

## "Open Quantum Systems: from qubits to quantum biology"

Neill Lambert

Theoretical Quantum Physics Laboratory, RIKEN Cluster for Pioneering Research, Wako-shi, Saitama 351-0198, Japan

In this talk I will discuss the role of noise in both quantum technologies and quantum biology. I will begin with an introduction to how noise is treated within quantum mechanics, and how we can obtain open-system dissipative models by including an environment in the closed system model and tracing it out. I will then discuss the importance of such models through practical examples in QuTiP [1], our open-source library, with a focus on how to model Noisy Intermediate Scale Quantum Technologies and quantum circuits.

I will then give an overview of why many of the same models can be used to study examples in quantum biology, including photosynthesis and avian magnetoreception. Finally, I will show what happens when the approximations in these approaches break down, and we must move to more sophisticated "non-Markovian" methods [3], where the environment begins to regain quantum features that we had earlier discarded.

[1] [www.qutip.org](http://www.qutip.org)

[2] Scholes, G., Fleming, G., Chen, L. *et al.* Using coherence to enhance function in chemical and biophysical systems. *Nature* **543**, 647–656 (2017). Lambert, N., Chen, YN., Cheng, YC. *et al.* Quantum biology. *Nature Phys* **9**, 10–18 (2013).

[3] Lambert, N., Ahmed, S., Cirio, M. *et al.* Modelling the ultra-strongly coupled spin-boson model with unphysical modes. *Nat Commun* **10**, 3721 (2019).