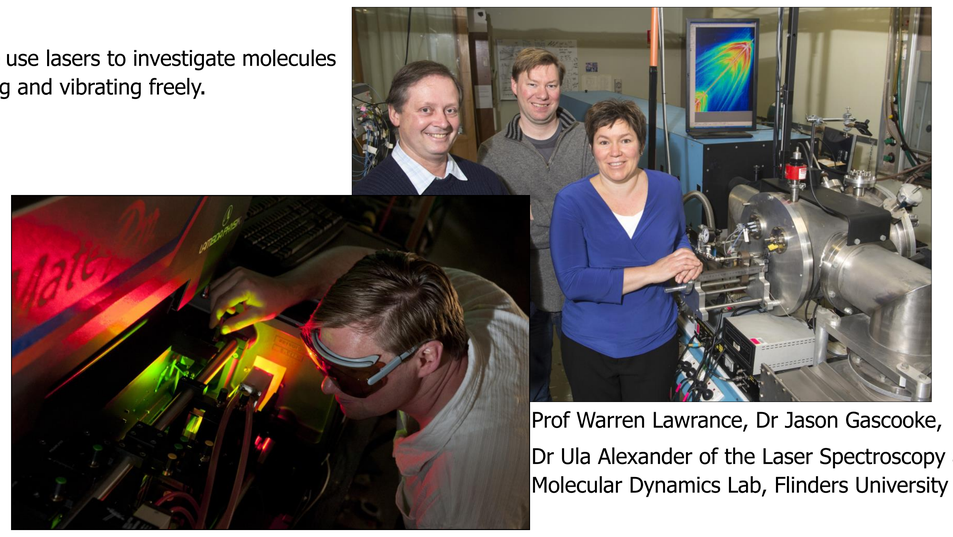
‘Quantum Conversations and the Art of Fluorescence’
2 Dimensional Laser Induced Fluorescence (2D-LIF)

Dr Ula Alexander, Dr Jason Gascooke, Prof Warren Lawrance, Flinders University

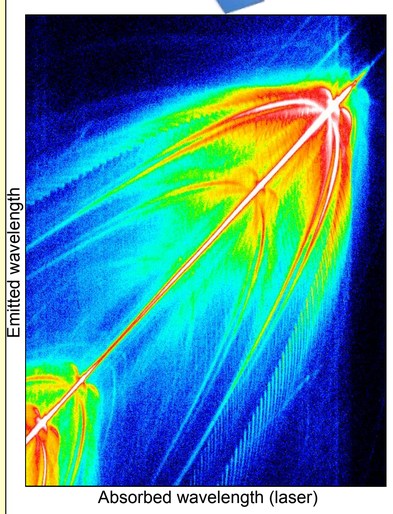
For Australian Institute of Physics Congress ”The Art of Physics”, Australian National University, Dec 2014

Figure 1: Information poster prepared for the exhibition to show the link between the lab and the art images.

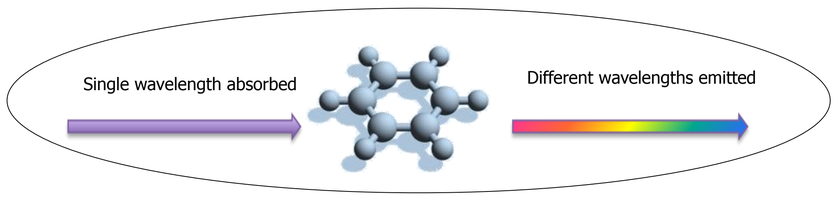
At Flinders University, we use lasers to investigate molecules and small clusters rotating and vibrating freely.



Prof Warren Lawrance, Dr Jason Gascooke, Dr Ula Alexander of the Laser Spectroscopy and Molecular Dynamics Lab, Flinders University

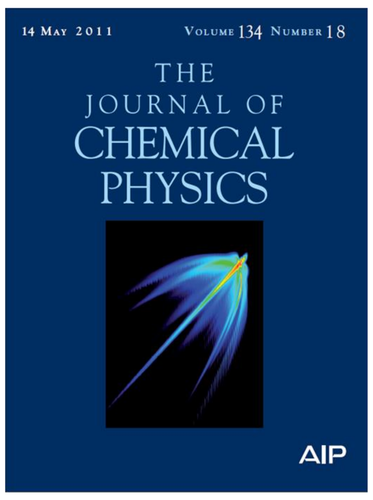


2-dimensional images are created by measuring wavelengths emitted while changing the laser wavelength.



The images are maps of the rotational and vibrational energy levels unique to each molecule. They allow us to find the 3-dimensional structure of the molecule.

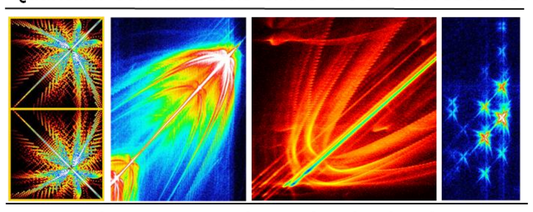
Our results have appeared on the cover of an international science journal.



A journal reviewer’s comment — “this could be art” —

and an invitation to exhibit for SALA has led to us being able to share our work with a wider audience.

Quantum Conversations & the Art of Fluorescence



Patterns in nature on the molecular level as seen by the Laser Lab, Flinders University.

Visit: www.salainc.com.au/artist-portfolio.aspx?artistid=819

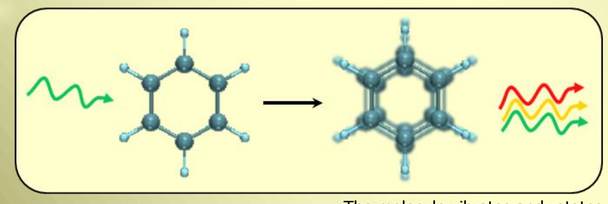
July 29–Sept 2 for SALA 2012
The Artisan Café (behind Bendigo Bank)
252 Main Rd, Blackwood | Phone (08) 8278 9888
Visit www.TheArtisanCafe.com.au for opening hours.
Opening night– Wed August 1st, 6–7.30pm – All Welcome

sala FESTIVAL
South Australian Living Artists
AUGUST 3–26 2012

About the exhibition -“Quantum Conversations and the Art of Fluorescence” : patterns in nature at the molecular level

- An exhibition was held for the South Australian Living Artists Festival, SALA 2012, which aimed to connect people to the small-scale quantised world through the intricate patterns molecules generate when interacting with light. (Figure 1 and 2(b))
- The artworks were generated by the molecules studied in the Flinders University Laser Spectroscopy and Molecular Dynamics Laboratory.
- The images are unique because they are direct observations of the quantum physics underlying the world of molecules.
- The apparatus used to generate these images was designed and built to gain detailed insight into the energy and motion of molecules. (Figure 2 (a) and 4)
- The exhibition title “Quantum Conversations – the Art of Fluorescence” :
  - refers to the fact that we can have a "conversation" with a molecule by "questioning" it with laser light and "listening" to its answer given in terms of light energy.
  - refers to the fact that collecting such images is an art in itself. Our lab is unique in its ability to generate such images.
- Each molecule will create its own unique pattern after interacting with light. This quantised energy pattern can be interpreted to tell us the molecule's shape and motion (rotation and vibration). (Figure 3)
- The observed dot and band patterning are physical manifestations of the abstract ideas of quantum mechanics where molecules can only have certain energies providing a means to connect with the quantum world.

Figure 3: The molecule’s ‘answer’ to ‘questions’ gives insight into the dynamic motion of the molecule.



Light is absorbed if the ‘questioning’ light energy matches the internal energy step size of the molecule.

The molecule vibrates and rotates more then releases ‘response’ light (fluorescence) which has a pattern characteristic of the molecule’s internal energy.

Exhibition feedback :

- People engaged with the images by seeing their own patterns of fish, feathers, comets, floating jellyfish, birds and stars. The detailed dot patterns in the calculated images were intriguing.
- Comparisons were also drawn with other dot-pattern art which observes natural events such as “Rain Showers” and “Sand Hills” by Australian artist, Lily Kelly Napangardi, which are dot paintings which observe the naturally occurring patterns in falling rain and sand dunes shaped by the wind.

More about the images :

- The images can be viewed purely for their natural harmony and symmetry.
- Images are built up from dots corresponding to changes in rotational motion of a molecule undergoing transitions involving electronic and vibrational motion. These dots build into a series that then builds into an overall contour for the transition. The blank areas between dots corresponds transition energies that are not allowed.
- In experimental images, these dots can blur into lines so banding patterns are seen.
- Calculated images were included in the exhibition as a necessary part of understanding the experimentally acquired images. They are represent the expected outcome derived from a quantum physics model. Comparison to experiment reveals the quality of the model.
- The intensity of features in images can vary over a 3-fold change in magnitude.
- Image analysis software, developed in-house, was tailored to help interpret features in images.
- Log scaling of the image and false colouring was added to the software to help highlight different features for data analysis and improve the impact of art images.

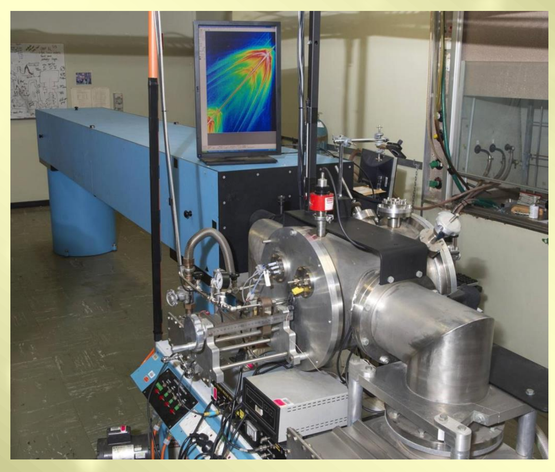
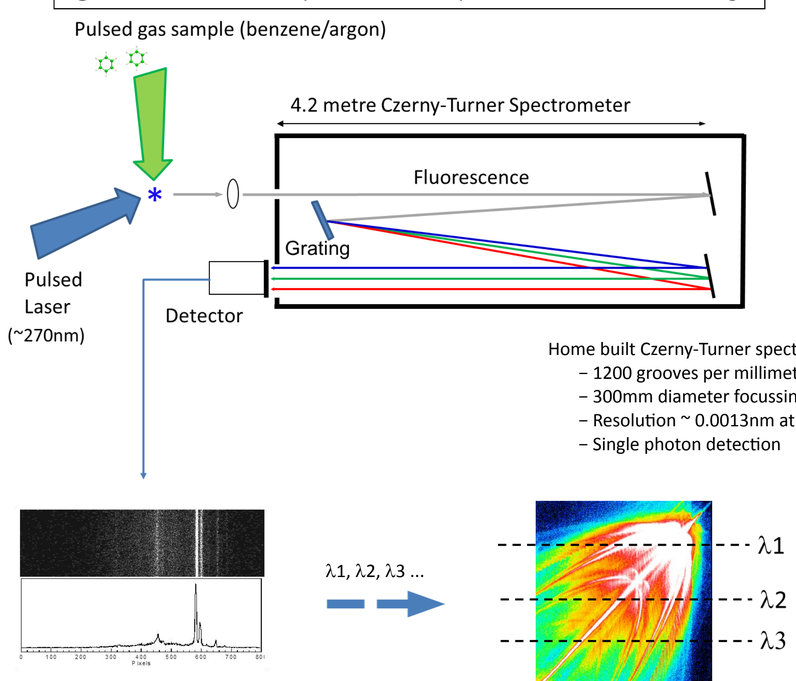


Figure 2: (a) The 4.2metre spectrometer (long blue box) and vacuum chamber used to collect images displayed at the South Australian Living Artists (SALA) Festival.

Figure 2: (b) A photograph of the “Quantum Conversations and the Art of Fluorescence” exhibition for SALA. These patterns in nature, where the molecule is the artist, were a mixture of experimentally observed images and calculated images.

Figure 4: Overview of experimental set-up used to collect 2D-LIF images



Home built Czerny-Turner spectrometer
- 1200 grooves per millimetre grating
- 300mm diameter focussing mirrors
- Resolution ~ 0.0013nm at 270nm
- Single photon detection

A typical dispersed fluorescence image (upper) and corresponding spectrum (lower) at one absorption wavelength, λ .

Collection of images is repeated at λ1, λ2, λ3 ... and processed to generate the 2D-LIF image.