DIRDI

The Durham Institute of Research, Development, and Invention

January 2023 Newsletter

FOREWORD - DIRDI'S DIRECTOR GENERAL

"For 10 years, we have had the great privilege of leading our Undergraduate Rolling Internship Programmes, giving undergraduates the opportunity to work with us in paid part-time and full-time Summer Internships, some of whom worked with us for 2 years at Durham and are with us today as Permanent Staff in our Research, Development, Design & Ergonomics Department.

These undergraduate internships were inspired by the Team Projects initially led by the exceptional Professor Paula Chadwick and Professor Douglas Halliday at the Department of Physics both of whom, are Advisory Board Members of DIRDI and who have done so much for me, and my family, for which I am so very grateful.

In those days we ran a selection process that involved volunteer students in 7 hours of written tests and 2 hours of interviews. From these we learned something that all academic staff must know themselves, that, if one looks, one will find the “intellectual gold dust” at Durham.

3 years ago we had an idea to match the spirit of invention to the majesty of world-class research at Durham University. Without the support of the Vice-Chancellor, Professor Karen O’Brien and her predecessor, Professor Stuart Corbridge, Professor Colin Bain, the Pro-Vice-Chancellor of Research, Professor Jacqui Ramagge, the Executive Vice-Dean of Science and the Senate, to whom I am more grateful than I can say, we would never have launched the Durham Institute of Research, Development, and Invention in partnership with Durham University, and at Hatfield College, my old College, under the fine leadership of its Master, Professor Ann MacLarnon, and which is the Institute’s spiritual home.

Thank you to all our Founding and Visiting Fellows, and a very special note of great gratitude to our Head of DIRDI, and Senior Physicist at Coltraco Ultrasonics, Mr Daniel Dobrowolski. This year is one of growth across all departments in the Faculty of Science. I hope that you will enjoy this newsletter, and wish you all a very Happy New Year."

Professor Carl Stephen Patrick Hunter OBE.

Ideas - Invention - Innovation

DIRDI'S AIMS

We are looking for passionate Durham Academic staff to join our network and to help us achieve these goals. If you would like to become a member, a fellow, or enquire further about DIRDI please contact us at daniel.dobrowolski@dirdi.org. Nominations are welcome.

We would like to thank the Vice Chancellor and Durham University Senate for the formation of DIRDI. In partnership with Durham University, DIRDI aims to encourage "Newtonian Discovery" of the fundamental physical laws of the universe, for the benefit of humankind. Alongside this, DIRDI supports "Edisonian Commercialisation" through applied research into acoustics, electromagnetism, and information engineering. We hope to identify and support "England's next Newton" and create a 20-year academic environment in which the UK's "intellectual gold dust" can become British Nobel Prize Winners of Science. DIRDI also strives to become a "gateway into academic research" for normal inventive people across the Northeast of England, so that they may bring their ideas to us, turn them into inventions, and inspire a new way of developing national prosperity by matching academic research excellence to the will to invent.

Fellows

Professor Carl Stephen Patrick Hunter: Director-General
Mr Daniel Dobrowolski: Head of DIRDI
Professor Paula Chadwick: Advisory Board Member
Professor Douglas Halliday: Advisory Board Member
Professor Stuart Corbridge: Advisory Board Member
Professor David Wilkinson: Advisory Board Member
Professor Del Atkinson: Advisory Board Member
Mr Adrian Saw: Executive Board Member
Mr Benjamin Cowan: Executive Board Member
Mr Angus Hodgkiss: Executive Board Member
Dr Michael Hunt
Dr Oliver Vogt
Professor Ian Ritchey
Professor John Girkin
Major Bernard Hornung
Canon Professor Michael Snape
Professor Gordon Love
Visiting Professor Jim Glockling
Professor Ann MacLarnon
Professor Daniel Maitre
Professor Bernard Piette
Professor Nigel Glover
Professor Alastair Edge
Dr Jennifer Topping

Gratitude


Professor Paula Chadwick
Advisory Board


Professor Douglas Halliday
Advisory Board


Professor Karen O'Brien
Vice Chancellor


Professor Ann MacLarnon
Master of Hatfield College


Professor David Wilkinson
Advisory Board Member


Professor Del Atkinson
Advisory Board Member

TERMLY DINNER

DIRDI's first termly dinner was held last term and was enjoyed by Fellows and undergraduate members alike. We wish to mention the following who have kindly done so much to encourage and assist us such as Professor Jacqui Ramagge, Professor Paula Chadwick, and Professor Douglas Halliday.

Professor Jacqui Ramagge is exceptional, Executive Dean of the Faculty of Science at Durham and Honorary Professor of Mathematics at the University of Sydney. She is a Fellow of the Royal Society of New South Wales and was President of the Australian Mathematical Society. Professor Ramagge was appointed as Professor of Mathematics at the University of Sydney in 2015 making her the second woman Professor of Mathematics in the history of the institution. Jacqui was Head of School of Mathematics and Statistics from 2016–2019. During this time, she supported the establishment of the Sydney Mathematical Research Institute. Jacqui returned to the United Kingdom to take up a leadership position at Durham

University as Executive Dean (Science). She is responsible for the strategic development financial performance of the Faculty. Jacqui's research interests overlap algebra, analysis and geometry. Her current major projects focus on the general structure theory of totally disconnected, locally compacted groups and operator algebras. In the field of totally disconnected, locally compact groups, Ramagge is driving the development of the geometric aspects of the theory. Jacqui has published 28 research publications in the areas of group theory, functional analysis, operator algebras, control theory, and statistical analyses of learning outcomes. She has received 10 Australian Research Council since 2002.

Professor Paula Chadwick FRAS, FInstP is a longstanding friend of our Director-General, Carl Stephen Patrick Hunter OBE, who admires her greatly and attributes to her Coltraco Ultrasonics' work at Durham University with undergraduates, the sitting of its laboratory being co-located with The Centre for Advanced Instrumentation, part of the Department of Physics and to Coltraco Ultrasonics developing its scientific capabilities. Paula is Head of the Department of Physics at Durham University. Her research investigates gamma-ray astronomy and astroparticle physics. She is a ground-based gamma ray cosmologist who conducted her doctoral research at Durham, where she studied high energy cosmic gamma rays from pulsars. Professor Chadwick leads gamma-ray astronomy at Durham University. She is particularly

TERMLY DINNER

interested in supernova explosions and black holes, which produce high-speed jets. When gamma rays (the most energetic form of electromagnetic radiation) hit the atmosphere, they produce a cascade of high energy matter that travels faster than the speed of light in air. This produces a brief flash of high energy light (Cherenkov radiation), which Chadwick tries to detect with large telescopes. Professor Chadwick was awarded the Lawrence Bragg Medal and Prize for her exceptional work to engage undergraduates with industry.

Professor Douglas Halliday of Durham University's Physics Department is also a friend of our Director-General, working with him for over 10 years in undergraduate team projects and is Professor of Materials Physics, Director of the Durham Energy Institute and Chairman of the Board of Examiners in Physics. Professor Douglas is Director of the Durham University Global Challenge Centre for Doctoral Training and director of the Multidisciplinary Centre for Doctoral Training in Energy.

The dinner was hosted at Hatfield College, the home of DIRDI, on the 17th of November, and we would like to thank **Professor Ann McLarnon** for her hospitality. We would also like to thank our Director-General **Professor Carl Stephen Patrick Hunter** for hosting the dinner. It provided the perfect opportunity for networking and the sharing of knowledge between our members. Professor Jacqui Ramagge inspired all present by speaking wonderfully about what constitutes a genuine scientific discovery. Head of DIRDI Daniel Dobrowolski, spoke about the proposed concept of 'extradisciplinarity' while speaking about Newton.

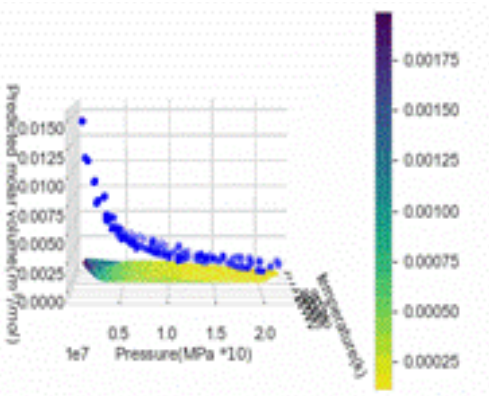
We are grateful to Professor Jacqui Ramagge, the Executive Dean of Science; Professor Ann MacLarnon, Master of Hatfield College; Major Bernard Hornung; Professor Ian Ritchey; Professor Jim Glockling; Dr Oliver Vogt; Dr Jennifer Topping; Professor Douglas Smith; Professor Daniel Maitre; and Professor Del Atkinson for joining us.

SUPERCRITICAL FLUIDS

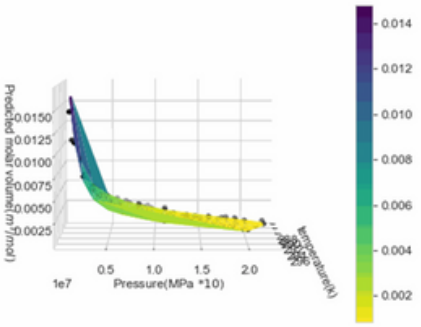
As part of an internship at DIRDI, undergraduate physicist Ms Athina Vogiatzi completed an investigation into the physics of supercritical fluids. An area which still requires much more research.

Supercritical fluids have temperatures and pressures that are found above the liquid-gas critical point, where distinct gas and liquid phases no longer exist. They have both gas-like and liquid-like properties. As a result, equations of state that are typically used, such as the real gas Van der Waals, do not produce an accurate prediction, especially at close to the critical point where the relationship between state variables is extremely sensitive to the position on the phase diagram. Indeed, around and beyond the critical point, it is no longer accurate to define the substance as belonging to any of the three classical phases of matter (solid, liquid, or gas).

As part of her research, Ms Vogiatzi collected data on supercritical Nitrogen and tested the fit of models, such as the crossover model, volume translated, and modified real gas equations.



Real Gas Equation



Modified Real Gas Equation

Ms Athina Vogiatzi
Undergraduate Physicist

Along the way, she encountered computational challenges when using curve-fitting functions, which can prove difficult for more complicated models. Ms Vogiatzi concluded that *"this research is ongoing, but the modification of the real gas equation has shown some promising and exciting results. I am looking forward to developing this model further and achieving accurate predictions."*.

The next step is to create a model with a parameter c that varies depending on our position on the temperature and pressure phase diagram.

Coltraco deal with the monitoring and measurement of certain pressurised fluids, that sometimes cross over into the supercritical region. Therefore, this research may inform future Research & Development. However, for now the research is purely for interest and to help further scientific understanding of the area. We look forward to working with Ms Athina Vogiatzi on this in future.

ULTRASONIC COUPLANTS

Last term, DIRDI provided the opportunity for undergraduate engineering students to contribute to our research on ultrasonic propagation in solids. The aim was to develop a convenient, effective, and inexpensive coupling material that may be easily adhered to a piezoelectric transducer operating at ultrasonic frequencies.

Solid couplants are of particular interest because they do not require clean up. Students were encouraged to consider the acoustic properties and malleability of materials. As well as the practical durability of couplants, how they might be affixed to a transducer, and what the effect of any adhesive may be on the transmission of ultrasound.

The students focused on the Ultracouple and a polydimethylsiloxane elastomer (SE).

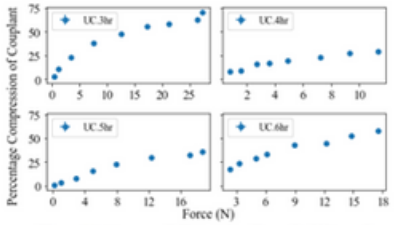


Figure 13: Compressibility against Force for UC couplants for 3-6 hour baking times inclusive in 1 hour increments. Errors are too small to be seen.

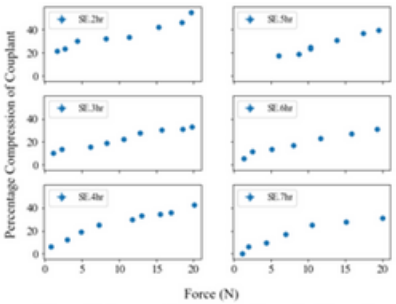


Figure 14: Compressibility against Force for SE couplants for 2-7 hour baking times inclusive in 1 hour increments. Errors are too small to be seen.

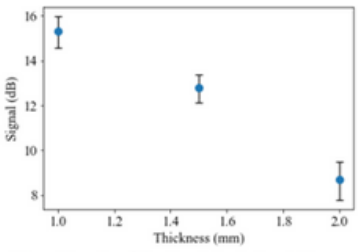


Figure 22: a plot of signal against couplant thickness.

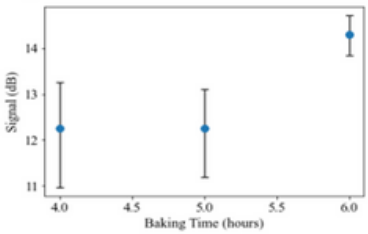


Figure 23: a plot of signal against couplant baking time.

During which they concluded the most reliable couplant was the Ultracouple with 5hr bake time and 1mm thickness. However, their conclusion highlighted the fiscal advantage to further research into SE couplants.

They also emphasised to the need for further research into the durability of Ultracouple and its performance overtime. Finally, they realised the need for a mould to non-adhesively attach the couplant to the transducer.

The project has led to a deeper understanding of the effect of compressibility and material composition on couplant effectiveness. The results will likely be used in the development of better, more practical, ultrasonic couplants, which may have a lasting effect on the industry.

COMPUTER SCIENCE

This academic year, DIRDI is supervising four Level 2 computer science software engineering projects for Durham University students. This provides an opportunity for students to contribute to commercialised research into ultrasonic leak quantification.

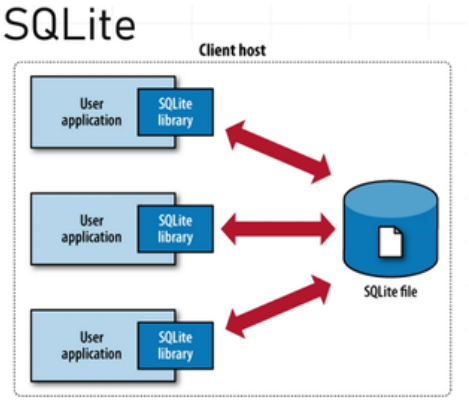
Designing an Android-Based Device with USB Serial Comms for Airflow Quantification in Buildings:

Two of the projects seek to design an Android-based application, influenced by an earlier Python, Kivy application. The aim is to interface with a pre-programmed ultrasonic sensor via a USB serial connection to read and analyse data. If successful, this would mark a significant improvement to a technology that is already the first in the world to quantify airflow through building fabric ultrasonically.

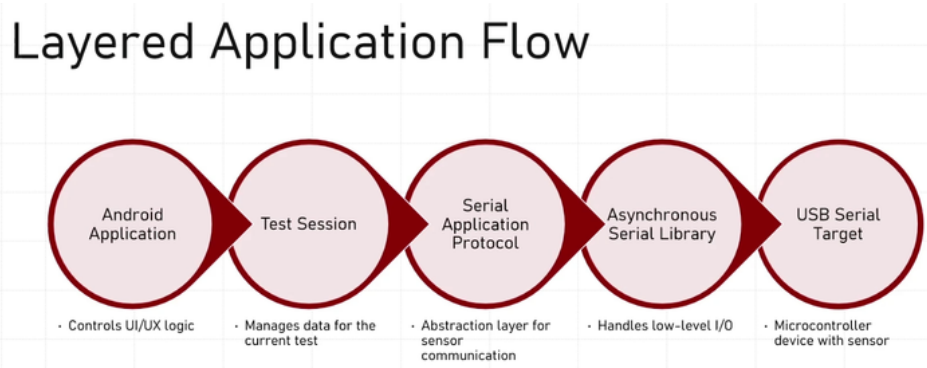
Designing an Android-Based Device with USB Serial Comms for Leak Detection and Quantification in Pipe Systems:

The other two projects involve the design of an Android-based application that also interfaces with a pre- programmed ultrasonic sensor via USB serial connection, this time for the application of passive leak detection in pipes.

Working with Durham University, DIRDI is providing students with real world applications for their studies. We hope to inspire creativity and problem solving by asking them to design a user interface and presenting students with unique challenges. We are excited to see the different approaches taken to the projects and gain a new perspective on Ultrasonic implementation.




```
class MainMenu : Fragment() {

    private var _binding: MainMenuBinding? = null

    // This property is only valid between onCreateView and
    // onDestroyView.
    private val binding get() = _binding!!

    override fun onCreateView(
        inflater: LayoutInflater, container: ViewGroup?,
        savedInstanceState: Bundle?
    ): View {

        _binding = MainMenuBinding.inflate(inflater, container, false)
        return binding.root

    }

    override fun onViewCreated(view: View, savedInstanceState: Bundle?) {
        super.onViewCreated(view, savedInstanceState)

        binding.quickTest.setOnClickListener {
            findNavController().navigate(R.id.HomeToQuick)
        }
        binding.fullTest.setOnClickListener {
            findNavController().navigate(R.id.HomeToFull)
```

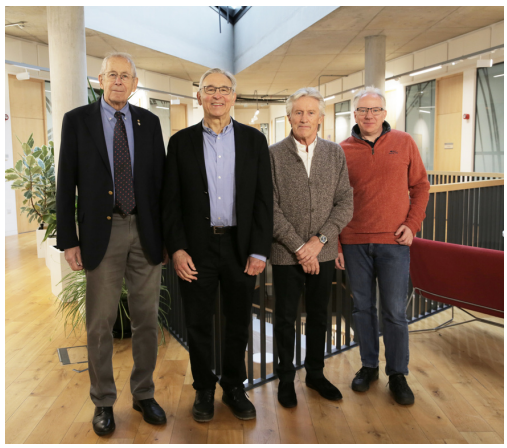


OGDEN CENTRE CELEBRATION

In December, Angus Hodgkiss, on behalf of our Director-General, attended the celebration of the 20th anniversary of the Ogden Centre's establishment.

Celebrations involved an open day demonstrating the research that has been conducted over the last twenty years. This included a virtual reality tour through time and the ability to create a model galaxy by adjusting several parameters. Each was manned by PhD students who would talk about their research.

In celebration Mr Damon de Laszlo generously donated a sculpture called "The Journey", created by Mr John Robinson. In Mr Robinson's words, this sculpture was designed "to symbolise the Journey through life which we all make, and which is so full of opportunities."



They also hosted a dinner in the Grand Hall of Durham Castle where senior members of the Ogden Centre spoke about its creation and their hopes for the future.

The day also included a Mini Symposium, which comprised of six speakers, including Professor Carlos Frenk, head of the Ogden Centre, and a guest lecture from theoretical cosmologist and Nobel Laureate, Professor Jim Peebles. Each speaker aimed to address one of the five key questions that were outlined at Ogden Centre's inception and to provide some insight into the progress that has been made towards finding answers for these. The questions addressed remain some of the biggest mysteries of the universe, such as "What is dark matter, how much is there and where is it?" and "Was Einstein right? Black hole archaeology with gravitational waves".

"I thoroughly enjoyed every aspect of the event, but I feel I must say, as a physicist, it was a particularly special privilege to hear a Nobel Prize winning physicist discuss some of his ground-breaking research." - Angus Hodgkiss MPhys

WOULD YOU LIKE TO BE INCLUDED IN OUR NEXT NEWSLETTER? WRITE TO US AT DANIEL.DOBROWOLSKI@DIRDI.ORG