Adriana Marais- Research Summary

Quantum Effects in Biological Systems

Quantum biology is the application of the theory of open quantum systems to aspects of biology where classical physics fails to give an accurate description. The most well-established area in quantum biology is the study of photosynthesis. There exists a body of evidence that the primary photosynthetic processes of energy and charge transfer exhibit quantum mechanical properties, essential for function and which cannot be described by classical physics. Adriana Marais PhD thesis entitled "Quantum effects in photosynthesis" describes results obtained on de-coherence-assisted transport in the context of photosynthetic excitation energy transfer [1,2], as well as the proposal of the direct role played by electron spin in a protection mechanism during photosynthetic charge transfer [3]. Together with her PhD supervisors, Prof. Francesco Petruccione, and Dr. Ilya Sinayskiy, and in collaboration with Prof. Rienk van Grondelle and his group at VU Amsterdam, she is now attempting to verify, test, and quantify this quantum protective mechanism in natural photosynthetic systems, as well as formalize a design principle whereby harmful events in artificial photosynthetic systems can be suppressed by the presence of particle spin. The identification of quantum effects in primitive photosynthetic organisms, such as bacteria, suggests that quantum effects may have played an important role in the emergence of the very first living systems from the inanimate matter of which they are constituted. A description of the emergence of life from the inanimate matter of which it is constituted is one of the greatest open problems in science. The detection of the molecular precursors of life in interstellar ices suggests that the building blocks of life may have emerged in space and been delivered to Earth by objects such as comets or meteorites. Techniques from open quantum systems approaches to quantum biology are transferrable to studies on the origins of life. Dr. Marais is currently investigating the extent to which an open quantum system approach can shed light on the non-equilibrium dynamical processes that led to the emergence of the molecular precursors of life in the interstellar medium [4]. This is a pioneer project that she has coined ***Quantum Astrobiology***. Dr. Marais is currently a pioneer in this exciting new field, thanks to progress made in her PhD thesis. An important acknowledgement of her contributions so far, and the promise of future breakthroughs, has been the award of the 2013 **L'Oreal-UNESCO Regional Fellowship for Women in Science in Sub-Saharan Africa**, and the 2015 **L'Oreal-UNESCO International Rising Talent Grant**. Dr. Marais is well positioned to be awarded the Royal Society of South Africa Meiring Naude Medal.

[1] Sinayskiy, I., A. Marais, F. Petruccione, and A. Ekert. "Decoherence-assisted transport in a dimer system." *Physical review letters* 108, (2012): 020602.

[2] Marais, Adriana, Ilya Sinayskiy, Alastair Kay, Francesco Petruccione, and Artur Ekert. "Decoherence-assisted transport in quantum networks." *New Journal of Physics* 15, (2013): 013038.

[3] Marais, Adriana, Ilya Sinayskiy, Francesco Petruccione and Rienk van Grondelle, "A quantum protective mechanism in photosynthesis." *Scientific Reports* 5 (2015): 8720.

[4] Marais, Adriana, Ilya Sinayskiy, Francesco Petruccione, "An open quantum systems approach to the formation of prebiotic molecules." *Astrobiology Science Conference* (2015) http://www.hou.usra.edu/meetings/abscicon2015/pdf/7545.pdf