



LASER AND OPTICAL SPECTROSCOPY

PROFESSOR ELMARS KRAUSZ

Light, chemistry and photophysics are the most natural and cooperative of partners, dancing together and enabling life on earth. The energy in a photon of visible light is just that needed to perform many chemical transformations. Photosynthesis, the most important chemical process on Earth, is an amazingly efficient and delicately balanced process. Photosynthesis captures light from the sun and converts it to chemical energy. The Earth's chemical storehouse of oil and coal, that we burn so freely and thoughtlessly, has been accumulated through millennia of photosynthetic activity.

Spectroscopy is our passion. We are fascinated by the subtle and utterly distinctive interactions of light with solids and liquids. Light, after hitting a sample, is usually absorbed, converted to fluorescence or just bounced off (scattered). Lasers, through such amazing characteristics as great intensity, purity and coherence, can drive far less familiar processes such as harmonic generation. By combining conventional and laser techniques, a truly impressive range of spectroscopic techniques becomes available. Even a single molecule can be detected and analysed.

Spectroscopy probes the innermost secrets of chemical and physical transformations. It maps out the detailed electronic structure of the different forms of matter: crystals, liquids, glasses, proteins *etc.* For each case, information can be gained on how constituents bind together, how they interact with their environment and how they transform.

Our group performs a wide range of spectroscopic measurements: absorption, dichroism, emission, Raman, excitation, hole-burning and line-narrowing. The systems we study may be organic or inorganic, molecular, ionic, amorphous, crystalline or biological. Our strength lies in our ability to design, develop and construct specialised experiments and apparatus to target fundamentally important questions in an area of interest. A persistent theme we have is that molecules can behave quite differently in solution to when they are 'trapped' or enclosed in a protein or crystal. Such environmental influences are ideally probed *via* laser-selective spectroscopy.

Over the last few years our group has made spectacular progress in identifying the true charge separating state of Photosystem II (PSII), the engine room of life. PSII is unique in its ability to oxidise water and provides virtually all the bioenergetic electrons on Earth. In 2005, aspects of this discovery were presented at the AIP meeting in Canberra, the RACI meeting in Sydney, international conferences in Beijing and Shanghai, and culminated in Elmars Krausz being invited to talk about these dramatic developments at a special symposium in Amsterdam in October.

This year our group hosted internationally renowned researcher in photosynthesis, Bill Rutherford, as the Craig lecturer. During his month-long stay at the RSC, he presented a series of energetic and exciting talks and was actively involved in experimentation in our labs. Also visiting during the year were Mark Riley and ARC Linkage PhD student Andrew Dick who further developed our new MCD spectrometer system. Sindra Peterson Årsköld, of Lund University, came last summer to perform further magneto-optical measurements on cytochrome b_6/f . Felix Ho, a former RSC summer scholar, currently a postdoctoral fellow in Uppsala, Sweden, spent an exciting month investigating some optical consequences of redox processes in PSII.

The PSII Saga

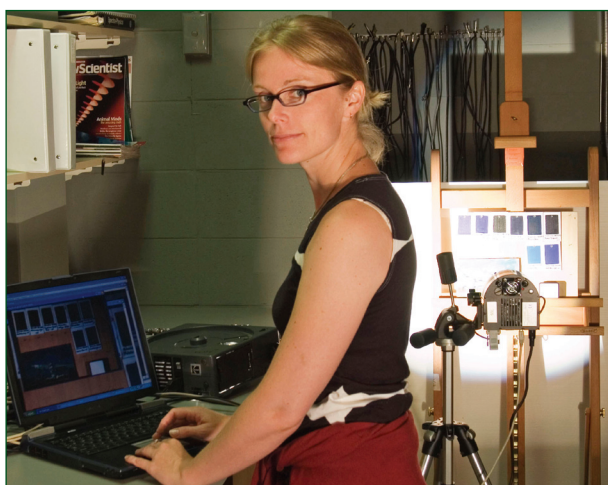
Following our utterly unexpected discovery that the charge separating state of PSII lies at far lower energy than thought, we have now firmly established a spectral and photophysical characteristic of this most critical state. Charge separation occurs with wavelengths as long as 730 nm, even at the lowest temperatures, and this 'red tail' phenomenon is general, occurring in both plants and cyanobacteria. Our efforts are attracting increasing attention and the significance of the phenomenon, particularly with respect to primary charge separation and the overall function of PSII, is being widely addressed. Significant discoveries have also been made with respect to secondary redox processes in PSII, again challenging long-held beliefs. *(With J Hughes, L Debono, and R Pace, P Smith [Dept Chemistry, ANU], A W Rutherford [Saclay, France], S Styring, K Sigfridsson, F Ho [Uppsala U, Sweden])*

The ANU and University of Queensland Magneto-enzyme Spectrometers

Faults in the superconducting magnet cryostats purchased for the ARC LEIF- and MEC-funded spectrometers for the ANU and the University of Queensland have been repaired, and both systems are now functional. The spectrometer interface, based on LabView software development, is proceeding at the University of Queensland and specialised sample handling and detector systems are being developed and refined at the ANU. *(With M Riley, A Dick [U Queensland], Lastek Pty Ltd [Adelaide])*

Multidimensional Spectral Characterisation of Art Works

Art objects are both unique and priceless. Consequently they cannot be extensively sampled or taken apart for analysis. We have developed a portable, powerful and remarkably cost effective imaging system based on a high sensitivity cooled CCD sensor, which accumulates spatially resolved fluorescence and reflectance spectra of art works *in situ*, with minimal impact on the object studied. The multidimensional optical characterisation of art works provided, also serves as a powerful tool for conservation, preservation and forgery detection. *(With M Kubik, and D Creagh [U Canberra])*



<http://rsc.anu.edu.au/research/krausz.php>