon absorption, magnetic field interactions, and catalysis. Crucially, it is independent of fluorescence or absorption properties, making it broadly applicable across diverse proteins and enzymes. By correlating dynamic signal traces with static structures and simulation-based predictions [3,4], we aim to uncover the mechanistic basis of protein function.

Your focus will be on cryptochrome [5], one of quantum biology's most intriguing proteins. Cryptochromes respond to Earth's magnetic field, undergoing structural changes that transmit magnetic information to the brain. Yet their detailed functional dynamics, particularly how magnetic sensing and photoactivation interplay, remain poorly understood [6]. Using our optical method [7], you will explore how cryptochromes achieve magnetosensitivity in action.

This project offers the chance not only to elucidate the molecular mechanisms of cryptochrome but also to establish a general framework for decoding protein dynamics across enzymes, photoreceptors, and signalling proteins, addressing the next challenge after AlphaFold. If time permits, you may extend the work to single-photon sensitivity in photoreceptors [8], providing insights into how biology harnesses quantum effects with remarkable precision.

[1] https://doi.org/10.1038/s41586-021-03819-2 [2] https://doi.org/10.1021/acsphotonics.3c01570 [3] https://doi.org/10.1073/pnas.1907875116 [4] https://doi.org/10.1016/j.csbj.2024.11.001 [5] https://doi.org/10.1146/annurev-arplant-

042110-103759 [6] https://doi.org/10.3389/fpls.2024.1340304 [7] https://doi.org/10.1016/j.cbpa.2019.05.003 [8] https://doi.org/10.1529/biophysj.106.098806