WESTERN SYDNEY
UNIVERSITY

Nanoscale Organisation
and Dynamics Group

NANOSCALE RESEARCH NEWSLETTER

ISSUE 4 – SEPTEMBER 2016

Biomedical Magnetic Resonance Facility

WHAT DO YOU CALL A TOOTH IN A GLASS OF WATER?

A ONE MOLAR SOLUTION

The Biomedical Magnetic Resonance Facility is operating on regular basis. The new 600 MHz spectrometer has been in use since May for imaging and is now available for spectroscopy. In July 2016 it has been extensively used in a collaborative project on magnetic resonance imaging fingerprinting with Prof. Yasuhiko Terada from the Institute of Applied Physics, University of Tsukuba, Japan.

The 500 MHz spectrometer has undergone small repairs in order to prevent acquisition boards overheating. This might also improve the user comfort as the repaired cooling system produces less noise.

We advise you to keep in mind while planning your experiments that the Facility is most likely to be closed during the end of the year University closedown.

Please note that the Facility Manager has moved from 17.G.04 to 17.G.05.

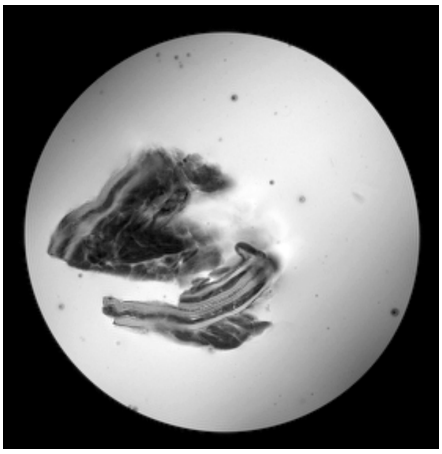
Dr Mikhail Zubkov Graduation September 2016

WSU - National Imaging Facility Node

Dr Tim Stait-Gardner

NIF case study: Imaging of colon cancer specimens

The Western Sydney node of the National Imaging Facility is working with the Ingham Institute and Liverpool hospital (with Prof. Michael Barton and Dr Trang Pham) on characterising colon cancer with MRI. Combining high resolution magnetic resonance images and 3D diffusion tensor images for fibre tracking with histological cross sections of a variety of colon tumour specimens along with specimens of healthy bowel tissue, we hope to better delineate the tumour boundaries and develop MRI techniques for performing 'virtual biopsies'. The image to the right is a single slice from an MRI 3D dataset of animal bowel tissue obtained from a butcher that was used to partially create the protocol for the human tissue scans. The tissue is embedded in an agarose gel to reduce magnetic susceptibility distortions. The complete 3D datasets along with the diffusion tensor datasets will be co-registered with the histology for the next stage of the project.



SPECIAL POINTS OF INTEREST

CEST: MRI based on chemical exchange

WHAT IS THE MOST IMPORTANT RULE IN CHEMISTRY?

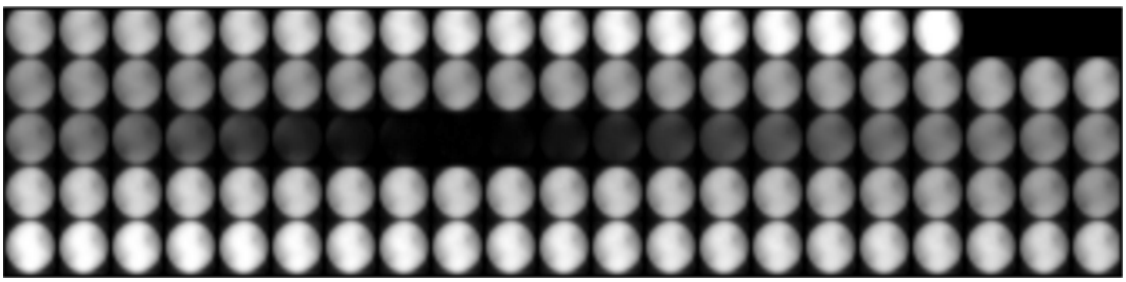
NEVER LICK THE SPOON!

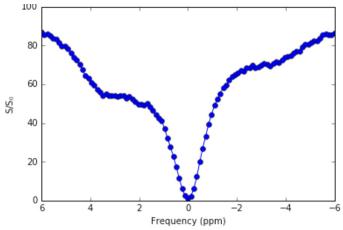
The human body is, speaking bluntly, a big bag of chemical reactions. Within the last two decades it was discovered that certain types of these chemical reactions can be exploited in magnetic resonance imaging (MRI) as contrast agents to provide metabolic information about the subject, namely, the chemical exchange of hydrogen between solutes (e.g., metabolites, proteins, or contrast agents) and the bodily water. This method of looking at the chemical exchange of hydrogen to measure metabolic changes is known as chemical exchange saturation transfer (CEST). The 'chemical exchange' comes from the aforementioned chemical exchange of hydrogens, whereas the 'saturation transfer' refers to a technique used in MRI for which we must delve into the basic mechanism of MRI.

In MRI, a subject is placed in a strong magnetic field (e.g., usually 1.5 to 3 tesla in hospitals) causing each hydrogen nucleus to precess in the field at a frequency called the Larmor frequency (i.e., behaving like a small precessing bar magnet). These individual magnetisations add up to give a 'bulk' magnetisation which points in the direction of the magnetic field. The bulk magnetisation can be manipulated with radio-frequency (RF) pulses of similar frequency to the precession frequency rotating it away from the bulk magnetic field (in a type of motion called nutation) so that it points in any desired direction, often perpendicular to the magnetic field. This bulk magnetisation precesses at the Larmor frequency giving rise to a signal in the spectrometer's receiver coil. 'Saturation' is a technique which involves applying an RF wave for a relatively long time to randomise the direction of specific individual magnetisations so they don't contribute to the bulk magnetisation and the final signal.

In CEST, a range of magnetisations are 'blindly' saturated by applying the RF wave with a range of frequencies. When the exchangeable solute hydrogen is hit with the RF wave and consequently saturated, the water signal will be reduced due to the chemical exchange of the saturated solute hydrogen and the water hydrogen. This mechanism is important as it allows the detection of minute concentrations of solutes (e.g., metabolites) by observing the reduction in the water signal. The contrast can also be turned off simply by not applying the saturation pulse.

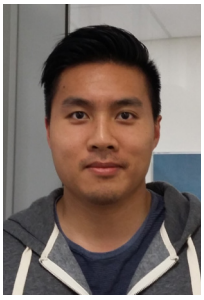
The figure below shows a collection of images of egg white in a vial, obtained at different RF wave frequencies. The blackness in the fifth row is the loss of the water signal due to the saturation of its hydrogens.





The application of CEST in MRI means that metabolic changes (e.g., pH changes, metabolite concentration changes) which predispose certain diseases can be observed in the images, allowing early diagnoses. This is a huge advantage over traditional MRI which usually requires the formation of macroscopic structural changes (e.g., formation of an observable tumour) before a diagnosis can be made.

Student Profile -



Johnny Chen completed his B.Med.Sc. (Honours) in 2015 at Western Sydney University, earning a place on the Dean's Merit list.

Johnny is currently in the first year of his PhD at Western Sydney University under the supervision of Dr Gang Zheng, Dr Tim Stait-Gardner, Dr Nirbhay Yadav, and Prof. William S. Price.

His research interests include NMR/MRI contrast enhancement via pulse sequence based solvent signal suppression and chemical exchange mediated saturation transfer (CEST).

He plans to complete part of his PhD abroad at John Hopkins University School of Medicine with Dr Yadav.

A new pulse sequence developed during his Honours year was presented at the international conference ANZMAG in 2015 and forms the basis of a just accepted (with minor revision) first author paper.

Johnny hopes to develop new techniques in CEST based NMR/MRI contrast enhancement during his PhD.

Upcoming Lectures

Abstracts from these and previous lectures can be found on the Nanoscale Research Group Website. (http://www.westernsydney.edu.au/nanoscale/nanoscale_organisation_and_dynamics)

8th September

"Three-dimensional controlled growth of monodisperse sub-50 nm heterogeneous nanocrystals and their luminescent properties"

2:00 pm
CA21.G.03
Lecture Theatre 5

Dr Xiaoxue Xu, ARC Centre of Excellence for Nanoscale BioPhotonics, Department of Chemistry and Biomolecular Science, Macquarie University

Dr Xiaoxe Xu has been working as Macquarie University Research Fellow in the Department of Chemistry and Biomolecular Science at Macquarie University since 2015. She joined Prof Dayong Jin's group in 2014 and researched to the inorganic luminescent nanocrystals for biomedical applications. Dr Xu received her PhD degree in 2012 from the University of Western Australia and also worked on the development of transparent ZnO and TiO2 monolith materials for sunscreen cream and the fabrication of novel bone scaffolds using 3D printing technique at UWA for two years.

TBA

"Bruises – Moving on to MRI"

2:00 pm
CA21.G.03
Lecture Theatre 5

A/Prof Neil Langlois Forensic Science SA , University of Adelaide, SA

A/Prof Neil Langlois qualified as a doctor at the University of Cambridge, UK, but always wanted to be a forensic pathologist. During his training he was introduced to the problem of ageing of bruises by his honours supervisor, Prof Austin Gresham, which lead to a study while working in an accident and emergency department. Having moved to Australia he started his consultant career at the Westmead Department of Forensic Pathology, continuing his research on bruises, including collaboration with the University of Western Sydney (as it was then). Now in Adelaide he is supervising projects at the University of Adelaide and Flinders University as well as collaborating with Monash University and the Victorian Institute of Forensic Medicine to investigate bruises.

6th October

"Integration of medical electron accelerators and MRI scanners:Next generation cancer radiotherapy"

2:00 pm
CA21.G.03
Lecture Theatre 5

Brendan Whelan Radiation Physics Lab, University of Sydney Ingham Institute, Liverpool Hospital

Brendan Whelan is a PhD student under Paul Keall at the University of Sydney's Radiation Physics Lab. His research primarily focuses on quantifying and mitigating unwanted electromagnetic coupling effects in MRI-Linac systems, with a particular emphasis on accelerator physics. He holds a Bachelor degree in Physics and a Diploma in Music from the University of Melbourne, as well as a Masters in Medical Physics from the University of Sydney.

Recent Lectures

16th August

"All Solid-State Batteries Using Sulfide Inorganic Conductors and Lithium-Metal Anode"

Professor Yuichi AIHARA, Samsung R&D Institute Japan

Dr Yuichi Aihara has been working as a Principal engineer at Samsung R&D Institute Japan (SRJ) since 2003. He joined SRJ in 2003 and developed "High temperature polymer electrolyte membrane fuel cells (HT-PEMFC)" for residential co-generation systems. Since 2010, he has been developing all solid-state batteries. Dr Aihara received his PhD degree in 2001 from the Mie University and also worked on the development of solid-polymer electrolytes and their application to all solid polymer batteries at Yuasa corporation (presently GS Yuasa), from 1991 to 2003.

31st August

"Chemical Exchange Saturation Transfer (CEST) Methods"

Dr Nirbhay Yadav is an Instructor in the Department of Radiology at The Johns Hopkins University School of Medicine and The Kennedy Krieger Institute.

Dr Nirbhay Yadav completed his PhD at the University of Western Sydney under the supervision of Prof. William S. Price. In 2010, he moved to The Johns Hopkins University School of Medicine to take up a Post-Doctoral Fellowship in Radiology under the supervision of Prof. Peter van Zijl. His current research interests include the development chemical exchange based MRI methods and the application of these methods in animal models and human patients with cancer, stroke, and neurodegenerative diseases.

7th Biennial Western Sydney University Symposium on NMR, MRI and Diffusion

When: Tuesday 29th November 2016

Where: Western Sydney University, Campbelltown

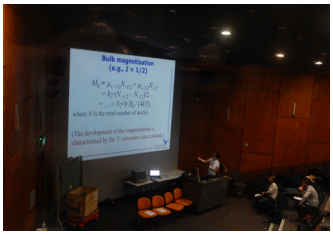
Venue: Lecture Theatre 5 (CA21.G.03)

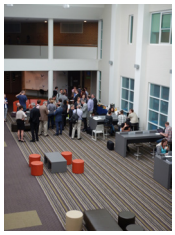
Audience: Open to all

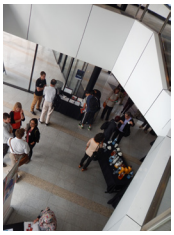
The Western Sydney University Symposium is held biennially and showcases theoretical developments and cutting edge application of Magnetic Resonance Imaging (MRI) and Nuclear magnetic Resonance (NMR) Diffusion measurements. The symposium will include platform and keynote lectures as well as poster presentations.

The symposium allows us to showcase our world class facilities, research and University and brings together leading domestic and international experts on topics ranging from medical to environmental, mining and industrial applications. This will result in knowledge transfer amongst researchers and uptake by industry of cutting-edge methods. The symposium is open to all including people from outside academia (e.g., clinicians and industry) and students. Consequently, one aim of the conference is to inspire the next generation of students and secondly to allow current students to access some of the brightest researchers at the forefront of MRI, NMR and diffusion research.

The symposium fills a void in research symposia in Australia – the university is unique in holding the only symposium in Australia to cover this area of research. There is no dedicated association for researchers in Australia in the diffusion magnetic resonance field.







Prof. Peter Basser (NIH)

Peter Basser is a Senior Investigator in the Tissue Biiophysics and Biomimetics department of the Natural Institute of Health.

Dr. Peter Basser received his A.B., S.M., and Ph.D. in Engineering Sciences from Harvard University and then received his postdoctoral training in Bioengineering as a Staff Fellow in the Biomedical Engineering and Instrumentation Branch (BEIP), NIH. In 1997, Dr. Basser became Chief of the Section on Tissue Biophysics and Biomimetics (STBB), NICHD and is currently the Director of the Program on Pediatric Imaging and Tissue Sciences there. Dr. Basser's group is primarily known for its invention, development, and clinical implementation of MR diffusion tensor imaging (DTI), and for explaining the physical basis of magnetic stimulation of nerve fibers. More recently, STBB has been developing several quantitative in vivo MRI methods for performing in vivo MRI histology. These include AxCaliber MRI, which measures the axon diameter distribution within nerve fascicles, and double Pulsed-Field Gradient (dPFG) MRI, which is used to study distinct microstructural features of both gray and white matter.

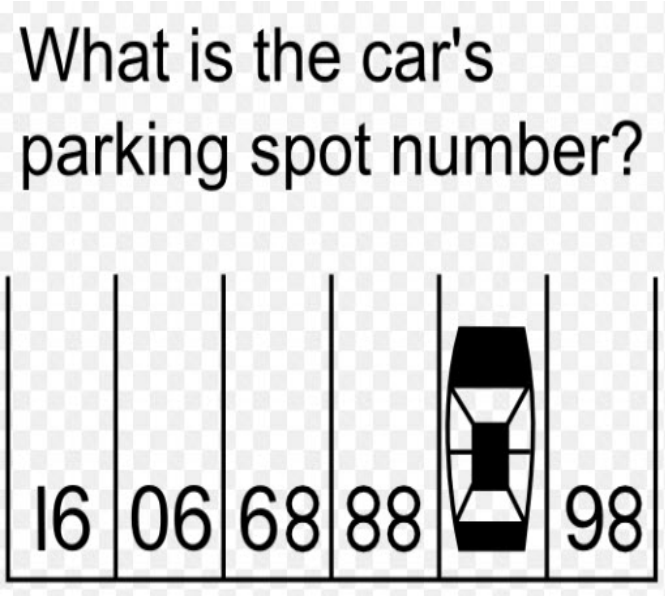
Prof. Gareth Morris FRS

Gareth Alun Morris FRS is a Professor of Physical Chemistry, in the School of Chemistry at the University of Manchester.

Gareth Morris is one of the world's foremost innovators in high resolution nuclear magnetic resonance spectroscopy, and has had a major influence on the determination of chemical structure by NMR. Almost all commercial NMR spectrometers contain hardware and software that he originated, including deuterium gradient shimming (now standard on commercial spectrometers) and ingenious pulse sequences such as DANTE (the prototypical selective excitation sequence) and INEPT (now a key component of multidimensional NMR techniques, including many of those used for protein 3D structure determination). The impact and wide applicability of Morris's contributions have made them indispensable components of the state-of-the-art NMR toolkit."

Morris received the James Shoolery Award 2015 awarded by SMASH (Small molecule NMR conference):

It is hard to imagine an NMR laboratory in the world which is not influenced daily by his developments from the foundations of INEPT and DANTE, through to modern gradient shimming, DOSY and pure shift methods.



Solution to the last editions

"Find a word "

	G	A	L	I	L	E	I	N	S	T	E	I	N	Y
D		G	E	R	U	T	H	E	R	F	O	R	D	R
L	N	A	L	M	E	N	D	E	L	E	E	V	H	R
O	I	U	B	L	L	E	B	N	G	C	N	O		U
G	L	S	B	V	M			N	O		B	N		W
N	K	S	U	I	O	F	I	U		T		E	A	A
I	N	A	H	G	A	L	L	A	C		W	M	R	T
K	A	C		R	E	O	T	S	B	D		E		S
W	R		A	E	M	R	U	A	L	Y	L	S	N	O
A	F	D	K	B	U	E	R	A	U	G			P	N
H	A			E	A	Z	W	N	I	W	R	A	D	
Y			T	N	Y	T	U	E	D	I	S	O	N	
	E	S	N	K	S	S	Z		K	C	N	A	L	P
	A	I	I	O	O				A	C	U	R	I	E
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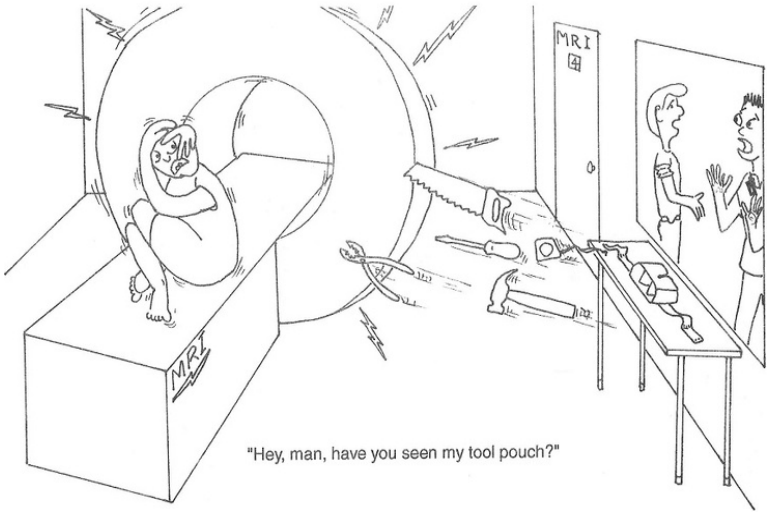
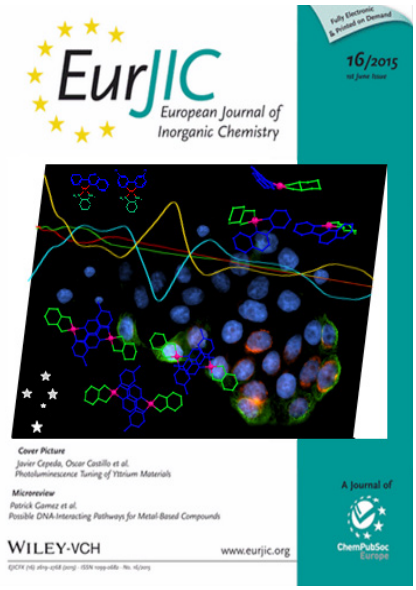


The cover picture shows X-ray crystal structures contrasting the differences in stacking and coordination geometry of platinum(II) complexes of 4,4'-dimethyl-2,2'-bipyridine and 2-(2'-pyridyl)quinoxaline. The CD spectra emphasise the effect that such structural differences can have upon the electronic properties of the compounds. Fluorescently stained HT29 human colon carcinoma cells make up the background, demonstrating the application of the complexes as anticancer agents. Finally, the Southern Cross refers to the country of origin of this work, while the yellow stars represent our acknowledgement to this journal and the European Union. Details are discussed in the article by J. R. Aldrich-Wright et al. on p. 4167 ff.



EUROPEAN JOURNAL OF INORGANIC CHEMISTRY

Front Cover: Cytotoxicity and Structural Analyses of 2,2'-Bipyridine-, 4,4'-Dimethyl-2,2'-bipyridine- and 2-(2'-Pyridyl) quinoxalineplatinum(II) Complexes (page 4146 - 4279)

Benjamin J. Pages, Yingjie Zhang, Feng Li, Jennette Sakoff, Jayne Gilbert and Janice R. Aldrich-Wright

Version of Record online: 1 SEP 2015

DOI: 10.1002/ejic.201500918

WHAT'S THE DIFFERENCE BETWEEN A MATHEMATICIAN AND A PHYSICIST?

A MATHEMATICIAN THINKS THAT TWO POINTS ARE ENOUGH TO DEFINE A STRAIGHT LINE

WHILE A PHYSICIST WANTS MORE DATA.

NANOSCALE ORGANISATION AND DYNAMICS

Professor William S. Price
Group Leader
- Medical Physics, MRI, NMR and diffusion

Professor Janice Aldrich-Wright
Lecturer
- Potent in-vivo cytotoxic agents

Professor Annemarie Hennessy
Dean of Medicine
- Preeclampsia

Assoc. Prof. Gary Dennis
Director Research School of Science and Health
- Polymer and surface chemistry

Dr Tim Stait-Gardner
National Imaging Facility Fellow
- MRI and quantum physics

Dr Allan Torres
Research Instrumentalist
Senior Lecturer
- NMR and MRI

Dr Gang Zheng
Lecturer
- NMR pulse sequence development

Dr Scott Willis
Post Doctoral Fellow
- NMR and MRI diffusion measurements

Dr Abhishek Gupta
Post Doctoral Fellow
- MRI contrast agent development and NMR relaxation

Dr Mikhail Zubkov
Biomedical Magnetic Resonance Facility Manager
- Modified diffusion sequences

THE SCIENCE OF TODAY IS THE TECHNOLOGY OF TOMORROW - EDWARD TELLER

Group Meetings

NANOSCALE RESEARCH / GRANT MEETINGS

Nanoscale Research/Grant Meetings are held monthly at Campbelltown with the next one to be held in February.

PROFESSOR WILLIAM PRICE'S LAB GROUP

Meet every Friday at 09:30 am in CA 21.1.65

BMRF USERS MEETING

February / May / August / November

PROFESSOR JANICE ALDRICH-WRIGHT'S LAB GROUP

Group meet every Friday at 10:00 am in 21.G.23

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