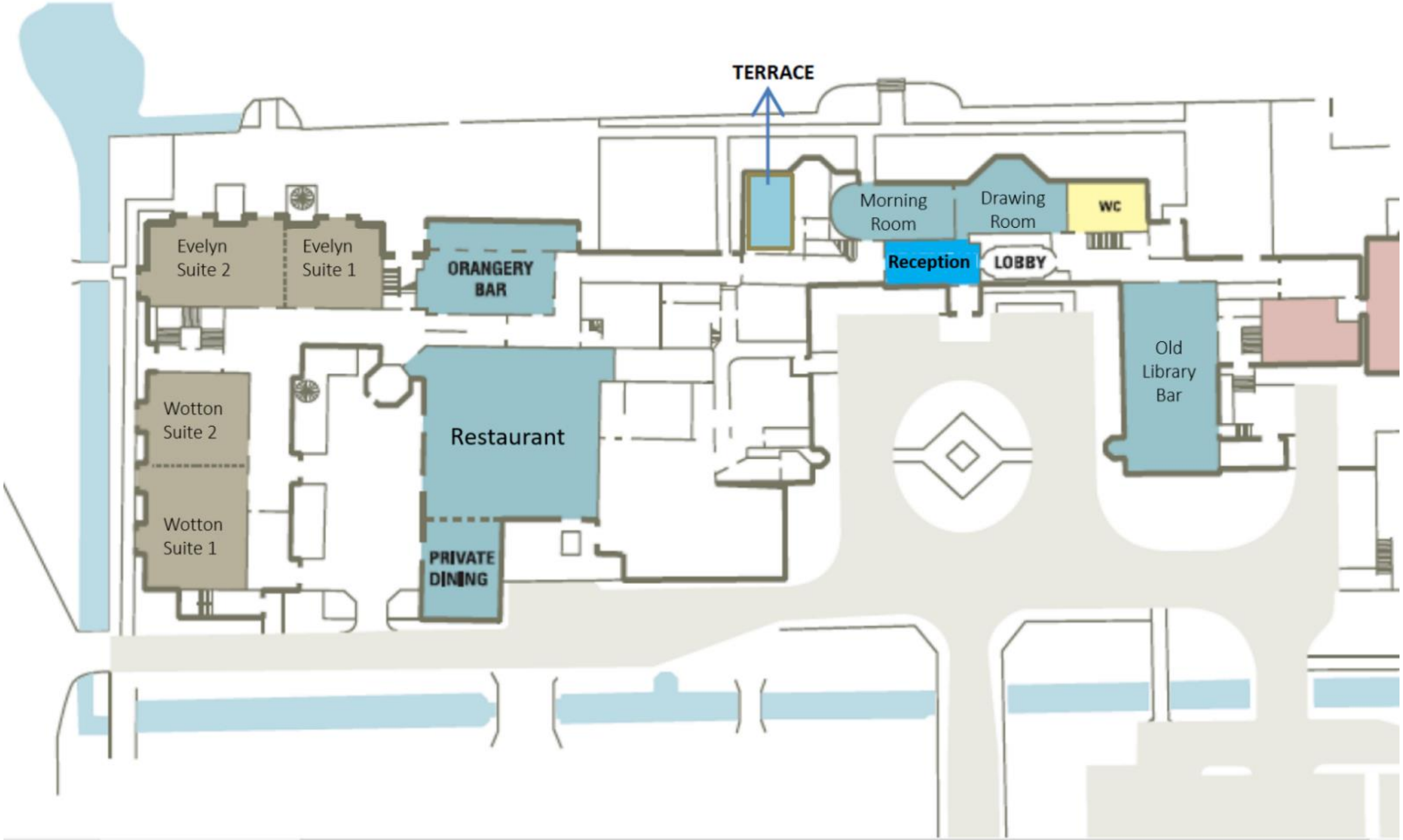
UK
META
MATERIALS
NETWORK

UK Metamaterials Conference & Forum 2024

19th – 23rd May 2024

Wotton House, Guildford Rd, Dorking, RH5 6HS


TERRACE
Evelyn Suite 2
Evelyn Suite 1
ORANGERY BAR
Morning Room
Drawing Room
WC
Reception
LOBBY
Old Library Bar
Wotton Suite 2
Wotton Suite 1
Restaurant
PRIVATE DINING

Welcome

UK Metamaterials Conference & Forum 2024

On behalf of the organising committee, it is our pleasure to welcome you to the UK Metamaterials Conference & Forum 2024.

This event brings together over 130 representatives from universities, industry, governmental agencies and other research institutions.

Talks, panels and discussion groups will take place in the WOTTON SUITES, the evening showcases will be take place in the EVELYN SUITES. The Drawing Room and Morning Room are open for use by the conference attendees as break out rooms from Monday to Wednesday.

If we could make one request: where possible, please attend all of the sessions, including those outside of your usual core area, so that we can share collective understanding and knowledge across the community.

The concept of this conference will only work if you bring along your curiosity and your willingness to learn, question, and contribute - as an expert and a novice in any of the discussion topics. Enjoy your time. We are happy to have you here.

Sponsorship

The UK Metamaterials Conference & Forum 2024 is kindly sponsored by the Engineering and Physical Sciences Research Council (EPSRC) and the Defence Science and Technology Laboratory (Dstl).

Image credit: Samples manufactured by Tom Whittaker, University of Loughborough

Booklet contents

This conference booklet is designed to include all the key items of information related to the conference. If you have any additional questions during the conference, please approach one of the organisers (red lanyards) or ask the hotel staff.

Phone contact during the conference:
Wotton House reception 01306 730 000

Email contact for conference related queries prior/after the event:
Henry Marsh, H.Marsh2@exeter.ac.uk; info@metamaterials.network

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Conference team

UKMMN+ Executive Board

Alastair Hibbins

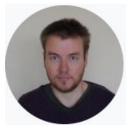
University of Exeter

Claire Dancer

University of Warwick

Simon Pope

University of Sheffield



Tom Allen

Manchester Metropolitan University

Helen Rance

University of Exeter

Katie Shanks

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Andrea Di Falco

University of St Andrews

Anton Souslov

University of Cambridge

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David Newman

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Poster sessions, presentation & vevox support, photography

Karen Pearson

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Registration, general support

Aim of the conference

The UK Metamaterials Conference & Forum 2024 2024 will focus on exploring how metamaterials research and innovation may be able to address big societal challenges such as **Health, Space & Aviation, Manufacturing & Scale Up, and Sustainability**.

The conference provides a space for the community to come together and widen knowledge horizons beyond subject-specifics, to lay the foundation for future collaborations between and across UK academia and industry (e.g., addressing grand challenges, joint projects, research grants, consultancy work etc.).

Target audience: Academics (incl. Early Career Researchers at/beyond post-doc level), postdocs outside the ECR scope, representatives from industry, governmental and other non-Higher Education research organisations.

Family members including children are welcome to attend.

Bring your mobile device to the table!

We will use *Mentimeter* as an online platform to engage with you during the sessions for polls, to gather questions and collect your input.

Please bring a fully charged device that can be used to access the internet via the free "Wotton House Hotel" wifi to be able to scan the QR codes.

You will be able to access this conference booklet via the link: https://metamaterials.network/uk-metamaterials-network-conference-2024/

Remember to keep your device on mute.

Code of conduct

We invite all conference attendees to help us make this event a safe and positive experience for everyone.

EXPECTED BEHAVIOUR

- Be considerate and respectful.
- Be curious.
- Listen and contribute in equal measure. Don’t talk over others.
- Refrain from demeaning, discriminatory, or harassing behaviour and speech.

UNACCEPTABLE BEHAVIOUR

Unacceptable behaviour includes, but is not limited to:

- Intimidating, harassing, abusive, discriminatory, derogatory, or demeaning speech, materials, or conduct by any participants of the event.
- Violence, threats of violence, or violent language directed against another person.
- Personal insults; sexist, racist, homophobic, transphobic, or otherwise discriminatory jokes and language.
- Failure to obey any rules or regulations of the event venue.

CONSEQUENCES OF UNACCEPTABLE BEHAVIOUR

Unacceptable behaviour will not be tolerated. Anyone asked to stop unacceptable behaviour is expected to comply immediately. If a participant engages in unacceptable behaviour, the event organisers may take any action it deems appropriate, including expelling the offender from the event with immediate effect.

WHAT TO DO IF YOU WITNESS OR ARE SUBJECTED TO UNACCEPTABLE BEHAVIOUR

If you are subjected to unacceptable behaviour, notice that someone else is being subjected to unacceptable behaviours, or have any other concerns, please notify the event organisers (red lanyards) or the hotel reception as soon as possible. All reports will remain completely confidential.

About the venue

The Wotton House Estate dates back to the 16th Century, when it was sold by Henry Owen to the Evelyn family. John Evelyn, one of three sons of Richard Evelyn, was passionate about botanicals and arboriculture and was particularly spellbound by the Italian Renaissance gardens he had seen on his tour of Italy.

Inspired by what he had discovered on his travels, on his return to Wotton he constructed an Italian garden and temple, designed by his cousin, Captain George Evelyn, which was soon joined by a parterre garden complete with an Italian fountain.

Since this time, the estate has been passed through the Evelyn family, who have all been passionate about preserving John's legacy, whilst adding their own eccentricities to the estate. Not so long ago, you may have even discovered Kangaroos on the lawn.

The Estate was home to the Canadian Army during the Second World War and in 1947 it became a fire training centre for The Home Office. Soon afterwards, the house became the national Fire Service College.

Today, it is a home away from home with 13 acres of garden. Wotton Estate had the first Italian garden in England, completed in 1652, adorned with Roman temples and original mosaics. The gardens have been deemed worthy of protection and are unusually, individually Grade II listed. Built for intrigue, discover their mystical nature that is fit for any romantic explorer.

How to find the venue

Wotton House, Guildford Road, Dorking, Surrey RH5 6HS | Use RH5 6QQ for Sat Nav

Wotton House can be easily accessed by the M25, the M3 South, the A24 East, and the A3 from London. Parking is extensive and free for guests of the hotel, conference venue and leisure club.

The closest train station, Dorking Station, is just 4 miles or a 15 minute drive from the hotel. Direct links and connections from London Waterloo, London Victoria, Reading, and Gatwick Airport are available.

Parking

Car parking is plenty available, but there is no option to charge electric cars at this point. Secure bike parking facilities are in development but not yet available.

What else to do

As a guest of Wotton House, you have free access to the venue's gym facilities, their pool, and the gardens to walk around.

A walking map can be provided by the hotel reception.

Hotel contact details

Wotton House reception: 01306 730 000 | www.wottonhouse.co.uk
Wotton House, Guildford Road, Dorking, Surrey RH5 6HS | use RH5 6QQ for Sat Nav.

Practical details

Conference registration

To receive your lanyard and name badge, please go to our conference registration desk between the Evelyn and Wotton Suites.

Registration times: **Sunday** 5-6pm and 8-9pm; **Monday/Tuesday** 8.30-10 am, **Wednesday** 8.30 – 10 am

What is paid for, and what not?

Your accommodation, meals (excl. all drinks unless provided) and refreshment breaks are paid for by the Network. Anything else (drinks you are purchasing at the bar, items from the mini bar, etc.) will need to be paid for by yourself.

On the Sunday night the meal has not been booked. The UKMMN+ will reimburse the cost of one main course per delegate for this meal. Please book your tables by contacting the venue.

Gala Dinner (Wednesday night): Any drinks will need to be paid for by yourself.

Wifi

To access the internet, we recommend to log in to the free 'Wotton House Hotel' Wifi. Use your browser to access the Wotton House Wifi page where you need to enter your email address to connect. The Wifi will work in both the meeting spaces and bedrooms.   If there are problems, please ask at reception for support.

Need a taxi?

There are a few taxi providers operating: DM Taxi – 01306 304050; Magnum Cars – 01483 281111.

Please ask the hotel reception staff for support, in particular to coordinate sharing of taxis to Dorking Station on the last conference day.

Walk

A walk has been planned for the 21st of May at lunchtime. This is a social event activity arranged by the UKMMN+'s a qualified Hill and Moorland Leader.

Wotton House reception: 01306 730 000

Introduction to Mentimeter

To include an interactive element that enables the sharing of thoughts and input from as many participants as possible (and as quickly as possible), we will be using Mentimeter as an online platform to engage with you during most of the sessions.

What you need: a charged device (e.g. mobile phone, tablet) with an internet connection and the ability to scan QR codes or to type / click on links to the Mentimeter sessions.
How to: Scan the QR code on the screen during the conference or on the website at: https://metamaterials.network/uk-metamaterials-network-conference-2024/.

Once the session is live, you should see a poll question appear on your screen.

*The link will only be active during the conference sessions. Outside of the session time, you may receive a "**Session Inactive**" notification.*

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There is also a Q&A function (speech bubble icon). You can use this to add your questions/comments and up-vote other participants' input.

Please note: We will monitor the Q&A box only when there is an active Q&A element in any given session. You can use it at any time once the session is live, but we may not be able to react in real time outside of the session.

Do not worry: There will be a "*How to use Mentimeter*" test run during the Welcome Talk session and people at your table to give a hand when needed throughout the week.

CONFERENCE SCHEDULE

Sunday 19th May 2024[1]

1. Arrival from 15:00
2. Registration between 17:00–18:00 and 20:00–21:00 (in front of Evelyn Suites)
3. Session Organiser Briefing session 21:00-22:00
4. Dinner in the Restaurant 18:00–21:30 (individuals are requested to book in advanced as this is not a centrally organised meal)

Showcase material setup times

1. Setup: **Monday**: 8:00–9:00; 18:00–18:45; **Tuesday:** 8:00 – 9:00 am, 18:30-19:00

[1] These times may be subject to adjustment. Any adjustments will be updated in the e-programme.

Monday 20th May 2024

Time	Location	Session	Speaker
8:30–09:00	Wotton Suite	• Registration	
9:00–09:50	Wotton Suite	**Welcome** • Update on Strategy and Leadership, Governance, Observatory, ED&I, website, and NetworkPlus successes	1. Alastair Hibbins (University of Exeter) 2. Claire Dancer (University of Warwick)
9:50–10:00	Wotton Suite	**Institute of Physics: Introduction**	1. Anne Crean (IoP) 2. Jenny Lovell (IoP)
10:00–10:50	Wotton Suite	**Underpinning Science: Part I** • Introduction & highlights • Fundamental Science theme	**Chairs** 1. Andrea Di Falco (University of St Andrews) 2. Anton Souslov (University of Cambridge) **Speaker** 1. Nikolay Zheludev (University of Southampton)
10:50–11:20	BREAK		
11:20–12:30	Wotton Suite	**Underpinning Science:**	**Speakers**

		Part II • Fundamental Science theme speakers • Fundamental Science theme panel	1. Riccardo Sapienza (Imperial College London) 2. Jack Gartside (Imperial College London) **Panel Discussion** 1. Simon Horsley (University of Exeter) 2. Ian Youngs (Dstl)
12:30–14:00	LUNCH BREAK Weather dependent: Conference Photograph *Gather in the Wotton Suite to be guided to the group photo spot*		
14:00–14:30	Wotton Suite	**ARIA Virtual Introduction**	
14:30–16:30	Wotton Suite	**Special Interest Group Roadmaps: Part I** • Acoustic Metamaterials • Active Metamaterials • Mechanical Metamaterials • Theory, Modelling & AI	**Acoustic** 1. Gregory Chaplain (University of Exeter) 2. Felix Langfeldt (University of Southampton) **Active** 3. Simon Pope (University of Sheffield)

			4. Diane Roth (QinetiQ) 5. Aakash Bansal (Loughborough University) **Mechanical Metamaterials** 6. Andrew Alderson (Sheffield Hallam University) 7. Oliver Duncan (Manchester Metropolitan University) **Theory, Modelling and AI** 8. Stefan Szyniszewski (Durham University) 9. Simon Horsley (University of Exeter) 10. Marcelo Dias (University of Edinburgh) 11. Malte Peter (University of Augsburg)
16:30-17:00	BREAK		
17:00-18:00	Wotton Suite	**Special Interest Group Roadmaps: Part II** • Photonic Metamaterials • Microwave & THz Metamaterials	**Photonic Metamaterials** 1. Mitchell Kenney (University of Nottingham) 2. Rupert Oulton (Imperial College London) 3. Sebastian Schulz (University of St Andrews)

			Microwave & THz Metamaterials 1. Stephen Henthorn (University of Sheffield) 2. Miguel Navarro-Cia (University of Birmingham) 3. Milo Baraclough (Dstl)
18:00–18:45	**BREAK**		
18:45–19:30	Wotton Suite	**Just a minute (posters)**	
19:30	Posters & Demonstrators and buffet in the Evelyn Suite		

Tuesday 21st May 2024

Time	Location	Session	Speaker
09:00–10:20	Wotton Suite	**Challenge – Sustainability: Part I** • Introduction to Sustainability Challenge • Talks and Q&A	**Chair** 1. Katie Shanks (University of Exeter) **Speakers** 1. Rox Middleton (University of Bath) 2. Ryan Bower (Imperial College London) 3. Simon Horsley (University of Exeter) 4. Gregory Chaplain (University of Exeter) 5. Simone Michele (University of Plymouth)
10:20–10:50	**BREAK**		

10:50–12:30	Wotton Suite	**Challenge – Sustainability: Part II** • Application Intro Talks and Panel Discussion • Roundtable Discussion: • Bio-based and abundant materials sourcing/reducing critical material requirement, fabrication, and applications • Metamaterials for Energy • Metamaterials for Environmental Monitoring	1. Joe Keddie (University of Surrey) 2. Peter Martin (University of Bristol) 3. Steven Hepplestone (University of Exeter)
12:30–15:00	LUNCH (PACKED) AND WALK		
15:00–17:25	Wotton Suite	**Challenge – Health: Part I** • Introduction to Healthcare Challenge • Talks and Q&A	Chair 1. Tom Allen (Manchester Metropolitan) Speakers: 1. Nick Stone (University of Exeter) 2. Richard Hall (University of Leeds) 3. Mazdak Ghajari (Imperial College London)

17:25–17:45	BREAK		
17:45–18:30	Wotton Suite	**Challenge – Health: Part II** • Panel Discussion (chaired by Calum Williams (University of Exeter) 1. Challenges and opportunities on clinical translation of advanced healthcare technologies. • Wrap-up and summary	1. Rob Hewson (Imperial College London) 2. Olga Kravchenko (Imperial College London) 3. Nick Stone (University of Exeter) 4. Richard Hall (University of Leeds) 5. Mazdak Ghajari (Imperial College London)
18:30–19:00	BREAK		
19:00	‘Street Food’ and posters in the Evelyn Suite		

Wednesday 22nd May 2024

Time	Location	Session	Speaker
9:00–11:00	Wotton Suite	**Challenge – Manufacturing: Part I** • Overview of SIG achievements and Review of the roadmap • Planned Activities for the Manufacturing Challenge • Panel Discussion	**Chairs** 1. Claire Dancer (University of Warwick) **Speakers** 1. Gianluca Memoli (University of Sussex) 2. Mike Sloan (Technical Composite Systems) 3. Jamie Williams (NPL) 4. Matteo Seita (University of Cambridge) 5. Thomas Morgan (University of Warwick)
11:00–11:30	**BREAK**		
11:30–12:30	Wotton Suite	**Challenge – Manufacturing: Part II** • Workshop on planning roadmaps to large scale investments • Wrap-up	**Chair** 1. Claire Dancer (University of Warwick)

12:30–14:00	LUNCH BREAK		
14:00–14:30	Wotton Suite	**Metamaterials and the National Materials Innovation Strategy**	1. Ian Youngs (Dstl and Member of the Materials Innovation Leadership Group)
14:30–16:05	Wotton Suite	**Challenge – Space and Aviation: Part I (Space)** • Introduction • Talks • Roundtables • Feedback and wrap-up	**Chairs** 1. Simon Pope (University of Sheffield) 2. Thomas Bassett (MBDA) **Speakers** 1. Aaakash Bansal (Loughborough University) 2. Iman Mohagheghian(University of Surrey) 3. Fred Claeyssens (University of Sheffield) 4. Stephen Henthorn (University of Sheffield)
16:05–16:30	BREAK		

16:30–17:45	Wotton Suite	**Challenge – Space and Aviation: Part II (Aviation)** • Talks • Panel Discussion • Wrap-up	1. Simon Masters (Future Flight at Innovate UK)
17:45-18:00	Wotton Suite	**Conference Summary & Close**	1. Claire Dancer (University of Warwick) 2. Alastair Hibbins (University of Exeter)
18:00-18:20	**Conference Photograph** *Gather in the Wotton Suite to be guided to the group photo spot*		
18:00–19:00	**BREAK**		
19:30-23:00	**GALA Dinner** **Dinner speaker: Miles Padgett**		

Thursday 23rd May 2024

Time	Location	Session	Speaker
Before 9:00	Check out and settle up by **9:00 am** for all delegates leaving on Thursday.		
09:00-10:30	Wotton Suite	**Aria interactive workshop: developing ideas for climate monitoring**	1. Gemma Bale (ARIA) 2. Sarah Bohndiek (ARIA) 3. Jessica Humphreys (ARIA)
10:30-11:00	BREAK		
11:00-13:00	Wotton Suite	**Metamaterials for Future Telecommunications**	1. TBC
13:00-14:00	LUNCH BREAK		

About the showcase sessions

The technical posters and demonstrators will be allocated a number and correlating spot in the Evelyn room. Poster boards are numbered 1 – 30. **Details will be available via the e-programme.**

Setup: **Monday**: 8:00–9:00; 18:00–18:45; **Tuesday:** 8:00 – 9:00 am, 18:30-19:00

Presentation: **Monday:** 18:45-19:30

Takedown: Tuesday evening at the end of the showcase session

Showcase

First name	Last Name	Title	Board no
Alex	Powell	Shape-morphing metamaterials for electromagnetic applications	
Alfredo	Fantetti	Developing a granular crystal-based experimental technique to monitor friction during vibration	
Anindita	Das	Investigation of the coupling properties between a graded epsilon near-zero medium and a plasmonic antenna array	
Anurag	Roy	Thermotropic Smart Hydrogel for Enhanced Building's thermal comfort while tacking with Climate Change	
Cameron	Gallagher	An Optically Switchable Metasurface for Multi-Band Filtering	
Changxu	Liu	Singular meta-nanoparticles for efficient photocatalytic hydrogen evolution at tri-phase sites	
Daniel	Townend	Metasurface based ultra-compact sensors for facilitating on-machine in-process metrology	
Dongyang	Wang	Topological metamaterial for super-imaging	
Evros	Loukaides	Multistable shells, lattices, and honeycombs	
Felix	Langfeldt	Blocking Low-Frequency Noise Using Thin and Lightweight Acoustic Metamaterial Plates	
Hammad	Ahmed	Optical Metasurfaces for Grafted Perfect Vortex Beams Generation	
Helen	Gleeson	Synthetic Molecular Auxetic Materials	
Hoi Tung	Lam	Textile Graphene and Beeswax Triboelectric Nanogenerator as Self-powered sound detectors and Mechano-acoustic energy harvesters	
Huanling	Zou	Efficient broadband mid-infrared linear-to-circular polarization conversion using a nanorod-based metasurface	
Imran	Bashir		
Jack	Binysh	Non-reciprocal Metamaterials	
Jack	Gartside	magnetic & photonic metamaterials for neuromorphic computing	
James	Capers	Generalising the Yagi-Uda Antenna: Multi-scale inverse design of disordered metamaterials	
Jensen	Li	Programmable metamaterials in optics and acoustics	
Jingchao	Jiang	3D/4D Printing metamaterials	
Joe	Shields	Highly parallel optical computation using phase-change metasurfaces	
Joel	Loh	Near-unity Index Meta-surfaces and Super-Blackbody Meta-surfaces for Effective Absorption of Gas Molecules	
John	Bows	Proposed "Metamaterials in Food" workshop in June 2024	
Joshua	Hamilton	The Radio Frequency Signatures Team: tailored electromagnetic control	
Kai	Sun	Metamaterial-based Optical Solutions for Space	
Maciej	Dabrowski	2D Magnetic Materials	
Mahdi	Bodaghi	4D Printed Metamaterial Boat Fenders with Excellent Recovery and Sustainability Features	
Malte	Peter	Graded arrays for spatial frequency separation and amplification of water waves	
Marc	Smilie	SuperK white light lasers - a powerful tool for material characterization	

Marcello	Ferrara	Nonlinear Photonics with Low-Index Oxides
Mayela	Romero-Gómez	Looking closely: s-SNOM as an interrogation technique of optical modes of Au-based plasmonic metasurfaces
Mingchao	Liu	Dehydration-induced corrugated folding in *Rhapis excelsa* plant leaves
Mitchell	Kenney	Visible-Light Metalenses for Imaging Applications
Muhammad Afnan	Ansari	Variable 3D polarization structures along the optical path
Negar	Gilani	Advancing Metamaterial Manufacturing with Drop-on-demand Molten Metal Jetting
Oliver	Nelson-Dummett	Multimaterial Inkjet Printing for Microwave Metamaterials
Olly	Duncan	Fast optimisation of honeycombs for impact protection
Pooya	Sareh	Hierarchical auxetics designed using a selective hinge removal strategy
Rafael	Fuentes Dominguez	Single- and multi-layer ultra-thin lenses on fibre endoscope probes for advanced imaging technologies
Richard	Moat	A family of hats: Tuneable Poisson's ratio Honeycombs
Richard	Watson	Active Metamaterials for Ultrasonics
Richard	Wiltshaw	Analytical solutions for Bloch waves in resonant phononic crystals
Rox	Middleton	Botanic Photonics: Colour and other optics at the waxy surface
Sarah	Clendinning	A Summary of Geodesic Lens Antennas
Sebastian	Schulz	Image processing for visually impaired athletes
Stephen	Henthorn	Spray-on Microwave Metasurfaces
Stuart	Berrow	Auxetic Liquid Crystal Elastomers: Tailorable Auxetic Behaviour Through Chemical Modification
Thomas	Raistrick	Sub-micron diffractive gratings facilitated by intrinsic deswelling of auxetic liquid crystal elastomers
Thomas	Whittaker	Anisotropic Circularly Polarising Graded Index Lenses for High Gain CP Antennas

TECHNICAL POSTERS & DEMONSTRATORS

2D magnetic metamaterials

Maciej Dabrowski

University of Exeter, Physics and Astronomy

Contact: m.k.dabrowski@exeter.ac.uk

Laser pulses provide one of the fastest means of manipulating electron spins in magnetic compounds and pave the way to ultrafast operation within magnetic recording, quantum computation and spintronics. Here we explore two-dimensional (2D) van der Waals (vdW) magnetic metamaterials for ultrafast control of electron spins down to a single laser pulse. In particular, we demonstrate that heterostructures composed of atomically thin transition metal dichalcogenides (TMDCs) and 2D ferromagnets allow for all-optical switching (AOS) via the spin-dependent interfacial charge transfer on the femtosecond timescale. We also show how to control the rate of heat flow, and hence the magnetization dynamics, induced by an ultrafast laser pulse within the 2D magnets. Finally, we demonstrate how the low thermal conductivity across vdW magnetic layers may be used to obtain magnetic domain memory behaviour, even after exposure to intense laser pulses. Our findings reveal the distinctive role of vdW metamaterials the ultrafast control of heat conduction, spin dynamics and non-volatile memory.

Key words: 2D materials, van dew Waals, magnetic metamaterials, ultrafast, magnetic memory

3D/4D Printing metamaterials

Jingchao Jiang

University of Exeter, Engineering

Contact: J.Jiang2@exeter.ac.uk

I am working on 3D Printing/4D Printing. I am interested in printing metamaterials for various applications including but not limited to optics, acoustics, mechanics, and biomedical engineering. The integration of 3D/4D printing techniques with metamaterial design has emerged as a revolutionary approach, offering unprecedented capabilities in material manipulation and functionality. It can fabricate intricate geometries with high precision, enabling the realization of complex metamaterial structures that were previously unattainable through conventional manufacturing methods. This precise control over material composition and architecture empowers engineers to tailor metamaterial properties, such as negative refractive index, electromagnetic response, and acoustic behaviour, leading to the development of novel functionalities. Please email me at j.jiang2@exeter.ac.uk (Jingchao Jiang).

4D Printed Metamaterial Boat Fenders with Excellent Recovery and Sustainability Features

Mahdi Bodaghi

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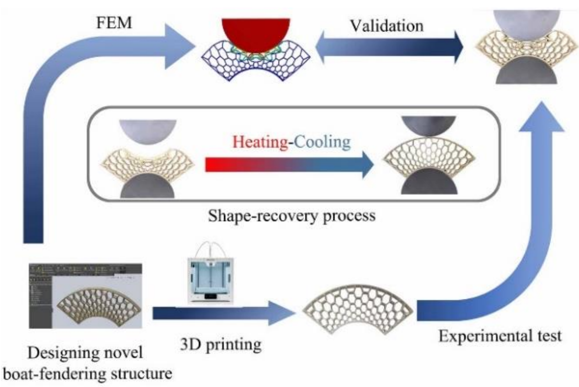
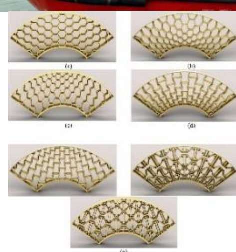
Contact: mahdi.bodaghi@ntu.ac.uk

Maritime transportation safety critically depends on advanced fendering systems capable of effectively absorbing impact energy, thus minimising damage during boat berthing against structures. Conventional solutions often fall short in terms of efficiency and sustainability, highlighting a pressing need for innovative approaches.

Addressing this need, the present study introduces a groundbreaking class of boat fenders that harness the unique properties of active mechanical metamaterials, designed with intricate patterns such as honeycomb, re-entrant, and chiral auxetic configurations. These fenders are fabricated using the 4D printing technique with shape memory polymers, enabling them to demonstrate exceptional energy absorption and dissipation capabilities. Furthermore, they showcase an unparalleled ability to recover their original shape after deformation, a feature rigorously validated through a comprehensive blend of experimental and numerical analyses. This innovative approach not only enhances the performance of boat fenders but also ushers in a new era of sustainability in maritime safety solutions.

Metamaterials are chosen for their ability to offer customised mechanical properties that traditional materials cannot match, enabling the design of boat fenders that excel in energy management. Their unique structure facilitates superior energy absorption and efficient shape recovery, making these fenders not only more effective but also significantly more sustainable by reducing the need for replacements and minimising environmental impact.





Key words: Metamaterials; Shape Memory Polymers; 4D Printing; Sustainability

A Summary of Geodesic Lens Antennas

Sarah Clendinning

KTH Royal Institute of Technology, EMF

Contact: sclendinning@aol.co.uk

Highly directive antennas capable of scanning over a wide angular range are of strong interest for modern applications. In addition to this, it is also desired for antennas to be fully-metallic as they are more suited for communication systems operating on satellites; for radar systems requiring the use of high-power or for systems using high-frequencies as measure to reduce overall losses. A solution capable of addressing all of these interests are geodesic lens antennas. Geodesic lenses are an equivalent to a graded refractive index lens, and operate by confining the propagating wavefront using parallel curved metallic plates thus forcing it to traverse a path that is equivalent to the optical path in the graded index lens. The properties of the lens are dependent on the profile selected, with one of the most useful being the Luneburg lens, where a point source can be transformed to a planar wavefront thus creating a directive beam. As geodesic lens antennas consist only of metallic plates, they can also be considered as fully metallic. This showcase will present a brief summary on various geodesic lenses developed for a range of differing applications.

Key words: Lens antennas, geodesic lenses, fully-metallic

Active Metamaterials for Ultrasonics

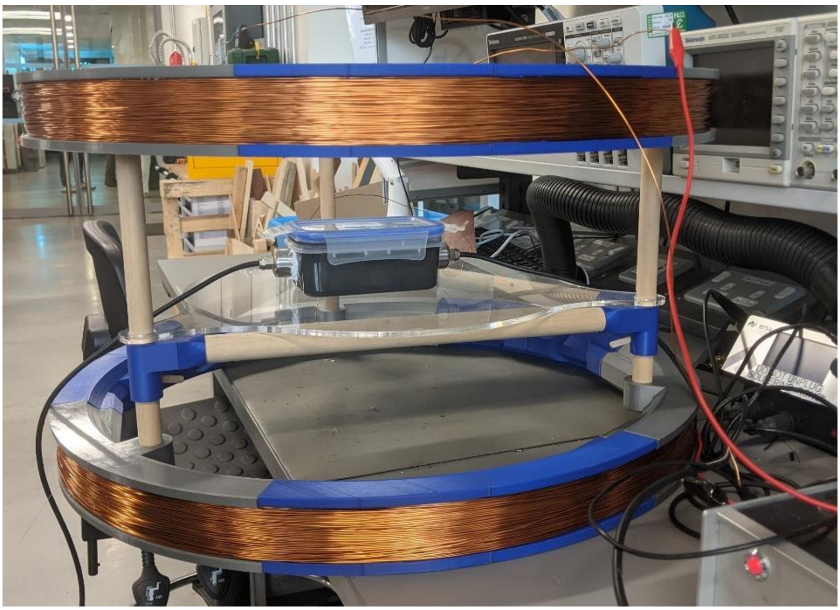
Richard Watson

The University of Warwick, School of Engineering

Contact: Richard Watson

A limitation of individual metamaterial designs are that the resonances are at limited frequencies dependent on their dimensions. Development of active metamaterials through use of active fluids may overcome this design limitation to widen the operational range of a given metamaterial structure. Acoustic metamaterial resonance depends on the interaction between the metamaterial structure and the fluid with which it is surrounded, and which is needed to transmit the acoustic waves. This is controlled by differences in fluid and material acoustic impedances.

Investigations of acoustic properties of active (magnetorheological) materials and development on non-magnetic metamaterial structures is ongoing to allow control of the frequency response of these metamaterials.



Key words: Acoustic metamaterials, Active fluids, Ultrasonics, Magnetorheological fluids

An Optically Switchable Metasurface for Multi-Band Filtering

Cameron Gallagher, Harry Penketh, Ian Hooper and Euan Hendry

University of Exeter: Electromagnetic and Acoustic Metamaterials, Physics

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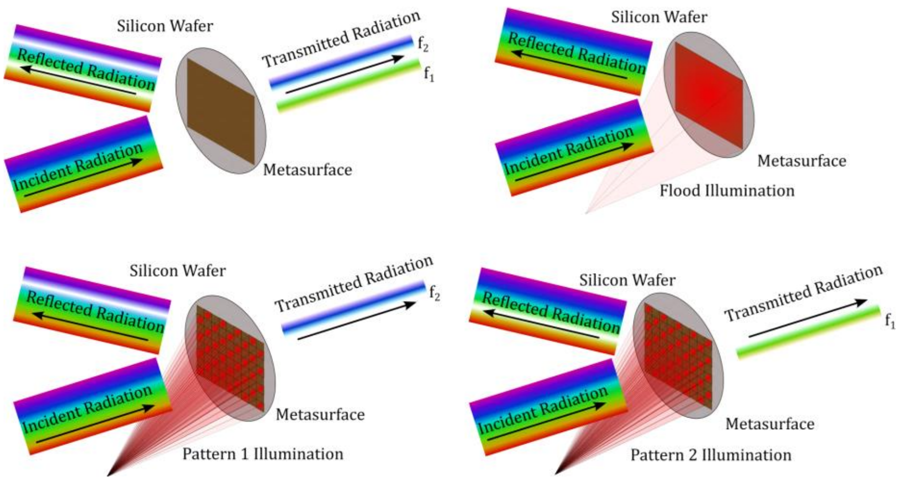
There is a growing need for communications devices that are actively switchable in real-time to allow blocking or modulation of signals at target frequencies. Some tunable metamaterials require moving parts, or electronic components that can ramp up the cost, weight and power consumption of devices. Here we present the use of a microwave metasurface mounted on a silicon wafer to demonstrate the ability to turn transmissive resonances on and off by the flick of a switch using an LED flashlight. A metamaterial is necessary here to provide the frequency selective behaviour that is required for communications devices, and allows a compact, laminar device to be created. There is extra functionality in the metasurface demonstrator as the metasurface actually supports two transmissive modes. This means with careful patterning of the excitation light, one can selectively block one frequency while allowing another to pass.



Key words: Active, Switchable, Metasurface, Frequency selective surfaces, Communications

Advancing Metamaterial Manufacturing with Drop-on-demand Molten Metal Jetting

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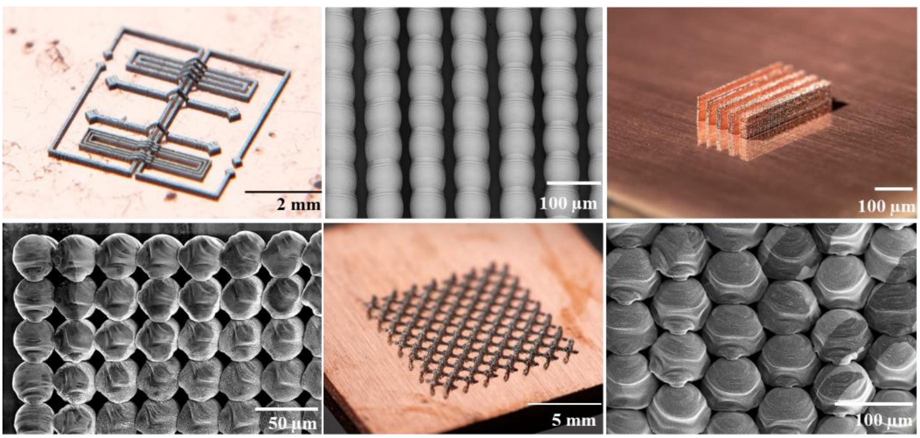
The full potential of metamaterials has yet to be realised due to manufacturing challenges, particularly in achieving precise control over composition, structure, and dimensions. Drop-on-demand Molten Metal Jetting (DoD-MMJ), an emerging additive manufacturing technology, presents a promising solution. Operating by depositing individual droplets of molten metal onto a substrate, DoD-MMJ offers precise control at a voxel-by-voxel level. The first and unique multi-metal jetting platform, MetalJet, is equipped with two printheads, enabling the printing of functional components from at least two different metals in a single operation. MetalJet can produce molten microdroplets (60–90 µm) at temperatures up to 2000°C, facilitating the creation of multi-material components at frequencies up to 2 kHz. Our capability extends to printing tin, indium, silver, and copper on ceramic, polymer, and metallic substrates. MetalJet streamlines the fabrication process and holds promises in advancing thermal and electromagnetic metamaterials, representing a significant leap forward in this research domain.



Analytical solutions for Bloch waves in resonant phononic crystals

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I will discuss the canonical problem of wave scattering by arrays of Neumann inclusions. Firstly, we consider the wavefield to be governed by the Helmholtz equation. We apply the method of matched asymptotic expansions to show how small scatterers can be modelled as singular perturbations to the free space. Analytical expressions then follow in terms of singular Green's functions, from which we construct an eigenvalue problem to consider Floquet-Bloch waves, or we can consider scattering problems as an extension to Foldy's method.

These methods will then be applied in an elastic setting to consider waves propagating through an elastic plate, whose surface is patterned by periodic arrays of elastic beams. Our methodology is versatile and allows us to solve a range of problems regarding arrangements of multiple beams per primitive cell, over Bragg to deep-subwavelength scales. We cross-verify against finite element numerical simulations to gain further confidence in our approach. The accuracy and flexibility of our solutions are demonstrated by engineering topologically non-trivial states, from primitive cells with broken spatial symmetries, following the phononic analogue of the Quantum Valley Hall Effect.

Key words: Floquet-Bloch waves, singular perturbations, metamaterials

Anisotropic Circularly Polarising Graded Index Lenses for High Gain CP Antennas

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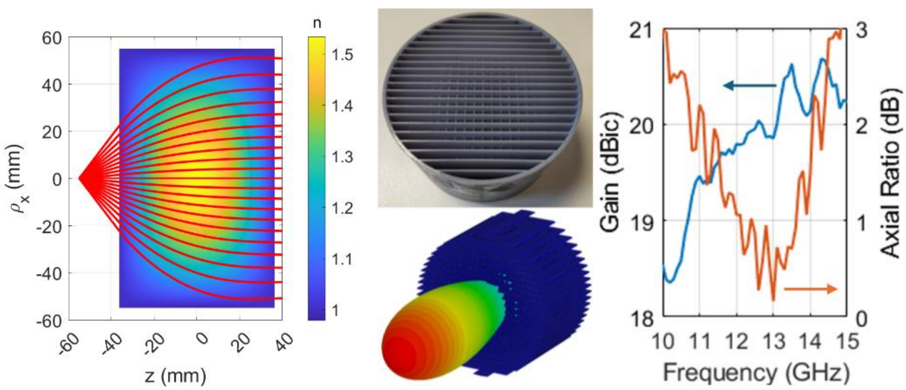
This work presents a multifunctional device which combines the functionality of a lens and a polarisation converter into a single device in order to generate a high gain, circularly polarised beam from a low gain, linearly polarised feed. Anisotropic metamaterials are utilised to create a 90° phase shift between orthogonal wave components. The properties of this multifunctional design are graded all three axes and is only realisable with metamaterials and not by other means. Additive manufacturing methods are used to manufacture the design due to the complex internal geometry. This circularly polarising lens can reduce complexity of the other parts of the design; namely the feed antenna and feeding network, hence reducing cost. Furthermore, cost, size, weight, and material loss reductions are also made by combining the lens and polariser into a single multifunctional device.



Key words: Anisotropy, lens, circular polarisation, Additive Manufacturing

Auxetic Liquid Crystal Elastomers: Tailorable Auxetic Behaviour Through Chemical Modification

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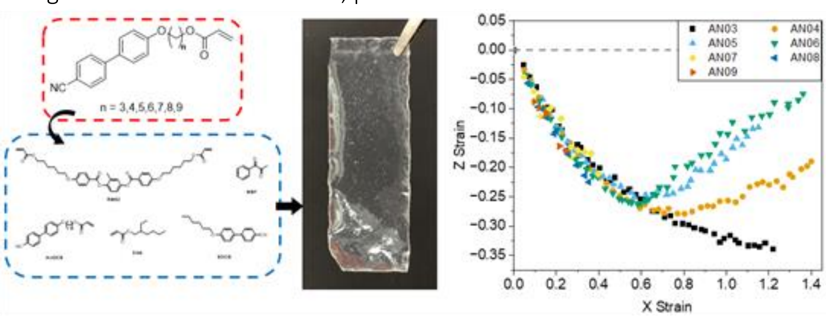
Synthetic molecular auxetic materials are highly sought-after with relevance in applications where impact resistance and delamination resistance are desired. Ideally, these materials have tunable physical properties, a significant auxetic response and are easy to manufacture.

The Leeds Group invented auxetic liquid crystal elastomers in 2018, marking the first non-porous synthetic auxetic material, and has since gained an understanding of the auxetic response occurs. The liquid crystal elastomers are readily synthesised into films through photopolymerisation of commercially available reactive mesogens. The films exhibit strain thresholds beyond which a negative Poisson ratio is observed and values of Poisson Ratio (depending on choice of mesogen) as large as -1.5. The threshold strain can also be tuned by selection of appropriate monomers, yielding a highly tunable auxetic response, with no need to modify fabrication methods. Uniquely, the films are highly transparent.

There are many potential applications of these novel metamaterials, and the invention is seen as an exciting platform technology. Initial target applications are being explored where films of the elastomers can provide impact and delamination resistance, for example in leading edge protection for wind turbines and for displays. These metamaterials offer increased strength, lifetime and efficiency, together with light-weighting in numerous applications. Their transparency could also offer advantages in relative to traditional, porous auxetic materials.



Key words: Liquid crystal elastomers, polymers, auxetic, mechanical metamaterials

Blocking Low-Frequency Noise Using Thin and Lightweight Acoustic Metamaterial Plates

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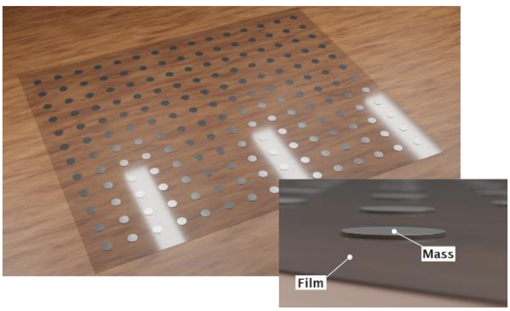
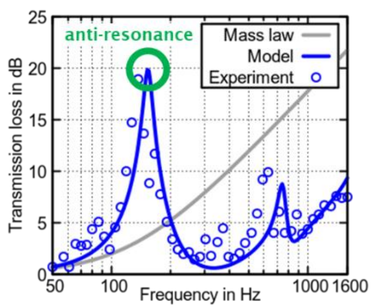
Blocking low-frequency noise is a very challenging task, especially when thin and lightweight structures are required to meet sustainability goals. Conventional noise treatments (e.g. partitions) are limited by the mass-law, which dictates that a doubling of the structure's mass can reduce the noise by just 6 dB

Plate-type acoustic metamaterials (PAM) have recently emerged, offering an outstanding noise reduction performance at low-frequencies that can greatly exceed the mass-law limitations. PAM consist of a thin, flexible baseplate with periodically attached rigid masses. They can be as lightweight as a sheet of paper and still offer frequency bands with sound reduction values that are comparable to that of a more than 20x heavier wall. Possible use cases for PAM are applications involving low-frequency tonal noise and requiring thin & lightweight noise treatments, e.g. in aircraft, cars, or home appliances.





Key words: acoustic metamaterial, plate, noise reduction, low-frequency, sound transmission

Botanic Photonics: Colour and other optics at the waxy surface

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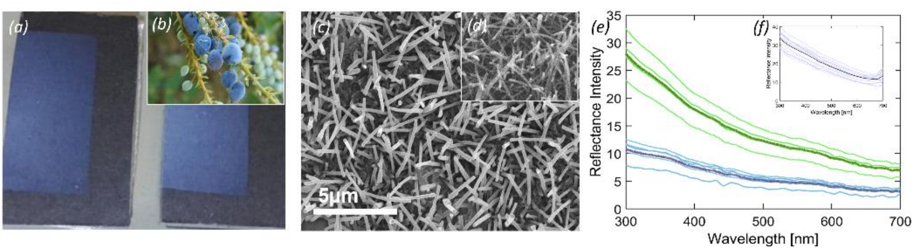
Traditional coloration involves the use of molecular pigments and dyes, these must be specific to the colour, and must be either mined, synthesised or harvested (indigo, spirulina). The replacement of pigments with structural colour presents challenges, but also many advantages. The challenges are that structural colour must be treated very differently to pigment molecules, meaning largescale change in manufacturing. However, the advantages are additional functionality, tuning active self-assembling, self-repairing, self-cleaning, biocompatible, non-absorptive and ultra-thin coatings.

Plant materials suggest a sustainable and evolutionarily tuned design methodology, and as an agricultural waste product, a facile and flexible engineering material. The solution we propose here is the use of scattering wax particles as a colorant and UV-protective coating, in the same way that we have found occurs on fruit skins.

Further, we propose to identify further optical effects that are already produced by plant surface coatings in nature, and to reproduce them in the lab and for use in applications and manufacturing. Routes to this are in the analysis, modelling and reproduction of the myriad epicuticular wax nanostructures that are to be found covering above-ground land-living plant organs.



Photo, SEM and optical reflectance from (a,c,e) Reproduced wax from *Berberis* fruits (b,d,f) untouched natural wax coatings of *Berberis* fruits.

Key words: structural colour, plant biomaterials, multifunctional coating

Dehydration-induced corrugated folding in *Rhapis excelsa* plant leaves

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The remarkable ability for morphogenesis in plant leaves, which yields a diverse spectrum of leaf shapes and shape-morphing behaviours in response to environmental cues, has spurred both scientific exploration and engineering innovations. Despite considerable research into certain modes of plant morphogenesis such as saddle bending, edge rippling, and snap-through instabilities, the mechanisms and principles governing the morphogenesis of extensive diversity of leaf shapes in nature remain elusive. This study presents a thorough investigation integrating experimentation, theoretical analysis, and numerical simulations to unravel the mechanics and mechanisms underlying the corrugated leaf folding induced by differential shrinking in the bamboo palm *Rhapis excelsa*. Through examination of dehydration-induced changes in sectioned leaves, we establish a direct correlation between variations in leaf-folding angle and water loss. Drawing from empirical observations, we devise a generalized mathematical model for the scaling relationship for water loss in sectioned leaves. Moreover, our structural characterization and numerical simulations unveils that corrugated folding induced by dehydration in *R. excelsa* leaves results from the deformation of a specialized structural component which we term the "hinge" cells. Exploiting these insights into the interplay among structure, environmental stimuli, and mechanics, we develop soft biomimetic devices, including a humidity sensor and a morphing "umbrella" capable of reversible folding. The unravelling of corrugated folding mechanisms in *R. excelsa* leaves presented in this study contributes to a broader understanding of the interactions between plant leaves and water and offers inspirations for the design of soft machines.

Key words: Plant morphology, Leaf folding, Dehydration, Biomimetics, Biomechanics

Developing a granular crystal-based experimental technique to monitor friction during vibration

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My Fellowship addresses the long-standing industrial problem of friction modelling in vibrating joints. The aviation sector stands at a pivotal point, with the urgent need to design aero-engines lighter, more flexible and environmentally sustainable to target Net Zero goals. Lighter components lead to increased vibration, which must be accurately predicted to limit unexpected failures. However, vibration modelling is not predictive yet due to the millions of components in contact, whose understanding is limited by a lack of experimental interface data.

My goal is to develop a new experimental technique, and related theory, to monitor friction contacts during vibration. I will use solitary waves, which are mechanical waves that propagate through highly nonlinear media, such as granular crystals. Changes in the solitary wave propagation have been used before for non-destructive evaluation but never to monitor friction contacts. I plan to correlate changes in the solitary wave propagation to the friction properties of sliding contacts, thus developing a new groundbreaking friction monitoring technique.

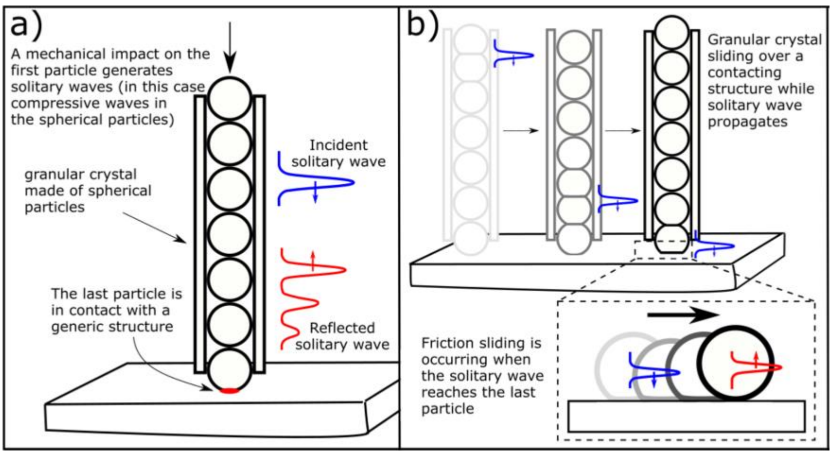

Fig.1. a) granular crystal and solitary wave propagation; b) solitary wave propagation while friction sliding occurs.

Key words: tribology and friction, granular crystals, solitary waves, nonlinear dynamics, vibration, ultrasound, non-destructive evaluation

Efficient broadband mid-infrared linear-to-circular polarization conversion using a nanorod-based metasurface

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Traditional quarter-wave plates have fundamental disadvantages, including bulky size and single operating wavelength. By engineering the structure at a sub-wavelength scale, metasurfaces enable the provision of anisotropic optical properties, operating analogously to natural birefringent materials, while also featuring broadband bandwidths, compactness, low loss, and integration capabilities. Consequently, much research has practically focused on designing metasurfaces as potential replacements for bulk optic components.

Building upon the nanorod-based metasurface design for the terahertz region [1], this design is rescaled, fabricated, and experimentally characterized to convert linearly polarized light to circularly polarized light in reflection with sub-wavelength thickness. Measured reflectivity detects two resonances at 3.4µm and 7.9µm and near-unity reflection within the off-resonance region (4-7µm). Measurements of the Stokes parameters of reflected light confirm circular polarization with an average axial ratio of 0.75 across a broadband from 3.5µm to 7.5µm.

This metasurface is particularly designed to operate in the infrared region of the spectrum, where many important chiral biomolecules have strong vibrational fingerprints; therefore, it has the potential to be used for circular dichroism spectroscopy, allowing the characterization of important chiral molecules.

[1] C. C. Chang, Z. Zhao, D. Li, A. J. Taylor, S. Fan, and H. T. Chen, “Broadband Linear-to-Circular Polarization Conversion Enabled by Birefringent Off-Resonance Reflective Metasurfaces,” Phys. Rev. Lett., vol. 123, no. 23, p. 237401, Dec. 2019.

Key words: mid-infrared metasurface, polarization conversion, Stokes parameters, FTIR

Fast optimisation of honeycombs for impact protection

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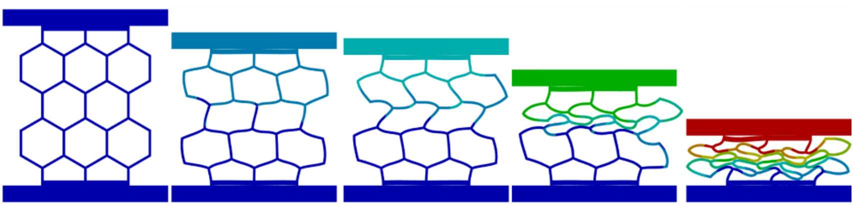
The requirements of equipment that protects people from impacts differs between risk scenario (e.g., loading conditions typically seen in a specific sport, defence, security, or transport application, etc.), and user requirements (e.g., body type, injury threshold, comfort, and accepted levels of restrictions to movement). Mechanical metamaterials show promise to tailor the response of protective equipment to meet user and application specific requirements. Yet, typical structural optimisation tools used to design mechanical metamaterials under the large dynamic deformations seen during impacts become prohibitively expensive for product customisation.

By developing and validating an analytical model for elastomeric honeycombs, that connects their geometry to large deformation, dynamic response, impacts can be analysed on a standard computer in a fraction of a second. As such, the model can be used to optimise honeycomb microstructure for a set of input requirements, returning near-optimal geometries almost instantly. Such a tool could be used near the start of standard numerical optimisation process, to reduce the number of iterations, or to adjust a standard honeycomb (i.e., design for an average user).

These mechanical metamaterials can be quickly tailored between users and applications, improving the limiting trade-off between protection and comfort.



Key words: Healthcare, protective equipment, prosthesis, mechanical metamaterials

Generalising the Yagi-Uda Antenna: Multi-scale inverse design of disordered metamaterials

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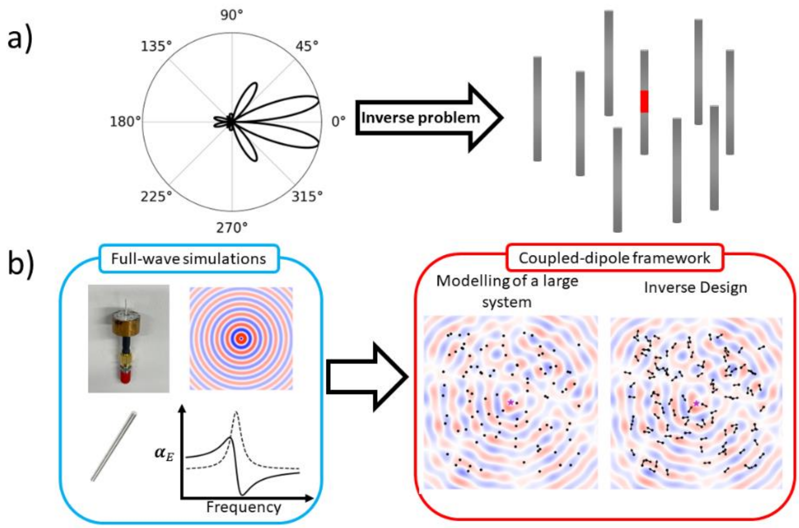
Next generation microwave communications systems face several challenges, particularly from congested communications frequencies and complex propagation environments. We present, and experimentally test, a framework based on the coupled dipole approximation for designing structures composed of a single simple emitter with a passive disordered scattering structure of rods that is optimised to provide a desired radiation pattern. Our numerical method provides an efficient way to model, and then design and test, otherwise inaccessibly large scattering systems.



Key words: Inverse design, antennas

Graded arrays for spatial frequency separation and amplification of water waves

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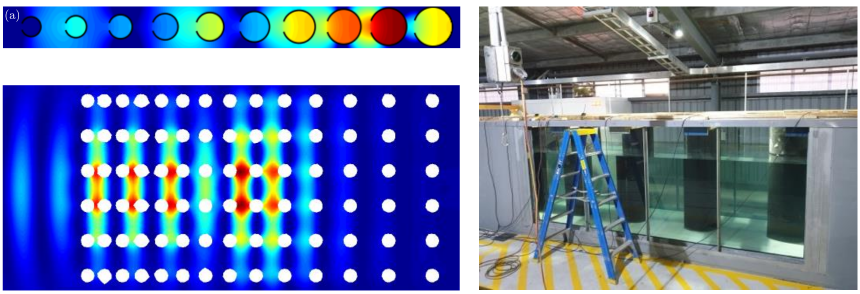
Wave-energy converters extracting energy from ocean waves are known to suffer from poor efficiency. We propose structures capable of substantially amplifying water waves over a broad range of frequencies at selected locations, with the idea of enhanced energy extraction. The structures consist of full or C-shaped bottom-mounted cylinders arranged in one-dimensional or two-dimensional arrays, constituting a metamaterial, with the cylinder properties or the array spacing graded along the array. Transfer-matrix analysis is used to analyse the large amplifications and we also show results from recent wave-flume experiments confirming the amplification phenomenon in practice.



Left: Wave response of two different water-wave metamaterials.
Right: Corresponding experimental setup at the University of Western Australia

Key words: water-wave metamaterial, water-wave-energy amplification, rainbow reflection, chirped arrays

Hierarchical auxetics designed using a selective hinge removal strategy

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Mechanical metamaterials are man-made structures capable of achieving different intended mechanical properties through their artificial, structural design. Specifically, metamaterials with negative Poisson's ratio, known as auxetics, have been of widespread interest to scientists.

It is well-known that some pivotally interconnected polygons exhibit auxetic behaviour. While some hierarchical variations of these structures have been proposed, generalising such structures presents various complexities depending on the initial configuration of their basic module.

Here, we report the development of pivotally interconnected polygons based on even-numbered modules, which, in contrast to odd-numbered ones, are not straightforward to generalize. Particularly, we propose a design method for such assemblies based on the selective removal of rotational hinges, resulting in fully-deployable structures, not achievable with previously known methods. Analytical and numerical analyses are performed to evaluate Poisson's ratio, verified by prototyping and experimentation.

We anticipate this work to be a starting point for the further development of such metamaterials.

Key words: Hierarchical metamaterial, Auxetic, Selective hinge removal, Deployable structure

Highly parallel optical computation using phase-change metasurfaces

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Demand for data and information processing is ever-increasing and therefore more efficient and accelerated ways of computing must be found to limit negative impacts. Phase-change material based optical metasurfaces can be used to produce computational devices that operate at the speed of light, with very little power usage and therefore could be used to overcome the current bottlenecks in technology.

Key words: optical, computing, photonics, metasurface, active, phase-change material

Image processing for visually impaired athletes

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Contact: Sebastian Schulz

Metasurface based optical Image processing for visually impaired athletes Visually impaired athletes often requires support personnel, such as a guide runner. This presents a large barrier to many potential athletes and results in reduced participation rates. The need for support personnel could be reduced through image analysis, e.g. through image processing and object tracking, to ensure that for example a runner or swimmer does not leave their lane. However, real time image processing requires fast computation, which is not convenient to carry during sports activities.

The aim of this project is to create metasurfaces that perform the image processing, e.g. contrast enhancement or edge detection and enhancement to in the future allow a low computation system, e.g. a mobile phone, to perform the remainder of the image processing and then provide feedback to the athlete.

Metasurfaces offer the ability to implement almost arbitrary filter and computation function with high resolution and amplitude and phase control, presenting significant advantages over conventional precision-machined aperture based optical computation. Here we showcase our latest developments in this field and demonstrate their efficacy at performing image processing.

Key words: Photonic metasurface, Sport, Wellness

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Conventional noise attenuation techniques cannot mitigate civil aviation noise. Therefore, the light-weight multi-functional acoustic metamaterials and metasurfaces those have already been proven in room acoustics and noise attenuation are being studied to test their performance in flow and modify their design to be suitable for aeronautical applications.

The work considers the development and re-formulation of existing techniques to incorporate the aeroacoustic environment and to validate results with experimental data. To achieve this, a 3D Boundary Element Method being developed, which is a standard collection technique that can optionally use the Taylor transformation and Fast Multipole Method library to simulate aero-acoustic problems. The metamaterials are being implemented as an impedance patch, by extracting the characteristic parameters. Non-local boundary conditions are being implemented in 3DBEM, which hales a significant leap in development of simulation method. This will allow a complete implementation of metamaterial as a non-locally reacting impedance patch in aero-acoustic environment. Initial experiments have been carried out inside windtunnel, which show reasonable agreement with 3DBEM predictions.

This work is being extended to a wider range of acoustic metamaterials and metasurfaces in order to enhance the controllability and tunability of sound propagation over wide frequency bands in aeroacoustic environments.

Image (if applicable)

Key words: aeroacoustic, 3D Boundary Element Method, metamaterials

Investigation of the coupling properties between a graded epsilon near-zero medium and a plasmonic antenna array

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The study investigates the interaction between epsilon-near-zero (ENZ) materials, particularly transparent conducting oxides (TCOs) like indium tin oxide (ITO), and plasmonic nanoantennas. In a thin film geometry, the long-range surface plasmon polariton mode of the ENZ film modifies in a manner that it has a very strong localised longitudinal field component within the film. This mode can strongly couple to plasmonic antenna arrays fabricated on top of such ENZ thin films, resulting in a resonance splitting/pinning to the ENZ wavelength, which results in intense field confinement inside the ENZ film and creates a highly nonlinear metasurface platform. Graded ENZ films, where permittivity varies throughout the film thickness, show stronger coupling and resonance pinning compared to non-graded films. A significant improvement in coupling strength is observed. This highlights the potential of using grading layers with effective permittivity values to enhance the understanding and engineering of hybrid ENZ metasurface systems. Our hybrid plasmonic-graded ENZ Metasurface offers an efficient nonlinear optical platform.

Key words: Effective permittivity, Hybrid plasmonic-graded ENZ Metasurface, transparent conducting oxides

Looking closely: s-SNOM as an interrogation technique of optical modes of Au-based plasmonic metasurfaces

Mayela Romero-Gómez[1,*], Toby Severs-Millard[1,3], Tom Vicent[1,2], Xiaofei Xiao[3], Nathaniel J. Huáng[1], Chris Philips[3], Rupert Oulton[3] and Olga Kazakova[1,†]

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Electromagnetic metamaterials and metasurfaces have emerged as the tools of choice to address several challenges in many areas of research. Their efficient performance strongly depends on the structural uniformity and composition purity, at the nanoscale, especially when the exploitation of induced local effects, such as non-linear optical responses, is desired for specific applications.

Generally, far-field optical responses, and numerical simulations of optical cross-sections help to elucidate the resonant frequencies, and optical modes distribution in the near-field, for an ideal scenario. Nevertheless, to establish a complete picture on experimentally obtained arrays, the accurate characterisation of the locally induced response is crucial, not only to track the evolution of induced modes under illumination and polarisation variations, but also to assess their performance. This can be achieved by implementing scattering scanning near field optical microscopy (s-SNOM), a technique that has been rapidly developed during the past few decades to allow for apertureless-SNOM measurements, in both reflection and transmission modes.

In this work we discuss general aspects of SNOM technique, and present as a case of study the near-field optical characterisation, in the mid-IR, of a gold-based plasmonic metasurface, under both s-SNOM modes. The obtained amplitude and phase maps, reveal the most suitable configuration to achieve a full characterisation of the polarisation state of the near-fields in the metasurface, as compared with numerical simulations.

Key words: Plasmonic Metasurface, Near-field characterisation, SNOM technique

Magnetic & photonic metamaterials for neuromorphic computing

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Conventional computer hardware for AI (CPU/GPU) is power hungry, inefficient and nothing like the brain. We urgently need new hardware paradigms for the next 50 years of computation, especially systems that can efficiently run machine learning.

We can engineer metamaterials that naturally embody the processing ability and interconnected architecture of neural networks. By doing this, we can leverage the complex physical dynamics of metamaterials to efficiently provide intelligent processing.

We need to be able to tune the physical dynamics to match the challenges of different processing tasks, and fabricate single devices that contain a range of dynamics.

Doing this using different materials is extremely hard, and depositing a wide variety of materials in the same device is industrially unscaleable.
Metamaterials allow us to use a single material, single deposition step, but access a huge variety of dynamics via engineering diverse metamaterial architectures.

Key words: Neuromorphic computing, Machine Learning, Low-loss electronics, beyond-Moore computing, artificial intelligence, photonics, magnetism

Metamaterial-based Optical Solutions for Space

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Our team has strong design and manufacture capabilities through one of the most advanced cleanroom facilities in the UK. This includes highest quality material growth through techniques, e.g. reactive sputter deposition, CVD, atomic layer deposition (ALD) as well as lithography techniques including a JEOL JBX-8100FS 200 kV e-beam lithography and a production-ready 8-inch Nikon NSR-S204B deep-UV scanning lithography. We have been working on the design, fabrication, and characterisations of various EO devices/coating solutions including tailored infrared emissivity control metasurfaces (Al:ZnO), smart thermal control coatings using phase-change materials (W:VO_2), and wafer-scale infrared meta-optics (Metalenses) on 8-inch substrate using DUV. We are interested in building collaborations on Electro-optical coatings for space thermal management and metaoptic solutions (Infrared Metalens) for space.

Key words: Metasurface, OSR, Thermal management, Metalens, Metaoptics

Metasurface based ultra-compact sensors for facilitating on-machine in-process metrology

D.J. Townend, J.H.-T. Chan, J. Kendrick, P. Yang, J. Williamson, D. Tang, N. Sharma, A.J. Henning, H. Martin, F. Gao, P. Scott, X. Jiang.

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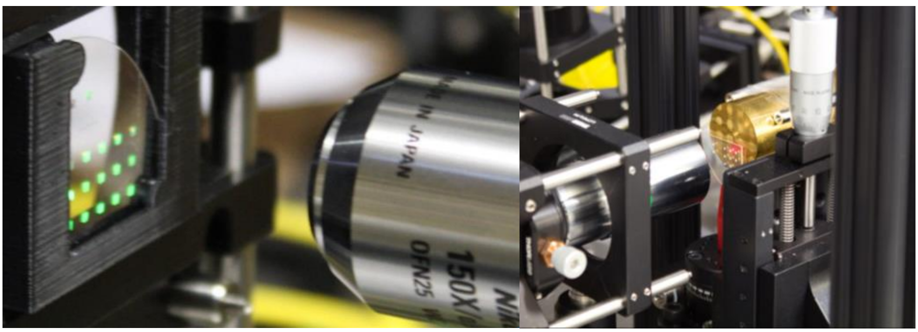
There is a drive to deploy more smart and autonomous processes within manufacturing to improve the production of elements, making them 'right first-time, every-time' and thus minimising scrappage, saving energy and time, and reducing costs. This can only be achieved through the proliferation of sensors throughout the manufacturing chain, integrating them in such a manner to allow them to provide the required feedback in real time to adapt ongoing processes. Current optical instrumentation is not suited for such tasks, having too much bulk and weight. Metasurfaces offer a path by which the required optical manipulations can be realised in a few ultra-compact and lightweight elements, allowing a step-change the form of optical instrumentation to be realised. Here we demonstrate the progress that we have made in developing several ultra-compact and lightweight sensors for just such applications as an initial step to overcome these issues [1].



A picture of two sections of sapphire wafer containing our metasurface elements mounted in two different experimental setups. The left image is taken from our metasurface chromatic confocal probe setup *[2,3]*, and the image on the right is taken from our metasurface confocal setup where it is being used to take a surface measurement *[4]*.

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Key words: Metasurfaces, Metrology, Sensors, Manufacturing

Multimaterial Inkjet Printing For Microwave Metamaterials

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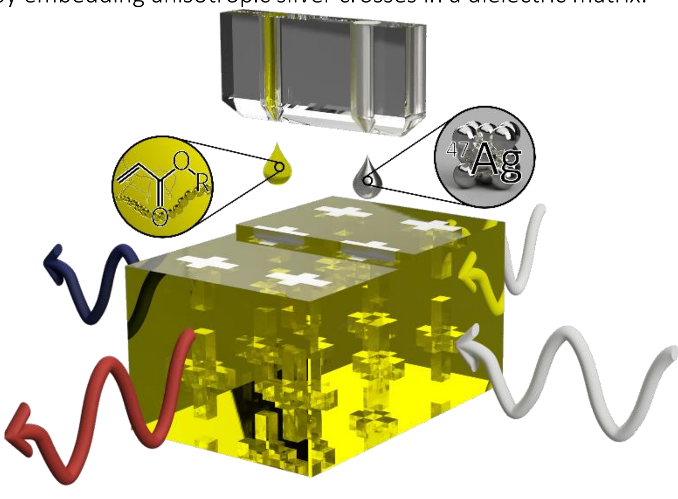
Additive manufacturing (AM) is an ideal technique for metamaterials, with its ability to vary the geometry of any part quickly and easily, as well as produce shapes that can't be made traditionally. Inkjet printing is an AM technique which can accurately deposit a wide range of materials, from polymers to metals and even ceramics. We are using a silver nanoparticle ink to create novel self-supporting, overhanging pillars with a diameter of 40 µm, which can form the basis of complex designs, such as lattices, photonic crystals arrays, and helices. They can be combined with a supportive polymer matrix to increase the dielectric contrast and also allow for floating elements. The feature-size is ideal for frequencies around the top end of the microwave regime and below, and we have produced a design for a tailorable dielectric by embedding anisotropic silver crosses in a dielectric matrix.



Key words: Inkjet printing; additive manufacturing; multimaterial; anisotropic dielectric; microwaves

Multistable shells, lattices, and honeycombs

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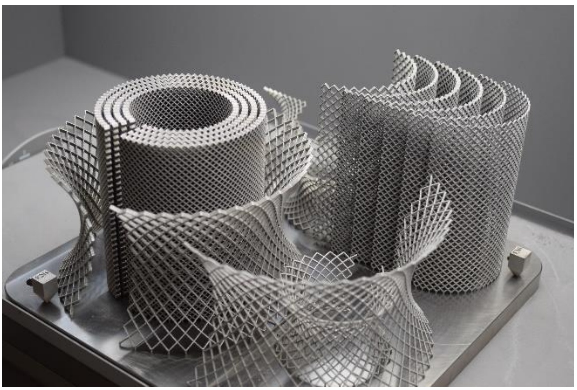
Multistability is inherently present in some shell geometries, such as spherical shells, but it can also be induced in diverse geometries by anisotropy and prestressing. These fundamental topics and their potential to enable new mechanical products have been a subject of research for several decades now, but several open questions remain, including consideration for freeform geometries, boundary conditions, different material systems and scalable manufacturing. The nature and challenges of this category of structures are illustrated through some demonstrators including everyday items and purpose-built lab prototypes.



Further to the underlying mechanics of these structures, I have a wider interest and expertise in sustainable manufacturing. Although additive manufacturing serves us well at lab scale, manufacturing mechanical metamaterials at scale requires alternative methods to be developed.

Key words: multistable structures, AM, forming processes

Near-unity Index Meta-surfaces and Super-Blackbody Meta-surfaces for Effective Absorption of Gas Molecules

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Metal-based photo-absorbing metamaterials can achieve electromagnetic field amplification and broadband absorption throughout the visible spectrum by reaching an effective refractive index similar to that of air. For instance, a ZnO/Cu metamaterial surface comprising periodically arranged nano-cubes demonstrates near-perfect 97% absorption from 350 to 650 nm. By having an index below 1, the plasmonic electric field expands to the entire visible spectrum, which enhances light-to-dark adsorption of CO_2 gas and with angular invariance. Fourier Transform Infrared Spectroscopy reveals additional intermediate species, suggesting new adsorption and reaction pathways.

Similarly, thermal metamaterials made of metal and dielectric materials can exceed the blackbody limit in near-field radiation intensity due to their large effective absorption cross-section. We designed and compared narrow and broader peak-emitting metamaterials for infrared radiation, finding the broader peak-emitting metamaterial to have higher near-field radiation intensity. In-situ Fourier-Transform Infrared Spectroscopy and atomic simulations confirm the enhanced gas absorption due to CO_2 activation energy barrier decrease to 0 eV. These results emphasize the need for combined electromagnetic, atomic, and experimental approaches to study metamaterial-gas interactions.

Non-reciprocal Metamaterials

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Non-reciprocal interactions in active solids yield elastic moduli forbidden in equilibrium. These odd moduli offer a bottom-up approach to designing autonomous materials that spontaneously crawl, roll or swim. However, current schemes for designing odd materials are typically overactuated, using excessively many active elements.

Here we show that odd moduli emerge in a broad range of robotic metamaterials made of non-reciprocal springs. However, the strength of odd response strongly depends on the precise lattice geometry. Hyperstatic lattices are needlessly hard to actuate, leading to sub-optimal odd response. By contrast, we find that in overly floppy lattices, zero modes couple to microscopic non-reciprocity, destroying odd moduli entirely. By avoiding these pitfalls, we identify optimal design principles for building odd lattices.

Our robotic metamaterials offer a proof of principle for efficient engineering of odd lattices, opening the door to experimental realisations that truly probe the continuum dynamics of active solids.

Key words: Non-reciprocity, Odd Elasticity, Robotic Matter, Active Mechanical Metamaterials

Nonlinear Photonics with Low-Index Oxides

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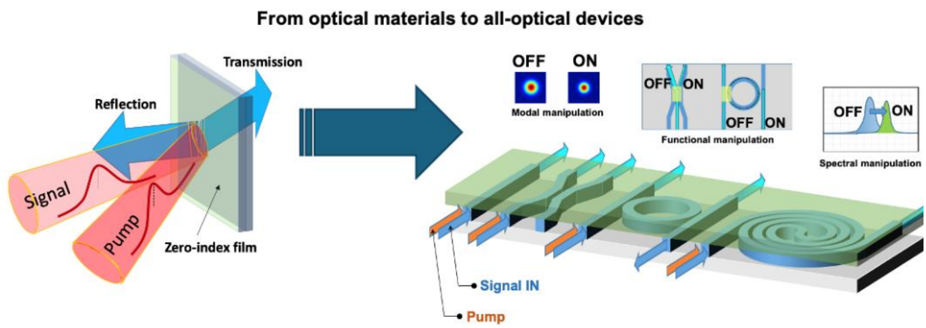
The problem: to find a CMOS compatible material exhibiting strong and efficient optical nonlinearities for the fabrication of all-optical ultra-fast devices. The solution: recently transparent conducting oxides (TCOs) have been demonstrated to be extremely nonlinear in the spectral region where their refractive index approaches zero. This is due to a slow-light effect that enhances material nonlinear properties. Why using our materials: Research in conductive oxide nonlinear optics has grown rapidly, with numerous experiments showcasing remarkable effects like unitary index change, bandwidth-large frequency shift, efficient ultra-low-power frequency conversion, etc. Our work develops around TCOs' foreseeable role in future all-optical integrated systems.



Key words: all-optical devices, ultra-fast optics, integrated photonics

Optical Metasurfaces for Grafted Perfect Vortex Beams Generation

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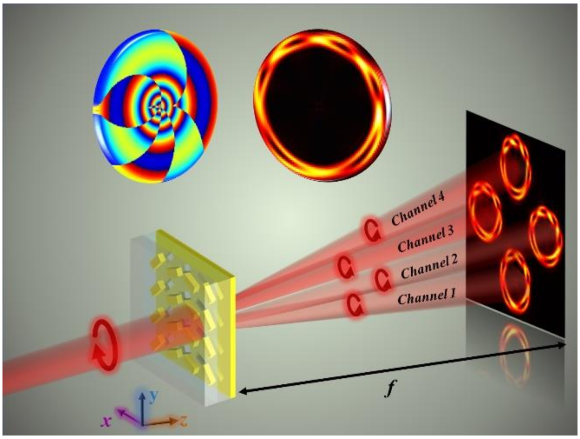
An optical vortex (OV) beam exhibits a helical wavefront due to its spiral phase profile, typically containing only one topological charge. Inspired by plant grafting, where a portion of one plant (scion) is placed on another plant (rootstock), grafted vortex beams (GVBs) can be formed by combining two or more helical phase profiles of OVs. However, current experimental setups are complex, requiring numerous optical components such as spatial light modulators, lenses, pinhole filters, polarizers, and dichroic mirrors. This complexity results in large space requirements and high costs. In this work, I present recent advancements in the generation and manipulation of GVBs using optical metasurfaces (Ahmed et al., Advanced Materials, 34, 2022; Ahmed et al., Nature Communications, 14, 2023). We envision that this work will inspire the development of an ultra-thin and compact platform capable of performing sophisticated tasks that are challenging or impossible with conventional optics. These advancements could open opportunities for studying and applying GVBs across various fields, including quantum science, data communication, and particle manipulation.



Key words: Optical Metasurface, Optical vortex beams, Grafted vortex beams

Programmable metamaterials in optics and acoustics

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Recently, the gain-loss contrast and the temporal modulation of material parameters are being added as new dimensions of metamaterials. Our group is working on various platforms to have programmable control along these lines. In acoustics, by using virtualized meta-atoms, acoustic active media with time-varying capabilities can be realised with microcontrollers to control all the elements of the constitutive matrix to obtain Willis coupling and also a temporal effective medium. In electromagnetics, we can use reconfigurable metasurfaces to achieve time-varying orbital angular momentum in the microwave regime, while a combination of a spatial light modulator and metasurface can be used to achieve programmable quantum algorithms. My group is looking forward to using these programmable platforms to further control non-reciprocal wave propagation and the generation of entangled states.

Key words: active metamaterials, time-varying metamaterials, quantum metasurfaces, programmable materials

Proposed "Metamaterials in Food" workshop in June 2024

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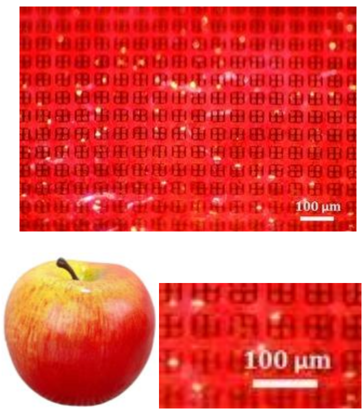
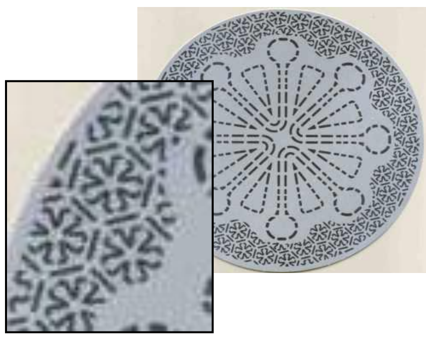
Metamaterials and metasurfaces present promising solutions to an extraordinarily wide array of enduring challenges within the food industry. They introduce innovative methods for altering mouthfeel sensory experiences, non-invasive content monitoring through to improving food processing capabilities.

Yet, the full potential of this field remains largely untapped. This workshop event is designed to unite researchers and industry professionals to address sector-specific needs and explore the solutions that metamaterials can provide. By pooling expertise, we aim to tackle significant challenges together.



Edible silk-based metamaterial probe for monitoring food quality
https://silklab.engineering.tufts.edu/



6 micron thick Aluminium metasurface for crisping pizza

Key words: metasurface, food, beverage, flavour, colour, aroma, texture, quality

Shape-morphing metamaterials for electromagnetic applications

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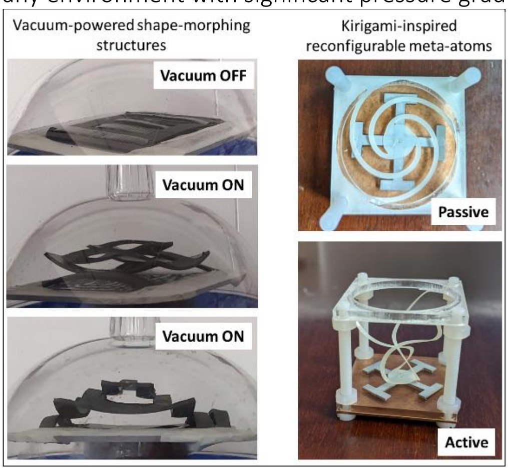
Most electromagnetic metamaterials are tuned electrically, through actively switching each element in an array. Whilst these devices can achieve high versatility and fast switching speeds, the tuning components add loss, and add cost during both production and operation. Mechanical tuning can reduce loss and power consumption (at the expense of speed), but the range of reconfigurability for mechanically actuated arrays to date has been limited.

Shape-morphing materials can be defined as structures which dramatically alter their shapes in a controlled manner in response to a simple stimulus, such as a pull along one axis, or a change in their environmental conditions. In this work, we propose the combination of shape-morphing metamaterials with electromagnetic arrays and devices. Firstly, we show that utilising shape-morphing concepts can greatly expand the range of possible electromagnetic behaviours mechanically tunable reflectarrays can achieve. Secondly, we demonstrate a novel type of shape-morphing material that reconfigures its shape in response to changing ambient pressure, and could be applied to deploying components in space, underwater, or in any environment with significant pressure gradients.



Key words: electromagnetic, microwave, shape-morphing, reconfigurable, reflectarray, antenna, space, underwater, subsea

Single- and multi-layer ultra-thin lenses on fibre endoscope probes for advanced imaging technologies

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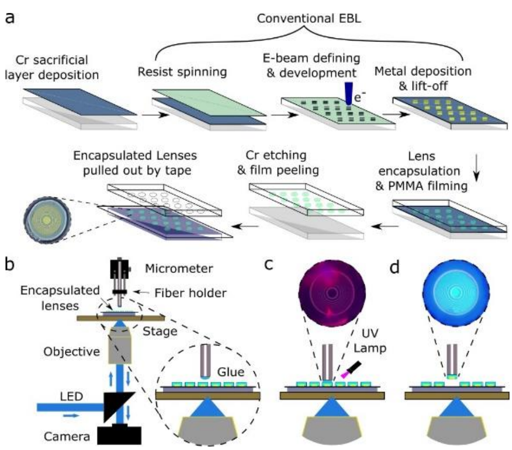
Hair-thin fibre endoscopes are creating new paradigms for biological imaging applications with minimal invasiveness and sub-cellular resolution. To properly perform functionalities desired by various imaging applications, fibre endoscopes may require on-tip light-shaping structures to manipulate the light flow. This can be achieved by fabricating 2D planar optics with sub-wavelength thickness, which can be designed with nano- and micro-scale structures that enable spatial control of amplitude, phase and polarization with subwavelength resolution.

Here, we present a novel method to fabricate single- and multi-layer ultra-thin lenses on optical fibres, which is transfer bonding pre-fabricated patterns onto fibre facets. As a proof-of-principle, we bond Fresnel zone plates, diffractive axicons and double-layer Fresnel zone plates onto optical fibre facets shaping output light with versatile depth-of-fields



Singular meta-nanoparticles for efficient photocatalytic hydrogen evolution at tri-phase sites

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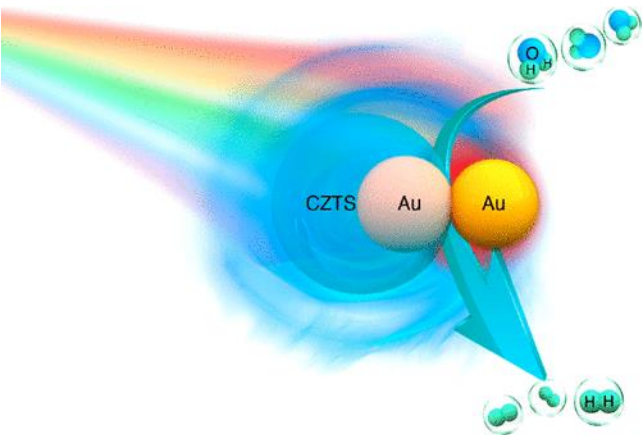
Inspired by transformation optics, we propose a new concept for plasmonic photocatalysis by creating a novel hybrid nanostructure with a plasmonic singularity. Our geometry enables broad and strong spectral light harvesting at the active site of a nearby semiconductor where the chemical reaction occurs. A proof-of-concept nanostructure comprising Cu2ZnSnS4 (CZTS) and Au–Au dimer is fabricated via a colloidal strategy combining templating and seeded growth. On the basis of numerical and experimental results of different related hybrid nanostructures, we show that both the sharpness of the singular feature and the relative position to the reactive site play a pivotal role in optimizing photocatalytic activity. Compared with bare CZTS, the hybrid nanostructure exhibits an enhancement of the photocatalytic hydrogen evolution rate by up to ∼9 times.



Key words: transformation optics, photocatalysis, plasmonics

Spray-on Microwave Metasurfaces

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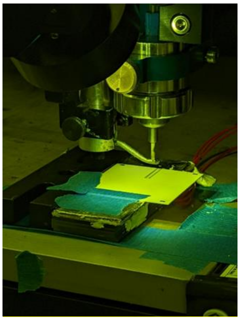
Additive manufacturing has enabled new structures of microwave metasurfaces to be fabricated for conformable and flexible applications. However, additive manufacturing of reconfigurable surfaces remains a challenge, due to the difficulty of integrating electronic devices or tuneable materials into structures.

This poster introduces how Aerosol Jet Printing technology allows reconfigurable electromagnetic materials and devices to be fabricated directly onto a platform in a process similar to "painting on" the capability, even if the surface is conformal or rough. As such, metasurfaces can be sprayed onto a vast array of platforms, vehicles or even buildings. Utilising polymer dispersed liquid crystals, the reconfigurable capability can be included in the same spray-on process as the rest of the material fabrication.



Key words: Microwave, fabrication, additive manufacturing, reconfigurable, active

Sub-micron diffractive gratings facilitated by intrinsic deswelling of auxetic liquid crystal elastomers

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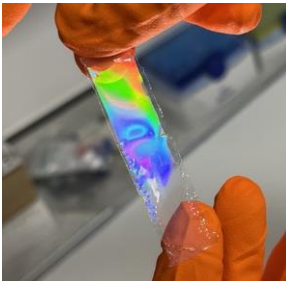

LCE displaying diffraction colour.

Due to the growing demand for flexible optical and electrical devices there is an increased need for flexible and sub-micron diffractive optical elements. [1] Liquid crystal elastomers (LCEs) are flexible, lightly cross-linked polymeric materials that contain mesogenic units within their network. The combination of viscoelasticity, liquid crystal order, and anisotropic physical properties leads to some remarkable behaviours such as stress-optical coupling, soft elasticity, auxeticity, and large deformations to various external stimuli. [2-3] Due to their dramatic stimuli-responsive nature, LCEs are ideal candidates as highly-tuneable optical devices for sensing, display, spectroscopy, and beam steering applications. [4,5] In addition to these, LCE display anisotropic swelling properties. [6] Here we take advantage of the intrinsic deswelling property of liquid crystal elastomers to produced sub-micron (707 nm) tuneable diffraction gratings by patterning with a commercially available micron-scale surface relief grating (1040 nm). Here, we demonstrate, via AFM and diffraction measurements, a thermal pitch tunability of +212 nm (+31%) or -322 nm (-33%) over a temperature range of 215°C depending on grating orientation. The liquid crystal elastomer selected shows an auxetic response when strained. We demonstrate that, due to its auxetic nature, the height of the diffraction grating is preserved under strains up-to 167%.

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Key words: diffractive optical elements, auxetics, deformable optics.

SuperK white light lasers - a powerful tool for material characterization

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The SuperK series is an industry-leading range of turn-key supercontinuum white light lasers used by the most innovative companies within bio-imaging, semiconductor inspection, sorting, device characterization, and scientific instrumentation. The sources are robust and reliable, built for intensive use, and can replace multiple single-line lasers as well as broadband sources like ASE sources, SLEDs and lamps.

The SuperK supercontinuum laser can give you light anywhere in the 390-2400 nm region, tunable or broadband, making it a great tool for the optical characterization of nanostructures. Many researchers around the World use the SuperK for measurements of nanoparticles, plasmonic waveguides, metamaterials, and other small structures.

The lasers are compatible with various characterization techniques like Raman spectroscopy, Brillouin light scattering spectroscopy, spectroscopic ellipsometry, SNOM, and s-SNOM which replace single-line lasers and traditional broadband sources.

NKT Photonics

Key words: Optical Characterization, Tunable laser

Synthetic molecular auxetic materials

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1. Synthetic molecular auxetic materials are highly sought-after with relevance in applications where impact resistance and delamination resistance are desired. They are also suggested as acoustic metamaterials. Ideally, these materials have tunable physical properties, a significant auxetic response and are easy to manufacture.

2. The Leeds Group invented auxetic liquid crystal elastomers in 2018 and has since shown that they can be highly tuned. We have also begun to explore the applications of auxetic liquid crystal elastomers. The liquid crystal elastomers are readily synthesised into films through photopolymerisation of commercially-available reactive mesogens. The films exhibit tunable strain thresholds beyond which a negative Poisson ratio is observed and values of Poisson Ratio (depending on choice of mesogen) as large as -1.5. Uniquely, the films are highly transparent and can be also be strong adhesives in their own right. Their potential as acoustic metamaterials is also beginning to emerge.

3. There are many potential applications of these novel metamaterials, and the invention is seen as an exciting platform technology. Initial target applications are being explored where films of the elastomers can provide impact and delamination resistance, for example in leading edge protection for wind turbines and for displays. These metamaterials offer increased strength, lifetime and efficiency, together with light-weighting in numerous applications.

Key words: Synthetic molecular auxetic; liquid crystal elastomer

Textile Graphene and Beeswax Triboelectric Nanogenerator as Self-powered sound detectors and Mechano-acoustic energy harvesters

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Revolutionary advancements in various technologies, from healthcare to environmental sciences and beyond, are increasingly harnessing the power of novel self-powered sensors integrated into textiles. Incorporating triboelectric nanogenerators (TENG) into textiles can harness the abundant energy from human movement and environmental interactions, presenting a sustainable solution for self-powered wearable electronics. Building on this potential, my research details the development of an innovative beeswax-based textile-integrated TENG designed for efficiency and durability. This device can convert environmental acoustic energies into electrical energy, demonstrating a flexible, mechanically robust, and effective energy output.

Developed with eco-friendly materials, the device features a beeswax-based triboelectric layer and a graphene electrode. The self-healing properties of beeswax enables efficient harvesting of acoustic pollution, low-frequency ground-borne and conversational sounds even in extreme conditions, including high levels of humidity and mechanical bending. Moreover, I demonstrate its potential as sensitive self-powered microphones and for applications in voice recognition and emotion detection. Finally, I showcase their applications as an acoustic hybrid energy harvester, capable of converting acoustic pollution and mechanical vibrations into practical electrical energy. The findings here paves the way for exciting advancements in energy harvesting, sound detection, and environmental monitoring, contributing to the scientific community's ongoing pursuit of innovative energy solutions.

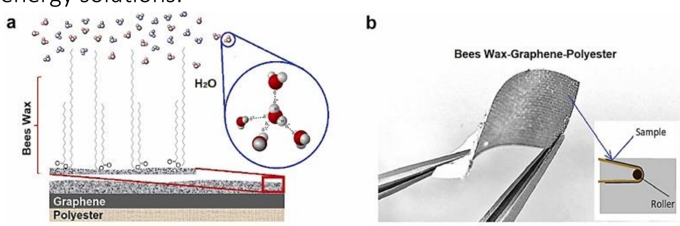

Figure 1: (a) Schematic of a beeswax tribolayer against a humid environment. (b) Digital image of a bent MLG-based electrode on polyester coated with beeswax

Key words: Self-powered, triboelectric nanogenerators, energy harvester, acoustic sensor

Thermotropic Smart Hydrogel for Enhanced Building's thermal comfort while tacking with Climate Change

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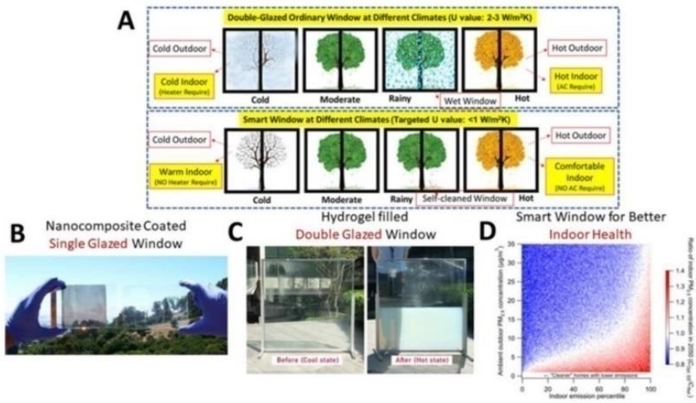
Improving the energy efficiency of buildings has a direct positive impact on indoor air quality and public health. These advancements underscore the significance of ambitious yet practical upgrades in building energy efficiency. In response to the challenges posed by climate change, a crucial strategy to mitigate extreme temperature fluctuations involves reducing solar heat intake through building windows. The intriguing physiochemical attributes, distinctive porous structural framework, water-absorptive characteristics, biocompatibility, and thermoregulatory phenomena associated with water content within biocompatible hydrogel metamaterial networks make them highly appealing materials for constructing energy-positive architectural elements. These elements aim to enhance human comfort and address climate change challenges. In this study, we have synthesized transparent hydrogel suitable for integration within a double-glazed window configuration, enabling effective thermal management within indoor environments. This innovation allows for up to a 30°C temperature difference amidst high external temperatures, contributing to energy-positive building designs.



A- Concept of smart window compared to Traditional Window.
B - Smart window as a single glazed unit developed through nanocomposite coating.
C- Smart window as a double glazed unit developed through hydrogel-based filling.
D- Simulation study to predict indoor air-quality while emplacement of smart windows.

Key words: Building, Hydrogel, Energy Savings, Cellulose, Sustainable Materials, Thermal

The Radio Frequency Signatures Team: tailored electromagnetic control

Joshua Hamilton, Dean Patient, Simon Berry

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The RF Signatures team comprises theoreticians, modellers and experimentalist who specialise in the characterisation, design, integration and optimisation of RF materials and systems. The team is experienced in the development and characterisation of innovative electromagnetic (EM) propagation and scattering control solutions across a number of different industries, both within the defence community and commercially. The team and the facilities that they manage are part of a best-of-breed UK capability in the EM design and characterisation of materials, primarily based at Farnborough. We have close working relationships with various industrial and academic partners and collaborate with a wide variety of commercial and governmental organisations, both in the UK and abroad.

Key words: Radio Frequency Signatures, Tailored electromagnetic scattering

Topological metamaterial for super-imaging

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Topological photonics has opened new windows for achieving electromagnetic wave control, however, less effort has been devoted to the study of optical imaging with topological materials. Here we report the results on the subwavelength imaging with topological metamaterials. Benefiting from the freedom in metamaterials design, the topological surface-state-arcs are tuned to be flat and then utilized to collect the sub-diffractional-limit information.

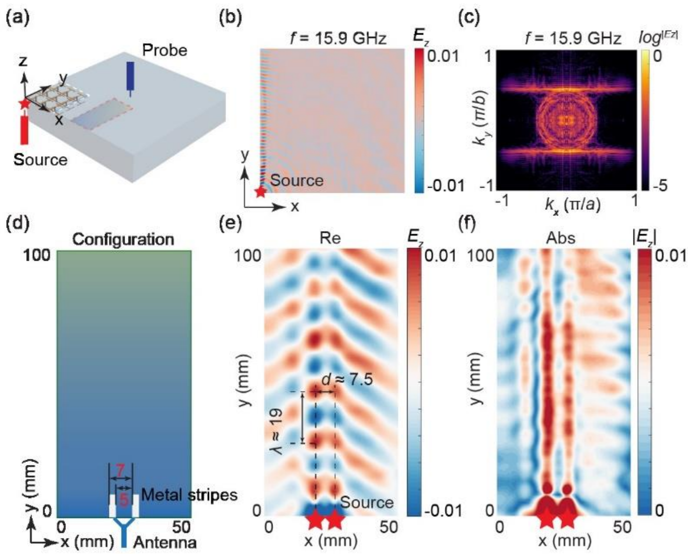

FIG. 1. Superimaging with topological Fermi arcs. (a) Schematic of the metacrystal for measurement. (b) Measured E_z field pattern with excitation from corner. (c) The experimentally retrieved flat EFCs of the surface wave at 15.9 GHz. (d) Configuration for superimaging demonstration. (e), (f) Real part and amplitude of the surface wave at 15.9 GHz.

Key words: Topological metamaterial, super-imaging.

Variable 3D polarization structures along the optical path

Muhammad Afnan Ansari[1], Yan Li[1,2], Hammad Ahmed[1], Ruoxing Wang[3], Guanchao Wang[1,4], Xianzhong Chen[1]

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[2]School of Materials, Zhengzhou University of Aeronautics, Zhengzhou 450015, China.
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Abstract: Generation and manipulation of three-dimensional (3D) optical polarization structures have received considerable interest because of their distinctive optical features and potential applications. However, the realization of multiple 3D polarization structures in a queue along the light propagation direction has not yet been reported. We propose and experimentally demonstrate a metalens to create longitudinally variable 3D polarization knots.

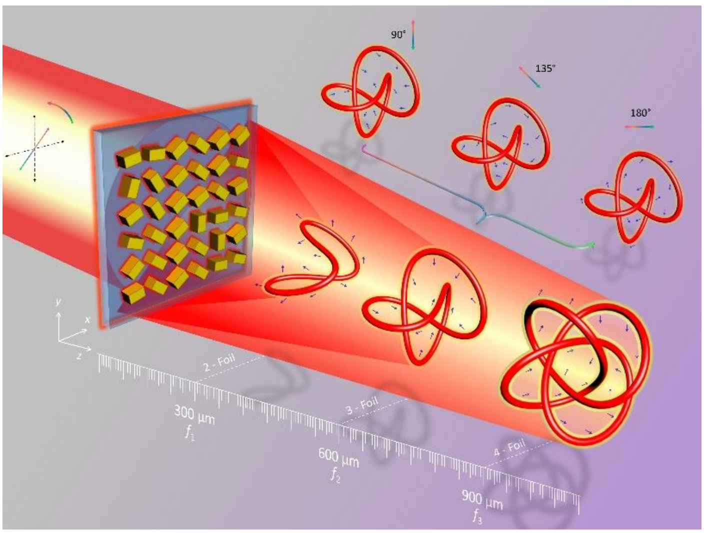

Figure 1. longitudinally variable 3D polarization structures.

References

Li, Y., Ansari, M.A., Ahmed, H., Wang, R., Wang, G. and Chen, X. Longitudinally variable 3D optical polarization structures. Science Advances, 9, 2023, 22eadj6675

Visible-Light Metalenses for Imaging Applications

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A particularly useful alternative of lenses are metalenses, which can focus light to diffraction limited spots yet are less than 1µm thick and exhibit efficiencies rivalling off-the-shelf glass lenses. Whilst a metalens by itself is not exciting, the fact that they can be fabricated using microelectronics processes could lead to mass manufacture at the wafer level for a fraction of the cost and space that normal lenses do, which is of particular interest to handheld imaging systems (e.g. mobile phone cameras). Arrays of these metalenses can be fabricated, creating a fly-eye effect – lens arrays are an essential part of many advanced imaging technologies, such as in wavefront sensing.

One such focus of my research is using dielectric (Silicon Nitride) metalenses which work across the visible spectrum for the computation imaging technique termed light-field imaging which can involves sub-images being focussed from a main lens onto an imaging sensor and then reconstructed into 2.5D, allowing refocussing, parallax, and depth of field estimations to be processed from a single Light Field image. Whilst typical lens arrays can be used for this, metalens arrays are much easier to design and fabricate and are not limited to numerical aperture (NA) values. Work is underway to incorporate High Dynamic Range contrast, polarimetry, and aberration-correction into the lens arrays for life sciences and commercial imaging.

Key words: metalens; imaging; lens-arrays; light-field; fabrication

COLLABORATION OFFERS

Dstl

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The Defence Science and Technology Laboratory (Dstl), an executive agency of the Ministry of Defence (MOD), is the science and technology (S&T) behind UK defence and security. We deliver vital research and expertise for the benefit of the nation and its allies, a significant element of that involves engagement with a large number of suppliers and other institutions.

For research taking place under our Advanced Materials Programme (developing generation-after-next S&T through materials) you can work with us through pathways including Research Cloud (R-Cloud) and the Defence and Security Accelerator (DASA). Organisations of any size can apply to develop innovative technology, with the opportunity to utilise state-of-the-art facilities and work with scientists, technologists, suppliers and military users.

Another way to collaborate with Dstl is through joining the Electromagnetic Materials Measurement and Applications Community of Interest (EMMA CoI), which brings together researchers interested in measuring the properties of electromagnetic materials.

Key words: Functional, animate, metamaterials, generation-after-next

Heriot-Watt University, ASN-Lab

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Contact: m.ferrera@hw.ac.uk

What we do

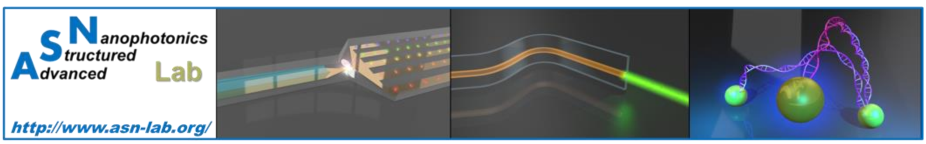
The ASN lab is focused on the development of novel all-optical integrated devices. This is attained through different roads: i) by exploring new optical materials; ii) by developing novel design for all-optical devices targeting maximum speed and low-power consumption; iii) by testing device prototypes to evaluate real-world performances.

What we are looking for

Our closest partners are labs, research institutions, and industries which are primarily focused on the synthesis of alternative optical materials and the fabrication of integrated photonic components. Of the three fundamental production steps in integrated photonics, namely design, fabrication, and testing, we currently rely on strategic partnership for fabrication aspects.

How you could work with us

There are no restrictions to work with us. However, to optimise time and resources, a research/industrial collaboration should be developed within the framework of a funded project. We are always open for discussing fundamental research and practical applications.



Key words: photonic material and device characterisation

Heriot-Watt University, Experimental Nanophotonics Group

Group members: Muhammad Afnan Ansari, Hammad Ahmed, Xianzhong Chen

Heriot-Watt University, Institute of Photonics and Quantum Sciences

Contact: x.chen@hw.ac.uk

The Experimental Nanophotonics Group (led by Prof. Xianzhong Chen) is dedicated to the fundamental physics of optical metasurfaces and ultrathin optical devices for imaging, display and information processing. Current research interests include structured light beams, metalenses, holograms, 3D polarization manipulation, polarimetric imaging and edge imaging. Our research has enabled the discovery of new phenomena and the development of new prototype devices, which might be essential for future technologies. We have built connections with local industry, including STMicroelectronics, Renishaw and Ceres Holographics. We are looking for new links with relevant researchers and industrial end-users to expand our knowledge of the application domain.

Key words: optical metasurfaces, ultrathin optical devices, imaging, display, information processing, metalenses, holograms, structured light beams, 3D polarization manipulation, polarimetric imaging, edge imaging

Imperial College London, Department of Mechanical Engineering, Tribology Group

Group members: Alfredo Fantetti

Contact: a.fantetti@imperial.ac.uk

I am an independent Research Fellow in the Tribology Group (Mech Eng Dept) at Imperial College London. I also collaborate with the Dynamics and Non-destructive evaluation groups in the same Department. Therefore, I have access to the following equipment:

- Vibration testing (shakers, laser, accelerometers, high-speed cameras)
- Contact interface analysis (friction, optical scans, pressure evaluations, transparent materials)
- Ultrasound technique (wave generators, controllers and ultrasonic transducers)
- Experiments on mechanical structures (static or dynamic loads, tribology purposes and industrial turbomachinery)
- High-quality 3D printing

My expertise is in:
- tribology and friction
- nonlinear dynamics
- finite element modelling
- mechanical testing and vibration
- ultrasound technique

I look for researchers with expertise in the use of granular crystals, or in general acoustic metamaterials used for non-destructive evaluation.

I also look for researchers who worked with solitary waves.

Key words: tribology and friction, granular crystals, solitary waves, nonlinear dynamics, vibration, ultrasound, non-destructive evaluation

Imperial College London, Waves Group

Group members: Richard Wiltshaw[1], Richard Craster[2]

[1]Mathematics, [2]Natural Sciences

Contact: r.wiltshaw17@imperial.ac.uk

What we do: develop mathematics to simulate structured materials

What we are looking for: solutions/experiments to contrast with theory

How to work with us: r.wiltshaw17@imperial.ac.uk

Imperial College London: Neuromorphic Physics & Metamaterials Group

Group members: Jack C. Gartside

Imperial College London, Physics

Contact: j.carter-gartside13@imperial.ac.uk

We study & control physical dynamics of magnetic and photonic metamaterials, looking at fundamental phenomena such as ultrastrong GHz magnon-magnon coupling and hybridisation and functional processing like image processing, machine vision and neuromorphic computing. We are always interested in applying our neuromorphic approaches and algorithms to new physical systems, implementing new metamaterial architectures in our magnetic & photonic systems and have a deeply collaborative approach.

Key words: Neuromorphic computing, Magnonics, Spintronics, Machine Learning, Low-loss electronics, beyond-Moore computing, artificial intelligence, photonics, magnetism, artificial spin ice

Imperial College London, Royce Facility

Group Members: Ryan Bower, Abul Hasnath, Bruno Rente, Chukwudike Ukeje, Mark Vaughan, Michael Leverentz, Peter K. Petrov

Department/Organisation
Imperial College London, Department of Materials

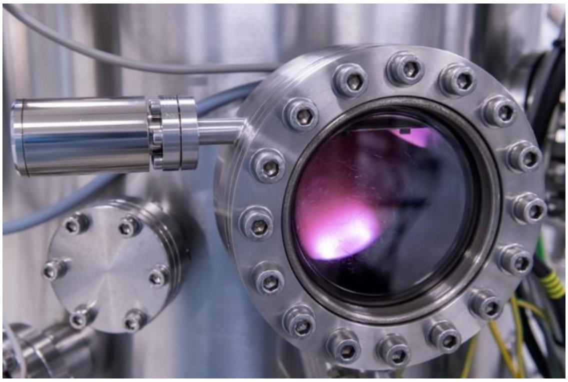
Contact: Michael Leverentz: royce@imperial.ac.uk (access queries)
Peter K. Petrov: p.petrov@imperial.ac.uk (technical queries)

1) **What we do**

We are a hub for start-ups, industry and academia enabling their advanced materials research and fast device prototyping. We provide the knowledge and equipment required to make, test and characterise materials, components and systems. Our expertise is in thin film deposition (Pulsed Laser Deposition, sputtering, evaporation), patterning (photolithography, e-beam lithography) and milling (ion milling, reactive ion etching), electrical testing, and advanced characterisation techniques. We have experience fabricating plasmonic materials and metamaterial arrays.

2) **What we are looking for**

We are always looking for collaborators and are interested in applying our deposition and patterning experience to assist with the fabrication of new devices and structures. We are also interested in collaborating with those experienced in the modelling and characterisation of metamaterials who could assist in designing and testing our materials.



3) **How to work with us**

If you wish to use our facilities they can be accessed through the Royce Access Scheme, which can support instrument time for an initial project lasting up to 6 months, for PhD students, PDRAs, PI and SMEs.
If you are interested in working with us or accessing our nanofabrication facilities, please contact Dr Michael Leverentz for access queries, or Dr Peter K. Petrov for technical queries.

Key words: Nanofabrication, Thin Film Deposition, Sputtering, Pulsed Laser Deposition, Reactive Ion Etching,

KTH Royal Institute of Technology, EMF

Group members: Sarah Clendinning; Oscar Quevedo Teruel

EMF

Contact: sclendinning@aol.co.uk

At the Center for Wireless Innovation at Queens University Belfast, we are always interested in potential ways to improve the imaging performance of our sensors for computational microwave imaging. So, if we can combine different lens architectures with our coded-apertures (i.e. metasurfaces), there can be potential benefits, such as improving the SNR and increasing the orthogonality of our radiated field patterns to improve the performance of microwave imaging. Additionally we are looking into developing conformal broadband microwave absorbers and have previously worked on polarisation converters, both of which use metamaterial technologies.

Key words: OAM Lenses, microwave absorbers, polarisation converters

University of Leeds

Group members: Helen Gleeson

School of Physics and Astronomy

Contact: H.F.Gleeson@leeds.ac.uk

We're a university group undertaking fundamental research on understanding auxetic liquid crystal elastomers. The scale-up and applications of our materials are being developed by our spin-out company, AuxeTec Ltd. We're interested in collaborating with colleagues in the space of mechanical and auxetic metamaterials, potentially to see if our systems can provide solutions to interesting and important problems, but also in taking the fundamentals as far as we can.

Key words: liquid crystal elastomers, polymer systems.

Loughborough University, Wireless Communications Research Group

Group members: Aakash Bansal, Thomas Whittaker, William Whittow

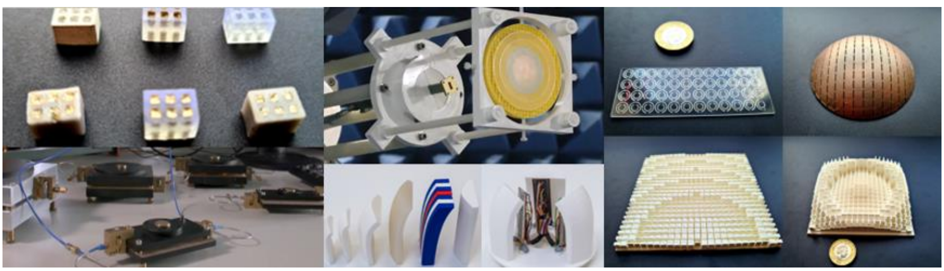
Wolfson School of Mechanical, Electrical, and Manufacturing Engineering

Contact: a.bansal@lboro.ac.uk, t.whittaker@lboro.ac.uk, w.g.whittow@lboro.ac.uk

Wireless Communications Research Group (WiCR) at Loughborough University is a group of leading specialists in RF, Antennas, Propagation, and Metamaterials led by Prof Whittow. We have extensive design experience in active electromagnetic metamaterials, metasurfaces, antennas, lenses, orbital angular momentum beams, filters, and RF circuits.

Our lab capabilities include (but not limited to) anechoic chambers (up to 67 GHz), network analysers (up to 70 GHz), dielectric & conductivity measurements (up to 70 GHz), optical & electron microscopes, surface analysis, crystallography, mechanical testing, thermal analysis, large under-water acoustic tank, and in-house PCB fabrication.

Our primary research is focused on developing new EM devices for applications in (non-)terrestrial networks, satellite communications on the move, 5G/6G, RADAR, automotive, imaging and sensing in medical, food and agriculture.



Key words:
Wireless Communications, Antennas, Metasurfaces, Electromagnetics, Satellite Communications, Vehicular Networks, Automotives, 5G, 6G, RADAR, Imaging, Sensing.

Manchester Metropolitan University, Sports Engineering Research Group

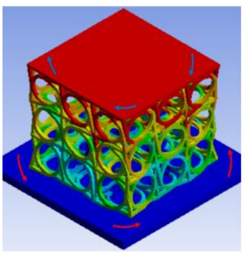
Group members: Olly Duncan, Tom Allen

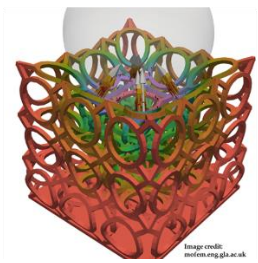
Engineering

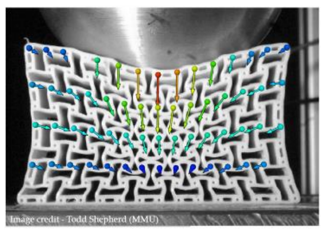
Contact: o.duncan@mmu.ac.uk

We use sports/healthcare applications to study complex equipment-user interactions, feeding into mechanical metamaterials design and optimisation. Our interests include the development of efficient numerical and analytical microstructural optimisation tools suitable for large strain and dynamic applications, and experimental validations.

Interesting use cases: healthcare applications, adapting and designing equipment (particularly safety equipment) to underserved groups (i.e., beyond the 50th percentile male), and improving sustainability of sports equipment (often related to fast fashion). Integration of multi-functional responses: strain or damage sensing metamaterials for prosthesis or protective equipment, active response to environmental stimuli, and deployable structures that can switch between stored/streamlined and protective functions.







Key words: Healthcare, protective equipment, prosthesis, mechanical metamaterials

NKT Photonics

Marc Smilie

Contact: marc.smillie@nktphotonics.com

NKT Photonics is the leading supplier of high-performance fibre lasers and photonic crystal fibres. Our main markets are Medical & Life Science, Industrial, Aerospace & Defense, and Quantum & Nano Technology. Our products include supercontinuum white light lasers, low-noise fibre lasers, ultrafast lasers, and a wide range of specialty fibres.

Key words: Optical Characterization, Tunable laser, SuperK, Fiber lasers

National Physical Laboratory, Quantum Materials and Sensors Group

Group members: Mayela Romero-Gómez

Quantum Technologies Department

Contact: mayela.romero@npl.co.uk

In the Quantum Materials and Sensors group at NPL, we specialise in the characterisation of structured materials, at the nano and micro scale with our wide range of cutting-edge probe techniques, which allow us to study fundamental physical properties such as electric, magnetic, and thermal transport at the nanoscale, in addition to photocurrent and optical near-field responses, in spectral ranges varying from the visible to the near and mid-infrared.

We are looking to establish collaborations, with both academia and industry, to support the development of new-generation devices based on novel materials, such as: Van der Waals 2D materials, plasmonic nanostructures, plasmonic/dielectric metamaterials and metasurfaces, for applications in quantum technologies, energy conversion, and sensors.

NPL offers access to our facilities through different programs, such as Measurement for Quantum (M4Q), and Measurement for Innovation (M4I), and we can collaborate with academia through the UK National Quantum Technologies Programme, and other UKRI schemes.

Key words: Scanning probe techniques, Characterisation Facilities, Quantum Materials

Nottingham Trent University

Group members: Mahdi Bodaghi

Department of Engineering

Contact: mahdi.bodaghi@ntu.ac.uk

At the 4D Materials and Printing (4DMP) Laboratory, we specialise in the innovation and development of 4D materials, design and additive manufacturing technologies. Our work encompasses multiscale studies on smart materials, active metamaterials, bio-composites, advancing 3D/4D printing techniques, and integrating AI for enhanced design processes. We aim to pioneer smart materials and metamaterials applications promoting resiliency and sustainability and improving adaptability and functionality across various sectors from healthcare to automotive. We are on the lookout for collaborative partners, passionate researchers, and innovative minds who share our vision for groundbreaking smart materials, metamaterials and 3D/4D printing technologies. Our ideal collaborators are those eager to push the boundaries of smart material science and additive manufacturing, contributing to the development of novel applications and resilient and sustainable solutions. To engage with us, we welcome inquiries from academic institutions, industry leaders, and technology enthusiasts interested in exploring the vast potential of smart materials, metamaterials, and 3D/4D printing. Whether it's through collaborative research projects, consultancy, or educational endeavours, we're open to a variety of partnerships. Connect with us to learn more about how our cutting-edge research facilities and expertise can complement your projects and drive innovation forward.

Key words: Smart Materials, Metamaterials, 4D Printing, Sustainability, Resilience

Teeside University: Smart Energy Group

Group members: Imran Bashir

Department of Engineering

Contact: i.bashir@tees.ac.uk

At Teesside University, a newly established Acoustic research group working in Low frequency acoustic sensors, Acoustic metamaterials, Water leakage detection using acoustics, Ultrasonic monitoring of batteries to study degradation and advanced signal processing techniques. We have anechoic chamber, full setup for acoustic testing, COMSOL and Battery monitoring testing facility. We have expertise in both experimental acoustics and simulations such as FEM, BEM and analytical modelling. We are part of Prestigious Net-Zero centre and looking for applications using acoustics metamaterials for Hydrogen monitoring.

We are looking for (i) collaboration, sharing resources and expertise (ii) Metamaterial manufacturing facility (iii) Acoustic sensor fabrication facility (iv) wave propagation modelling in complex heterogenous medium and (v) expertise in ultrasonic testing.

Collaboration: Funding bids, Research papers and sharing resources such as expertise and lab equipment. Early career academics in acoustics are actively looking to collaborate with universities and industry. Acoustic Metamaterials science have been well understood, looking to collaborate to these for different acoustic applications. The research group is looking to expand through collaboration and research. The team is flexible and have support from the school to expand and show its impact.

Key words: Low frequency acoustic sensors, Acoustic metamaterials, Water leakage detection, Ultrasonic monitoring, battery degradation, advanced signal processing

The Open University, Aperiodic cellular structures research group

Group members: Richard Moat

Engineering and Innovation

Contact: Richard.moat@oprn.ac.uk

We work on applying the mathematics of aperiodic order to the design of materials and structures. We have been exploring the fundamental science underpinning the behaviour of mechanical metamaterials based on aperiodic order primarily focusing on 3d printed honeycombs resulting in some exciting findings which could have widespread practical applications. We are looking for opportunities to exploit our findings through real world applications and further academic investigation. We are a multidiciplinary research group at the intersection of mathematics, materials and computational design and are looking for collaborations leading to future UKRI bids.

Key words: Honeycomb, Poisson's ratio, Aperiodic tiling

Trelleborg Applied Technologies

Research & Development

Contact: rebecca.randle@trelleborg.com

At Trelleborg Retford, we manufacture a wide range of elastomeric polyurethane (PU) and rubber products from the smallest squeegee blade to the largest bend stiffener. We are a large batch production site with a technical team working in both production support and material innovation. Our area of technical interest and expertise is in radar, noise and vibration absorbing and attenuating materials for various large-scale applications such as rail, wind turbines and subsea stations. These products minimise disturbance to the public and local wildlife. We are interested in metamaterials to explore and continue to innovate our material across several projects. We are open to intellectual collaboration in this area as well as in specialised material testing facilities not available to us at our site. Feel free to get in touch and come and read more at our poster.

Key words: Vibration mitigation, radar absorption, sound attenuation, polyurethane, rubber, manufacture, wind blades, rail, subsea

University of Amsterdam, The Machine Materials Lab, PI: Corentin Coulais

Group members: Jack Binysh

Institute of Physics

Contact: jack.binysh@gmail.com

The Coulais lab focuses on the understanding of the physics of soft structured active materials. The goal is to develop the physics of Machine Materials, i.e. artificial materials which combine microstructure and out-of-equilibrium processes to interact with their environment in a programmable fashion. We are located at the Institute of Physics of the University of Amsterdam. We are looking for applications of active metamaterials to areas such as vibration damping and new approaches to robotic locomotion. Alongside applications we are also interested in active metamaterials as a fruitful platform to explore new concepts in metamaterial design, for example self-learning materials.

Key words: Active Metamaterials, Robotic Matter, Mechanical Metamaterials

University of Augsburg, Applied Analysis

Group members: Malte A. Peter, Lisa Beck, Tanja Lochner, Sophie Thery, Ursula Weiß, Ferdinand Eitler, Timo Neumeier

Institute of Mathematics

Contact: malte.peter@math.uni-augsburg.de

Modelling, simulation and experiment design for acoustic and water-wave metamaterials at the University of Augsburg

The research unit applied analysis at the University of Augsburg in Germany focuses on mathematical modelling and simulation as well as analysis of partial differential equations. Special emphasis is given to multiscale problems. The group is headed by Professor Malte A. Peter and regularly collaborates with scientists from physics, chemistry and engineering on problems of continuum mechanics (fluids and solids), biophysics and the geosciences in particular. Malte Peter is an expert in (periodic) homogenisation methods and their applications as well as (water-)wave–structure interaction problems. Recent projects of the group include mathematical aspects of wave propagation through heterogeneous media (metamaterials in particular), mechanical damage of materials with microstructure, degradation mechanisms in porous materials as well as physico-chemical processes in biological materials.

Key words: Mathematical modelling, simulation, experiment design

University of Bath, Botanic Photonics

Group members: Rox Middleton

Physics

Contact: rm2950@bath.ac.uk

I am a new lecturer and group leader at the University of Bath from Sept 2024. I am looking for collaborators of any kind who are interested in questions around optical nanostructured biomaterials, plant waxes and surface structures.

The work we will do is on the use of - generally plant-based - biological materials. The main focus of the group will be initially self-assembling plant waxes (with an interest also in insect waxes) to 1. Understand the ways that plants use and manipulate light at the surface using nanostructure. 2. Understand the optics of scattering in ultrathin scattering materials and in particular the role of disorder. 3. Reproduce structures in wax and other materials (understanding molecular mechanics and chemistries).

As an expansion from my own core research interests, I'm interested in mechanical characteristics of nanostructured surfaces, heat transfer, themes of translation in biomaterial uses, and scale-up, sustainability and harvesting of waxes, applications in solar harvesting and solar concentration, nano- and micro-characterisation and fabrication.

I'm always interested in characterising, understanding and mimicking biological materials with interesting optical effects.

Key words: plant biomaterials, optical metamaterials, structural colour, surface nanostructure, self-assembly

University of Cambridge, Theory of Condensed Matter Group Souslov Lab

Group members: Anton Souslov

Cavendish Laboratory

Contact: as3546@cam.ac.uk

We are a theoretical physics research group. We are interested in modelling the mechanics of soft materials and designing new states of matter. Our interests include active mechanical materials, topological metamaterials, and the intersection of metamaterials and fibre optics. We design mechanical metamaterials with novel properties and functionalities using patterns on scales from nanometres to the macroscopic.

Modelling and design of novel functionalities in mechanical metamaterials, including active mechanical metamaterials and topological mechanics.
We are open to research collaborations, including with academia and industrial partners. We are also enthusiastic about co-organizing Metamaterials NetworkPlus events and submitting joint grant proposals to funders such as EPSRC.

University of Exeter: Centre for Metamaterial Research and Innovation (CMRI)

Contact: Karen Pearson, CMRI Centre Manager metamaterials@exeter.ac.uk

Who we are:
The Centre for Metamaterial Research and Innovation (CMRI) is a vibrant community of academic, industrial, and governmental partners that harnesses research excellence from theory to application. Our capabilities span the simulation, measurement, and fabrication of metamaterials and metamaterial-based devices.

Our breadth is our strength: we are uniquely positioned to solve multi-faceted research questions and industry challenges. Our academic expertise spans electromagnetism (from visible and infra-red through to THz and microwave wavebands), acoustics and fluidics. The materials we work with have wide applications, e.g. imaging, sensing and spectroscopy, acoustic and RF signature reduction, energy storage and harvesting.

Work with us:
Academics: Are you working in metamaterials or a related area and wondering whether joint supervision of a PhD project or collaboration for a grant application could be beneficial for research progress?

Are you interested in PhD student exchange to provide the next generation with insights in other HE institutions and support their training?

Would you like to give a guest lecture at the University of Exeter or host one of our academics to provide a guest lecture at your institution?

Industry: Our long-standing experience in working with industrial partners in ICT, energy, healthcare, and defence & security sectors enables us to provide fit-for-purpose collaborations, adjusted to the needs of a variety of businesses, from SMEs to large companies.

We collaborate with a variety of different industry partners to develop projects that are costed appropriately with regards to their Technology Readiness Level (TRL). We can work with you to determine the appropriate structure for your project that benefits both the company and the University, whilst recognising the importance of State Aid.

If you'd like to establish or strengthen a collaboration, please get in touch via metamaterials@exeter.ac.uk.

Key words:
Metamaterials, Optical, Acoustic, Fluidic, Mechanical, Electromagnetic, Magnetic, Quantum, 2D, modelling, design, defence, security, energy, health, ICT, nanofabrication, testing.

University of Exeter, NEST

Group Members David Wright, Joe Shields

Physics & Engineering

Contact: j.shields@exeter.ac.uk

David Wright's group focuses on phase-change materials based metasurfaces and other opto-electronic devices.

Key words: phase-change materials, metasurfaces, switching, active, memory

University of Exeter, Quantum Systems and Nanomaterials

Group Members: Hoi Tung Lam

Physics and Astronomy

Contact: o.lam@exeter.ac.uk

Our research group is pioneering novel fundamental science and applied research based on advanced- and quantum-materials. We are working at the forefront of novel information, communication, energy and healthcare challenges by exploiting the unique properties of novel systems such as atomically thin (2D) transition metal dichalcogenides, 2D oxides, sustainable lead-free perovskites, and 2D perovskites to list a few. Highlights from our interdisciplinary research include the demonstration of pioneering self-powered sensing technologies based on the triboelectric properties of 2D and natural materials, the development of sustainable alternative opto-electronic platforms to silicon, and conceptually novel ways to manipulate light-matter interaction in 2D semiconductors. Finally, by working with leading materials engineering and science groups, we are pioneering in the development of multi-functional devices on emerging fully biodegradable organic substrates which hold the promise for a step change to a sustainable development of mankind.

Key words: Quantum materials, 2D materials, energy, healthcare, self-powered, triboelectric, semiconductors, sensors

University of Exeter, Solar Energy Research Group

Group Members: Mustafa Alfartos, Anurag Roy

Renewable Energy

Contact: ma994@exeter.ac.uk

The Solar Energy research group focuses on the development of affordable solar energy technologies and allied devices. We provide solutions to counter energy challenges that can lead us towards a sustainable future. The key subjects within the group include high efficiency solar energy conversion and storage, concentrating photovoltaics, solar fuels, 3rd generation solar cells, allied devices, glazing, thermoelectric glazing. The group is composed of leading and emerging scientists who undertake interdisciplinary research on frontier issues of environment and sustainability along with both national and international partners.

Key words: solar energy, photovoltaics, themoelectric, glazing

University of Huddersfield: Centre for Precision Technologies, Optical Metrology

Group members: D.J. Townend, J.H.-T. Chan, J. Kendrick, P. Yang, J. Williamson, D. Tang, N. Sharma, P. Kumar, H. Muhamedsalih, A, Mustafa, Y. Xu, Y. Li, M. Boon, M. Hassan, Z. Zhang, B. Zhang, A.J. Henning, H. Martin, F. Gao, X. Jiang.

Computing and Engineering

Contact: a.henning@hud.ac.uk

The optical metrology group within the Centre for Precision Technologies at the University of Huddersfield has a strong focus on developing technologies that enable improved manufacturing processes through the wider deployment of measurements, and a better use of the data that is acquired. We are always interested in hearing from groups that would benefit from our expertise in metrology to aid with measurement problems they are having, or who believe they have novel materials/techniques that would aid our sensor design and instrument development. We have well equipped facilities for the characterisation of sensors, expertise in instrument development, experience in the design of optical metasurfaces, and strong industrial links by which exploitation of technologies can be realised.

Key words: Metrology, Instrument development, Manufacturing

University of Liverpool, Electrical Engineering and Electronics

Group members: Jiafeng Zhou

Science and engineering

Contact: jiafeng.zhou@liverpool.ac.uk

Wireless Charging and Wireless Communications Using Microwave Metamaterials

What we do

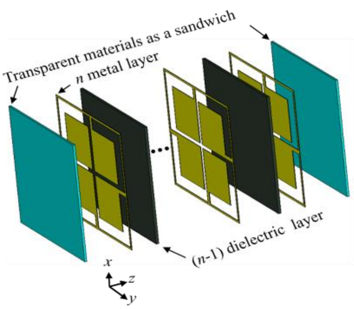
We conduct research on microwave and RF devices and systems for wireless charging and wireless communications. We utilize metamaterials to overcome the theoretical limitations of antennas in traditional areas. Additionally, we develop innovative systems for both short-distance and long-distance wireless power transfer.

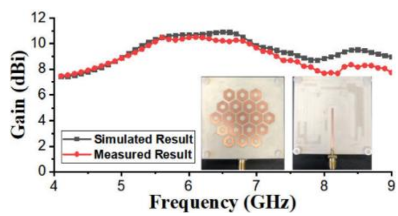
What we are looking for

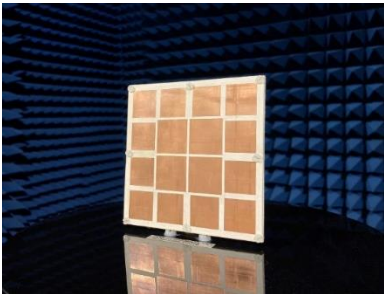
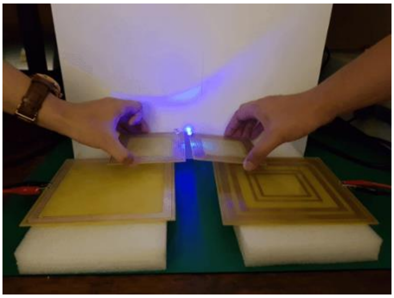
We are seeking potential collaborators for joint grant applications. Also, we are very keen to work with industrial partners to explore the commercial potential of these technologies for space, 6G, medical, and communication applications.

How to work with us

We are very open-minded. Please get in touch if you are interested in any way.





Key words: Microwave, RF, Wireless Charging, Wireless Communications

University of Nottingham, Centre for Additive Manufacturing

Group Members: Feiran Wang, Negar Gilani

Faculty of Engineering

Contact: f.wang@nottingham.ac.uk

The research undertaken by the Centre for Additive Manufacturing spans across both fundamental and applied research. The next stage of development of this new technology will be to go beyond using single materials (either polymer or metal) and instead use multiple materials – both functional and structural – in unison to engineer highly functional, durable and life-changing items such as prosthetic limbs, complex pharmaceutical devices and advanced engineering components. The core research carried out within the group is focussed on investigating the underpinning processes, materials and computational methods for multifunctional Additive Manufacturing, giving the potential to move beyond structural applications and create fully functional systems using Additive Manufacturing rather than passive individual components.

Key words: Additive Manufacturing, Inkjet printing, Digital light processing, Laser powder bed fusion

University of Nottingham, Kenney Lab, Optics and Photonics Research Group

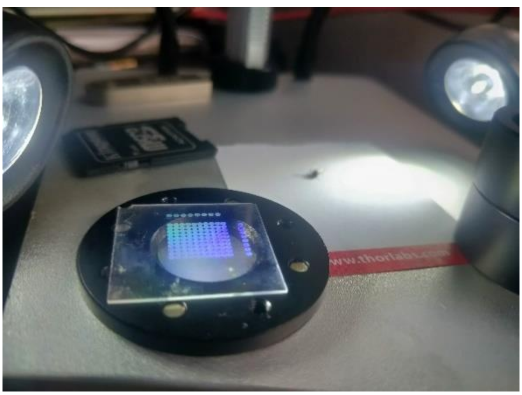
Group members: Mitchell Kenney

Electrical and Electronic Engineering

Contact: mitchell.kenney@nottingham.ac.uk

The Kenney Lab (University of Nottingham) focuses on the design and fabrication of real-world applicable metasurfaces using high refractive index and low loss dielectric materials, particularly Silicon Nitride. All fabrication is done on-site, with dedicated cleanrooms for patterning, material deposition and etching.

Our main focus is using these metasurfaces for visible light – due to obvious applications in imaging and sensing; because of the complexity of making dielectric nanostructures with high aspect ratio, we are one of the few groups in the UK with the capability and expertise to achieve this. Our focus lies in the development of new and exciting imaging techniques alongside novel metasurfaces. One such technology is Light Field Imaging which relies on arrays of metalenses in conjunction with an image sensor to computationally reconstruct the scene in 2.5D, with post-capture focus, parallax, and depth-of-field being possible with only a single image. Other fields of research are wide-angle imaging and sensing, polarimetry and High Dynamic Range (HDR) contrast using polarised metasurfaces, optical-bench-on-a-chip, and optical trapping. These can be applied to numerous sectors, such as life sciences, biomedical imaging, defence and security, fibre-based imaging, novel physics, and augmented reality.



Key words: biosciences; imaging; fabrication; sensing

University of Oxford, Mechanical metamaterials for advanced implants

Group Members:Reece N. Oosterbeek[1]

1 Department of Engineering Science, University of Oxford, Oxford OX1 3PJ, UK

Contact: reece.oosterbeek@eng.ox.ac.uk

Dr Oosterbeek is setting up a new research group at the University of Oxford, to develop mechanical metamaterials for medical implant applications. Key areas of interest include:

- Development of manufacturing methods for biodegradable metamaterials, aiming to achieve site-specific control over the microstructure of polymers and polymer composites during additive manufacturing.

Development of new metamaterial architectures specifically designed to influence the evolution of mechanical properties over time. This evolution results from phenomena such as material degradation or fatigue.

- Design and testing of metamaterial-based implant devices, targeted at specific applications such as orthopaedic fixation devices.

Collaborations are welcome across a range of areas, especially on medical application of mechanical metamaterials. Other collaboration areas include new polymers and composites for metamaterial fabrication, and biologically relevant testing of prototype materials and devices. To get in touch please email reece.oosterbeek@eng.ox.ac.uk

Key words: mechanical metamaterials, polymers, composites, biomedical, degradable

University of St Andrews, Nanophotonics

Group members: Sebastian Schulz, Anindita Das, Iman Alhamdan, Bhupesh Kumar, Laura Wynne

School of Physics and Astronomy

Contact: sas35@st-andrews.ac.uk

We are specialised in the design and fabrication of nanophotonic structures, including but not limited to metasurfaces, photonic crystals, waveguides and plasmonic systems. What we can offer Design and modelling: a range of techniques including plane wave expansion methods, finite difference and finite element methods and home build codes.

Fabrication: lithography (UV and electron beam), dry and wet etching, material deposition (sputtering, ALD, evaporation) for materials such as ITO, zirconia, polymers, dieletric and plasmonic structures etc.

Characterisation: linear and nonlinear characterisation (CW) of metasurfaces and waveguide systems. Material chacterisation including ellipsometry, Energy dispersive X-ray spectroscopy etc, SEM and more.

Decade long experience in the design of photonic devices with precisely controlled dispersion properties and control over k-space distributions and optical scattering. Longstanding experience in the integration of novel materials into photonic system.

We mostly look for partners with application or challenge-driven needs for the design and fabrication of new devices and for collaborators with advanced device characterisation methods and facilities.

Key words: Device design, epsilon near zero, tunable metasurfaces, nanofabrication, modelling

University of Sheffield, Communications Group

Group members: Stephen Henthorn, Rola Saad

Electronic and Electrical Engineering

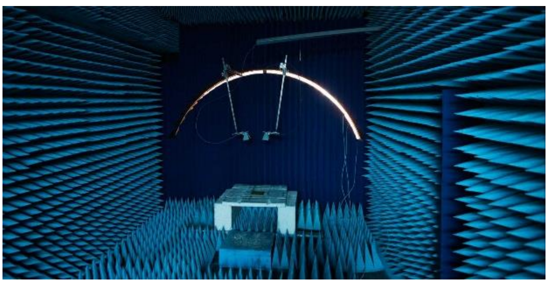
Contact: s.henthorn@sheffield.ac.uk, r.saad@sheffield.ac.uk

The Communications Group covers almost the whole field of wireless communications from application layer to physical layer, with particular interest in radio waveforms, active arrays, and electromagnetic structures. Our metamaterials expertise focuses on the microwave and mmWave domains, producing imaginative solutions in applications including antenna enhancement, communications equipment, wireless security, healthcare and stealth. This includes extensive research into reconfigurable metamaterials,

as well as non-standard fabrication approaches including weaving, knitting and printing of electromagnetic materials.

Our extensive measurement facilities include three anechoic chambers and an NRL arch, allowing reflection, transmission, radar cross section, SAR imaging and antenna pattern measurements from 100 MHz to 20 GHz. Our Group is home to the UKRI National mmWave Facility, taking pattern, transmission and reflection measurements up to 110 GHz, including on-wafer measurement of devices. We are also home to the UKRI National 6G Radio Systems Facility, extending our over-the-air test capability to 220 GHz with a direct digitisation oscilloscope of 110 GHz bandwidth.

These facilities are open to commercial and academic use with specialist technical support. Contact mmwave@sheffield.ac.uk for further information. We are also always interested in potential collaboration on any of our areas of expertise listed above.



Key words: Microwave, mmWave, reconfigurable, metasurfaces, antennas, wireless communications

University of Sheffield, Mechanical and Acoustic Metamaterials

Group Members: Simon Pope, Frederik Claeyssens

Department of Automatic Control and Systems Engineering
Department of Materials Sciences and Engineering

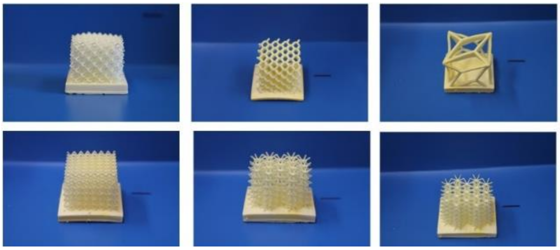
Contact: s.a.pope@sheffield.ac.uk, f.claeyssens@sheffield.ac.uk

At the University of Sheffield we design and manufacture passive and active mechanical and acoustic metamaterials. We also investigate and develop new approaches to manufacture metamaterials, with a focus on sustainability and reconfigurability. Applications for these include defence, automotive and healthcare. We have recently started a project focused on the design of such metamaterials for sustainability applications in these sectors.

For example, we have developed printing technology that can produce 3D printed object of polymer foams. The objects only contain ~10-20% the amount of polymer that is in normal 3D printed objects, so are extremely light weight, but they can be printed in complex and metamaterial structures. We originally developed this technology for healthcare technologies, but we are also exploring acoustic applications and mechanical metamaterials for aerospace applications. The technology we developed is versatile and can be tuned in mechanical properties, and is a platform technology to build light-weight materials, either polymeric, ceramic (via coating or carbonisation) or metal-based (via electrodeposition) via sustainable low-energy production methods. Also, functionality could be included via incorporation of functional nanomaterials.

We are looking for both academic and industry collaborators interested in design and end use of acoustic/mechanical metamaterials. We are particularly like to hear from potential industrial collaborators with an interest in increasing the sustainability of parts used in their products.

We are open to collaboration in most ways: joint proposals, studentships, etc.



Key words: Acoustic metamaterial, Mechanical metamaterials, Active metamaterials Manufacturing, Sustainability, Space & Aviation, Health

University of Southampton

Group members: Felix Langfeldt

Institute of Sound & Vibration Research

Contact: F.Langfeldt@soton.ac.uk

Fundamental and applied research in passive and active acoustic and mechanical metamaterials for noise and vibration control. Analytical and numerical modelling as well as experimental studies, small-scale (e.g. impedance tube) and large-scale (e.g. transmission tests).

Key research areas:

- Membrane- and plate-type acoustic metamaterials
- Partitions with embedded acoustic metamaterials
- Active acoustic and mechanical metamaterials

The Institute of Sound & Vibration Research offers state-of-the-art testing facilities for noise and vibration control testing and aeroacoustic measurements as well as world-leading experts covering all areas of sound and vibration.

What we are looking for:

- Opportunities to collaborate with other academic institutions and/or industrial partners in national and international research projects
- In-situ validation of acoustic metamaterial designs
- New challenges and applications for acoustic metamaterials
- PhD student funding

Key words: sound, vibration, noise, active noise control, modelling, experiments

University of Warwick

Group members: Claire Dancer, Nicholas Grant, Jisun Im, Oksana Trushkevych,
Richard Watson, Sophie Pain.

Warwick Manufacturing Group

Contact: c.dancer@warwick.ac.uk

At the University of Warwick our interests in the Manufacturing and Scale-Up of metamaterials span length scales and materials classes.

We have expertise in both additive and formative manufacturing of metamaterials, and facilities for subtractive manufacturing are available. We also have experience in working with metals, ceramics, polymers, and composite materials.

Our materials characterisation facilities are among the best in the UK and are accessible to academics (e.g. through the Warwick Analytical Sciences Centre) and to industry partners (e.g. through Warwick Scientific Services).

Our poster will showcase some of our previous research as well as the facilities available and accessible at Warwick which could be ideal for metamaterials manufacturing and scale-up collaborative projects.

Delegate contact details

Higher Education Institutions

Name	Organisation
Aakash Bansal	Loughborough University
Alastair Hibbins	University of Exeter
Alex Powell	University of Exeter
Alfredo Fantetti	Imperial College London
Andrea Di Falco	University of St Andrews
Andrew Alderson	Sheffield Hallam University
Anindita Das	University of St Andrews
Anton Souslov	University of Cambridge
Anurag Roy	University of Exeter
Calum Williams	University of Exeter
Cameron Gallagher	University of Exeter
Changxu Liu	University of Exeter
Claire Dancer	University of Warwick
Daniel Townend	University of Huddersfield
David Newman	University of Exeter
Dongyang Wang	University of Southampton
Edmund Linfield	University of Leeds
Evros Loukaides	University of Bath
Fabrizio Scarpa	University of Bristol
Feiran Wang	University of Nottingham
Felix Langfeldt	University of Southampton
Frederik Claeyssens	University of Sheffield
Gregory Chaplain	University of Exeter
Hammad Ahmed	Heriot-Watt University
Helen Gleeson	University of Leeds
Helen Rance	University of Exeter
Henry Marsh	University of Exeter
Hoi Tung Lam	University of Exeter
Huanling Zou	University of Exeter
Ibrahim Patrick	University of Bristol
Iman Dayyani	Cranfield University
Iman Mohagheghian	University of Surrey
Imran Bashir	Teesside University
Isaac Luxmoore	University of Exeter
Jack Binysh	University of Amsterdam
Jack C Gartside	Imperial College London

Name	Organisation
James Capers	University of Exeter
Jensen Li	Hong Kong University of Science and Technology
Jess Wade	Imperial College London
Jiafeng Zhou	University of Liverpool
Jingchao Jiang	University of Exeter
Jisun Im	University of Warwick
Joe Shields	University of Exeter
Joel Loh	University of Manchester
Jonny Blaker	University of Manchester and Henry Royce Institute
Kai Sun	University of Southampton
Karen Pearson	University of Exeter
Katie Shanks	University of Exeter
Kevin MacDonald	University of Southampton
Maciej Dabrowski	University of Exeter
Mahdi Bodaghi	Nottingham Trent University
Malte Peter	University of Augsburg
Marcello Ferrera	Heriot-Watt University
Marcelo A. Dias	University of Edinburgh
Maria Crespo-Ribadeneyra	Queen Mary University of London
Mazdak Ghajari	Imperial College London
Miles Padgett	University of Glasgow
Mingchao Liu	University of Birmingham
Mitchell Kenney	University of Nottingham
Negar Gilani	University of Nottingham
Nicholas Grant	University of Warwick
Nick Stone	University of Exeter
Nikolay Zheludev	University of Southampton
Oksana Trushkevych	University of Warwick
Oliver Nelson-Dummett	University of Nottingham
Olly Duncan	Manchester Metropolitan University
Peter J. Christopher	University of Nottingham
Peter K Petrov	Imperial College London
Peter Martin	University of Bristol
Pooya Sareh	Newcastle University
Rafael Fuentes Dominguez	University of Nottingham

Name	Organisation
Reece Oosterbeek	University of Oxford
Riccardo Sapienza	Imperial College London
Richard M Hall	University of Birmingham
Richard Moat	The Open University
Richard Watson	University of Warwick
Richard Wiltshaw	Imperial College London
Rob Hewson	Imperial College London
Rola Saad	University of Sheffield
Rox Middleton	Bristol / Dresden / Bath
Rupert Oulton	Imperial College London
Ryan Bower	Imperial College London
Sarah Clendinning	KTH Royal Institute of Technology
Sebastian Schulz	University of St Andrews
Simon Horsley	University of Exeter
Simon Pope	University of Sheffield
Simone Michelle	Plymouth University
Sina Saremi	Loughborough University
Sophie Pain	University of Warwick
Stefan Szyniszewski	University of Durham
Stephen Henthorn	University of Sheffield
Steven Hepplestone	University of Exeter
Stuart Berrow	University of Leeds
Tanmoy Chatterjee	University of Surrey
Thomas Raistrick	University of Leeds
Thomas Whittaker	Loughborough University
Tom Allen	Manchester Metropolitan University
Will Dawber	Sheffield Hallam University
Will Whittow	Loughborough University
William Wardley	University of Exeter
Xiangqian (Jane) Jiang	University of Huddersfield

Industry, governmental agencies, other

Name	Organisation
Anne Crean	IOP
Daniel Underhill	Mbda
Dean Patient	QinetiQ
Diane Roth	QinetiQ

Name	Organisation
Euan Humphreys	Dstl
Gemma Bale	ARIA
Ian Youngs	Dstl
Jessica Humphreys	ARIA
John Bows	PepsiCo
Joshua Hamilton	QinetiQ Ltd
Marc Smillie	NKT Photonics
Mayela Romero-Gómez	National Physical Laboratory
Michael Tagima	QinetiQ
Nathaniel J. Huáng	National Physical Laboratory
Rebecca Randle	Trelleborg
Sarah Bohndiek	ARIA
Sarah Clendinning	KTH Royal Institute of Technology
Simon Berry	QinetiQ
Thomas Bassett	MBDA UK
Jenny Lovell	Institute of Physics
Mike Sloan	Technical Composite Systems
Peter Tipping	Auxetec
Robert Quarshie	KTN
Zaffie Cox	UKRI

MAKE YOUR OWN METAMATERIAL

Make your own metamaterial

The herringbone tessellation is an auxetic / mechanical metamaterial structure you can make yourself with (origami) paper.

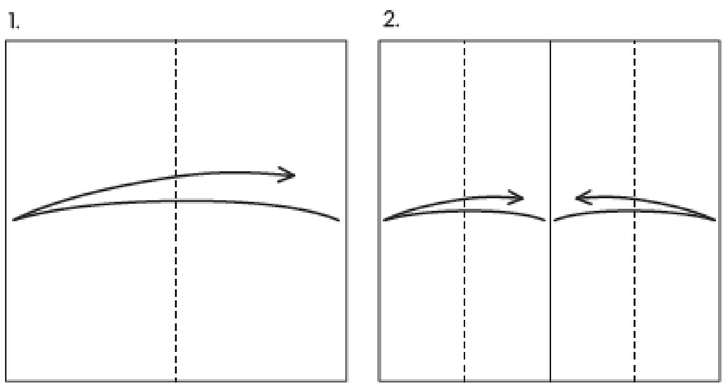
The instructions provided here are publicly available on https://www.origamitessellations.com/2018/01/bauhaus-foundation-course-instructional-booklet/.

Credit: Eric Gjerde.

Folding instructions

Dashed line = valley fold, looks like a valley pointing away from you
Solid line = mountain fold, looks like a mountain tip pointing towards you

If you are unsure how to fold it, here is also a video with instructions (NB loud music!): *https://youtu.be/LpwfcOXFKtQ*



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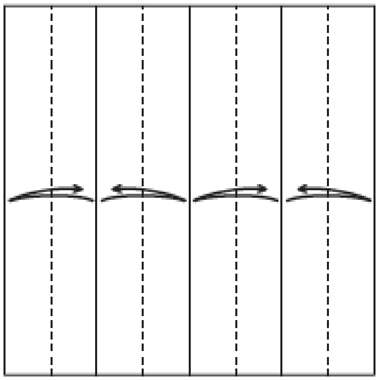

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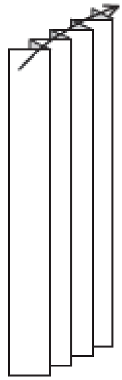

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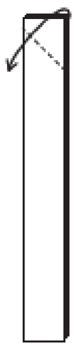

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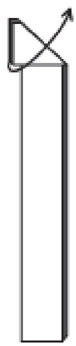

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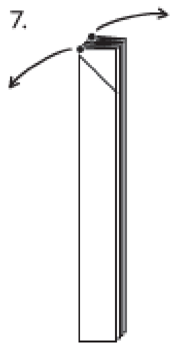

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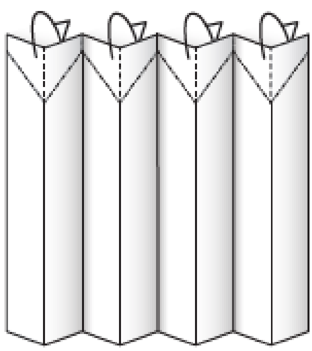

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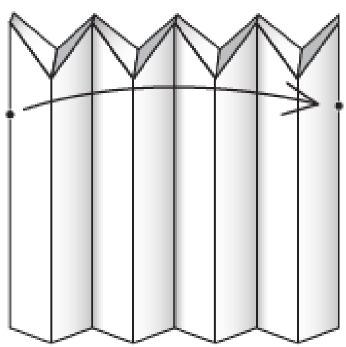

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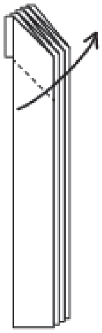

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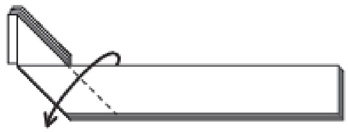

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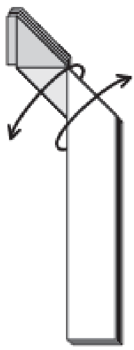

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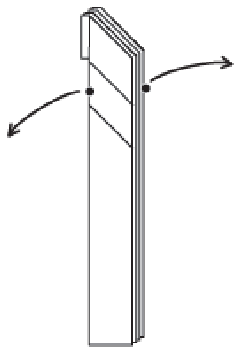

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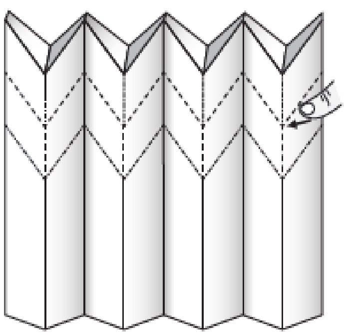

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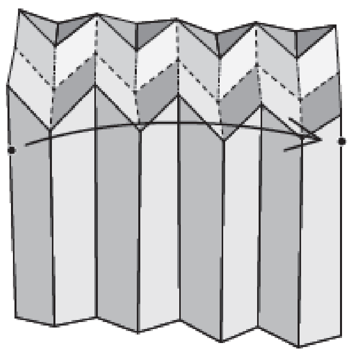

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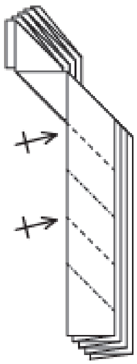

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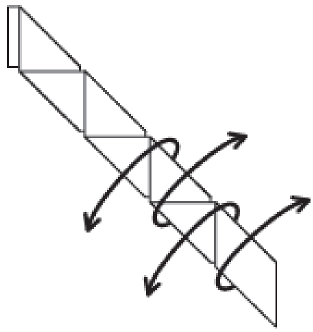

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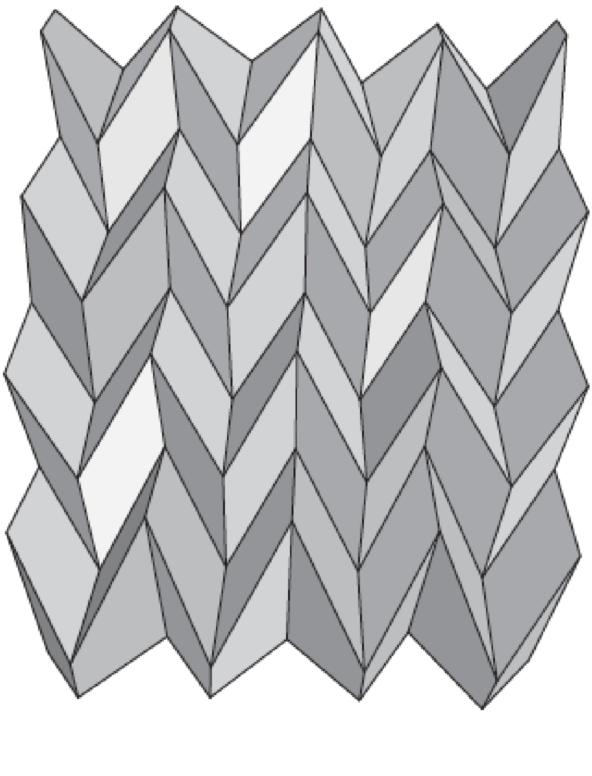


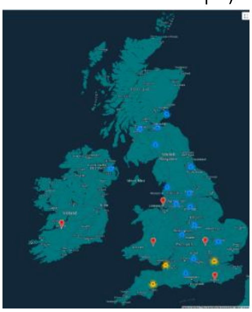
ABOUT THE NETWORK

About the Network

In March 2021, the UK Metamaterials Network started as a jointly funded endeavour between the EPSRC UK Metamaterials Network grant (EP/V002198/1), the UK's Defence and Security Laboratory (Dstl) and the Innovate UK KTN Commercialising Metamaterials Innovation Network. In March 2024 the EPSRC provided a further grant and the UK Metamaterials Network transitioned into the UK Metamaterials NetworkPlus running until September 2028.

The UK Metamaterials NetworkPlus will drive the development of a well funded, self-sustaining and world-class metamaterials-enabled UK ecosystem, benefiting the nation's science superpower status and contributing to our nation's security. It will continue to develop the vibrant and creative, multidisciplinary metamaterials community to accelerate novel and innovative metamaterials research and exploitation pathways.

The NetworkPlus's extensive promotion of the benefits of metamaterials technology (e.g., case studies; promotional material on social media; strategic documents for UKRI; etc.), facilitation of access to metamaterial experts and facilities (through the online database[2]) and closer interactions with end-users at appropriate events (e.g. industry-academia workshops) will help grow external investment in metamaterials research.



As of 1 May 2024, the NetworkPlus consists of members in the following categories:

- 694 Academia,
- 131 Industry,
- 46 RTO (Research and Technology Organisations),
- 12 Research Council or other funding body,
- 25 Government or policy organisation,
- 42 Other.

The NetworkPlus funding can be utilised to run conferences, workshops, discussion groups, and other collaboration building events through its Special Interest Groups and Forums, as well as profile raising initiatives and activities to support the talent pipeline development. The NetworkPlus will distribute funding through a Pump Prime Fund and a Small Grants fund to further its strategic priorities, delivering projects to promote and advance metamaterials research in the UK.

[2] https://metamaterials.network/expert-database/

The Dstl investment is dedicated to support summer studentships, the annual conference, and in particular the activities of the Microwave Thz Metamaterials Special Interest Group.

Governance structure

The NetworkPlus is governed on 3 levels:

- **Executive Board**
- Prof Alastair Hibbins (University of Exeter; co-lead)
- Dr Claire Dancer (University of Warwick, co-lead)
- Dr Helen Rance (University of Exeter, Science and Strategy Manager)
- Dr Katie Shanks (University of Exeter, joint investigator)
- Professor Andrea Di Falco (University of St Andrews, joint investigator)
- Dr Anton Souslov (University of Cambridge, joint investigator)
- Dr Simon Pope (University of Sheffield, joint investigator)
- Dr Tom Allen (Manchester Metropolitan University, joint investigator)

2. Voluntary Leadership Team

The management team is being supported by a strong group of academics, early career researchers, and industry representatives who are leading to focus areas:

- 6 Special Interest Groups (SIGs)[3], covering the core scientific metamaterials domains:
  - Acoustic Metamaterials
  - Active Metamaterials
  - Mechanical Metamaterials
  - Theory, Modelling and AI
  - Photonic Metamaterials
  - Microwave & THz Metamaterials

- 3 Challenge Areas[4]:
  - Metamaterials for Health
  - Metamaterials for Space &Aviation
  - Metamaterials for Sustainability
  - Metamaterials for Manufacturing & Scale Up

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[3] https://metamaterials.network/focus-areas

4

Honorary members of the Leadership Team are Dr Milo Baraclough, Dstl; Dr Jamie Williams, NPL; Prof Ian Youngs, Dstl; Dr David Newman (Public Engagement Manager)

The members of the Leadership Team dedicate their time voluntarily to drive Network activities forward and build this community.

3. External Advisory Board

The role of the External Advisory Board (EAB) is to provide advice on strategic direction and activities for the UK Metamaterials Network.

EAB membership:

- **Dr Jonny Blaker** (Research Area Lead: Biomedical Materials, the Royce Institute, UK)
- **Dr Zaffie Cox** (Senior Portfolio Manager for Advanced Materials / Physical Sciences, EPSRC, UK)
- **Prof Nader Engheta** (Professor of Electrical and Systems Engineering, University of Pennsylvania, US)
- **Mr Jason Field** (Head of S&T Commissioning, Defence Science and Technology, UK)
- **Prof Hugh Griffiths** (Chair of the Defence Science Expert Committee; Professor of Radio Frequency Sensor Systems, University College London, UK)
- **Prof Mike Hinton** (Consultant – R&T Partnerships, High Value Manufacturing Catapult, UK)
- **Prof Dame Jane Jiang** (Professor of Precision Metrology, University of Huddersfield, UK)
- **Prof Maria Kafesaki** (Assoc. Prof in the Dept. of Materials Science and Technology, University of Crete, Greece)
- **Prof Edmund Linfield** (Henry Royce Institute Research Area Lead for 'Atoms to Devices'; Director of Research and Innovation, University of Leeds, UK)
- **Dr Robert Quarshie** (Head of Materials and Nanotechnology, Innovate UK Business Connect, UK)
- **Dr Jessica Wade** (Lecturer in Functional Materials, Imperial College London, UK)

The EAB members have been appointed with a term time until the end of the Network funding in September 2024. The Board is chaired by **Prof Edmund Linfield**.

Thank you for joining the
UK Metamaterials Conference & Forum2024!

UK
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UK Metamaterials Conference & Forum 2024

One community, one voice.

SPONSORSHIP

The UK Metamaterials Conference & Forum 2024 is kindly sponsored by the Engineering and Physical Sciences Research Council (EPSRC) and the Defence Science and Technology Laboratory (Dstl).

Engineering and Physical Sciences Research Council

[dstl] The Science Inside

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