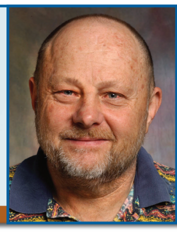


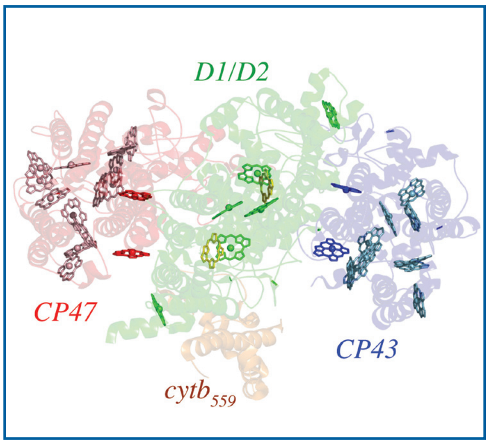
Laser and Optical Spectroscopy   Professor Elmars Krausz

Light, chemistry and photophysics are the most natural and cooperative of partners. The energy in a single particle (photon) of visible light is just that amount needed to perform a chemical transformation. Nature takes ruthless advantage of this synergy in the single most important chemical process on earth. This is the amazingly efficient, yet fascinatingly complex process of photosynthesis. Photosynthesis is the driving force for all life on our planet.

We specialise in spectroscopy. This delves into the subtle yet totally distinctive interactions of light, both visible and invisible, with the many forms of matter. Light, when impinging on a sample, is usually absorbed, emitted or just scattered. We often use lasers, and, *via* their special properties of intensity, purity and coherence, other much less familiar processes become possible. A very wide range of spectroscopic techniques is now available. These techniques may be utilised as either analytical or diagnostic tools, right down to the ultimate limit of chemistry of measurements on *single* molecules, or used to probe fundamental processes.

When spectroscopy is applied at a fundamental level, it is the most potent method with which to probe the innermost secrets of systems. Spectroscopy can map out the detailed electronic structure of the very many different forms of matter: crystals, liquids, glasses, proteins *etc.* In each case, information can be gained on how their constituents bind together and how they interact and transform.

Laser technology has become more familiar to us all with the advent of laser pointers and alignment devices, CDs, DVDs etc. Lasers have also revolutionised spectroscopy and indeed continue to do so. Laser light is *very different* to "ordinary" light (*e.g.* sunlight or lamplight). The spectral purity of a laser can be made better than one part in a billion. Laser pulses can be made shorter than one billionth of one billionth of a second (a femtosecond) or amplified to a level where the very distinction between light and matter becomes blurred. Put simply, lasers induce processes to occur that are just not seen with "ordinary" light sources.



Our group has a well-equipped lab and performs a wide range spectroscopic measurements; absorption, dichroism, emission, Raman, excitation, hole-burning, line-narrowing, on a range of materials. The systems studied can be organic and inorganic, molecular, ionic, amorphous, crystalline, and now predominantly, biological. Our strength is the ability to design, develop and invent special experiments and apparatus to target fundamentally important questions in a particular area of interest. One broad theme we have is that molecules can behave quite differently in solution to when they are 'trapped' or enclosed in a protein or crystal. These critical environmental influences are ideally probed *via* laser-selective spectroscopy.

Photosystem II remains at the centre of our gaze. The figure (PSII) shows its pigments imbedded in its trans-membrane proteins. This year, we have made outstanding discoveries on the nature of P680, the charge-separating assembly and also in the way in which excitation is transferred into the reaction centre. This led to an ANU press release in June, national coverage and invited articles. The group attended the Australasian Conference on Physical Chemistry in Hobart in February and reported some preliminary results. Professor Elmars Krausz and Mr Joseph Hughes attended the International Congress on Photosynthesis in Montreal and the Satellite Conference on Photosystem II in Trois Rivieres where Joseph spoke on some of our key results. Ensuing interest and discussion identified our work as one of the highlights of the congress. Mr Lesley Debono also spoke at the Student Conference on Physical Chemistry at Wagga.

The group hosted a number of visitors. These included the AAS Lemberg Fellow, Professor Charles Dismukes from Princeton and Professor Jim Barber from Imperial College. Joint ARC Linkage PhD student Andrew Dick came to develop our new MCD spectrometer system. Mr Richard Baxter, performed critical experiments towards his University of Chicago PhD on crystalline bacterial reaction centres. Dr Sindra Peterson Årsköld, now at Lund University, returned last summer to perform magneto-optical measurements on cytochrome b_6f. Ms Hendrike Thauern came from the University of Bonn in May to work on chromium and cobalt phosphate crystals.

A New Paradigm for PSII

Exciting developments have evolved from our discovery that PSII undergoes efficient charge separation and hole-burning with long wavelength excitation. Measurements of homogeneous hole-widths establish that excitation transfer from CP43 and CP47 light harvesting assemblies to the reaction centre is remarkably slow. Charge separation occurs with excitation longer than 700 nm, and thus at far lower energy than previously thought. We have been able to establish the source of PSII fluorescence, and develop new paradigm for this system. *(With J Hughes, L Debono, and R Pace, P Smith [Dept Chemistry, ANU], H Riesen [UNSW College, ADFA])*

Magneto-enzyme Spectrometer Development

The ARC LEIF- and MEC-funded spectrometers for ANU and the University of Queensland are now a reality. Software development is proceeding at UQ with sample handling and detector systems being further developed and refined at ANU. *(With M Riley, A Dick [U Qld], Lastek [Adelaide])*

Multidimensional Spectral Characterisation of Art Works

A new project has been initiated taking advantage of high performance and inexpensive broad wavelength-sensitive CCD arrays to create wavelength-dependent spectral images of art works, from the UV to the near IR. Such images will establish unique signatures of both the pigments and the methodologies used by the artist. *(With M Kubik, and D Creagh [U Canberra])*

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