UNIVERSITY OF KWAZULU-NATAL ™
INYUVESI YAKWAZULU-NATALI

COLLEGE OF AGRICULTURE, ENGINEERING AND SCIENCE

The Centre for Quantum Technology
School of Chemistry & Physics

cordially invites you to attend a

PUBLIC TALK

The Quantum Design of Photosynthesis

by

Professor Rienk van Grondelle

Department of Biophysics, VU University Amsterdam, The Netherlands

Date:
Tuesday, 11 December 2018

Time:
16h00 for 16h30 -17h30

Venue:
Senate Chamber, Westville campus

Light refreshments will be served

ENQUIRIES: Ms Nelisiwe Mncube • Tel: 031 260 7570 • email: mncubene@ukzn.ac.za

INSPIRING GREATNESS

Synopsis: In photosynthesis sunlight is absorbed by the photosynthetic pigments, chlorophyll and carotenoid and the resulting excited state is stored as chemical energy. This energy conversion under optimal conditions occurs with a remarkable efficiency that scientists hope to mimick in bio-inspired solar energy converting devices, based on abundant elements. Two ultrafast (femtoseconds-picoseconds, 10-15-10-12 sec) processes are at the basis of the success of photosynthesis: excitation energy transfer in a light-harvesting antenna followed by charge separation in the photosynthetic reaction center. In plants pigments involved in light-harvesting antenna and charge separation are bound to specialized proteins that are organized in a membrane, the thylakoid membrane. Plants make do with two reaction centers that operate in series, Photosystem 1 and Photosystem 2, the former is sufficiently reducing to reduce CO_2, the latter has the capacity to extract the necessary electrons from water and produce molecular oxygen. Upon absorption of light collective excitations (excitons) are formed that are delocalized over a number of pigments that move extremely rapidly through the light-harvesting antenna to the reaction center in such a way that the quantum coherence is maintained even during the final charge separation. Two-dimensional (2D) electronic spectroscopy is an ultrafast laser technique that allows a visualization of how these coherences are involved in the primary processes of energy and charge transfer. Based on quantitative modeling we identify the exciton-vibrational coherences observed in 2D photon echo of the photosystem II reaction center (PSII-RC). We find that the vibrations resonant with the exciton splittings can modify the delocalization of the exciton states and produce additional states, thus promoting directed energy transfer and allowing a switch between the two charge separation pathways. We conclude that the coincidence of the frequencies of the most intense vibrations with the splittings within the manifold of exciton and charge-transfer states in the PSII-RC is not occurring by chance, but reflects a fundamental principle of how energy conversion in photosynthesis was optimized.

For a recent review of this work see:
Romero, E., Novoderezhkin, V.I. and van Grondelle, R., Quantum Design of Photosynthesis for Bio-inspired Solar Energy Conversion, Nature 543, 355-365 (2017) http://rdcu.be/p6Wg

BIOGRAPHICAL PROFILE:

Professor Rienk van Grondelle, together with Professor Roberta Croce, heads the Biophysics of Photosynthesis programme at the VU University Amsterdam, the Netherlands.
Professor van Grondelle is one of the most influential experimental physicists working on the primary physical processes of photosynthesis world-wide. Using the tools of ultrafast spectroscopy he has made major contributions to elucidate the fundamental physical mechanisms that underlie photosynthetic light harvesting and charge separation. He has developed theoretical tools to infer the effective electronic and molecular structure and dynamics from complex spectroscopic data. His work recently led to a fundamental new understanding of light-driven charge separation in the oxygen evolving photosynthetic reaction center of plants. Using multi-dimensional electronic spectroscopy he was able to show that in photosynthesis ultrafast charge separation is driven by specific molecular vibrations that allow electronic coherences to stay alive. Five years ago he proposed an explicit molecular model for photoprotection and demonstrated that the major plant light harvesting complex operates as a nanoswitch, controlled by its biological environment. These results, of utmost importance for our understanding of photosynthesis, inspire technological solutions for artificial and/or redesigned photosynthesis, as a possible route towards sustainable energy production on a global scale.
Van Grondelle has published 535 papers in international, peer reviewed journals that in total have attracted over 25K citations (h-index 80, WoS). In addition he is the co-author of three textbooks.