PhD Opportunity

Hydroacoustic Metamaterials for Focusing and Filtering of Underwater Sound

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Hydroacoustics is the study of the propagation of sound in water and the interaction of the mechanical waves that constitute sound with the water, its contents and its boundaries. It is a critical underpinning technology for a multitude of activities, ranging from oceanographic and environmental studies, offshore oil and gas, and defence, covering applications that include surveying, communication, navigation (SONAR) etc. This PhD project is concerned with the generation, transmission, and reception of sound in the underwater environment including the interaction between sound and underwater surfaces and structures. You will undertake your work within the research labs of the University of Exeter's Centre for Metamaterials Research and Innovation, and will be employed for the duration of the programme by Atlas Elektronik UK, an internationally leading maritime high-technology enterprise in the fields of hydroacoustics, sensor engineering and information technology.

Metamaterials are engineered materials with bespoke or artificial characteristics and functionality gained through intelligent, digital design of their structure. Metamaterials are a technology enabler, finding application across an enormous range of markets including energy, health care, imaging, transport etc. In particular, the benefits that metamaterials bring are particularly relevant to the terrestrial transfer of energy and information now ubiquitous in our everyday lives, through an increase in device functionality (e.g. bandwidth, security) and efficiency. However, despite intense efforts, there is still a huge gap between what we can do in air, and the equivalent underwater. This is mainly because undersea communication faces challenges including multi-path propagation, time-variations of the channel (e.g. scattering, refractive index changes etc), strong attenuation and small bandwidth. Hence communication underwater requires complex, expensive and cumbersome hardware. For example, devices typically use complex arrays of active transducers to generate beams of sound in the water. In this project we will tackle some of the challenges presented in the precise generation, manipulation and detection of sound in water using acoustic metamaterials [1] (AMMs). These AMMs will be designed using sub-wavelength structures to incorporate functional properties, such as acoustic filtering, absorption, impedance-matching, and focussing.

You will model, fabricate and characterise acoustic metamaterial structures that will underpin the science for the next generation of metamaterial based hydroacoustic devices. The work will build on our recent works in underwater acoustics that have investigated acoustic surface modes [2], beaming [3], and focussing [4]. We are particularly interested in understanding how to improve the detection ability of weak signals, through manipulation of phase fronts and beam profiles, as well as filtering out unwanted sources of sound. Each of these examples uses structure to manipulate the local acoustic field at the metamaterial/water interface to induce designer mode dispersions with properties such as negative or zero group velocities or diffraction to tailor the wave propagation and energy redistribution. As a recent example of the pioneering work developed in Exeter, Figure 1 shows an aluminium plate with two regions of concentric rings that modify Scholte (a type of elastic wave) modes on the plate causing diffraction and the radiation of sound to a focal point in the water above the sample, at which position a detector can be placed. We have been able to use our longstanding expertise in finite element method modelling to design and model the response of this structure, and have undertaken proof-of-principle experimental verification using our hydroacoustic facility within our lab. It is strongly anticipated that you will undertake a similar mix of theoretical, design and experimental work.

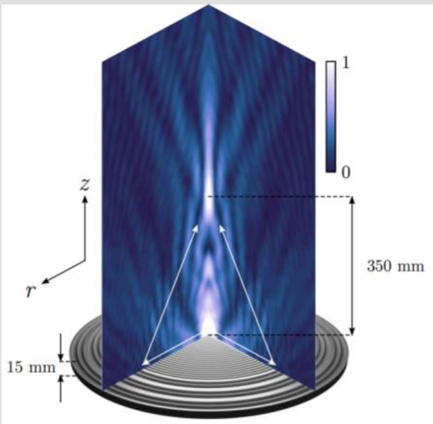

FIG. 1. Example of acoustic-focussing using Umklapp diffraction [4].

You will be employed full-time on band 3 in a permanent position by Atlas Elektronik UK. After a short induction at Atlas Elektronik's headquarters in Winfrith, you will undertake a 4 year PhD project as part of the Centre for Metamaterials Research and Innovation's doctoral training programme, the Centre for Doctoral Training in Metamaterials (XM2), and will be awarded a PhD in Physics/Engineering upon successful completion of the PhD programme. Since 2014, XM2 has been home to more than 100 PhD students (~55 active, ~50 graduates) and their individual research projects, embedded in strong academic groups and supervisor teams. The PhD students learn together in targeted courses, self-driven activity groups, and events with exposure to industry to gain scientific background knowledge beyond their areas of expertise, and to equip themselves with transferable professional skills such as creative thinking, project management, and leadership. To date, our graduates went on to careers in academia and industry, and started to act as role models for the next generation of researchers. We believe in the benefits of a cohort model that fosters knowledge exchange and peer support to prevent isolation.

Contact the student advisory group if you'd like to learn more about our doctoral training from your potential new peers!

You will spend the majority of your time at the University of Exeter although some aspects of the studies will be undertaken at Atlas Elektronik UK Winfrith (all expenses will be reimbursed). During the full-time PhD project, you will be encouraged to work up to 180 h per study year on different projects within the Atlas Elektronik UK Sonar team. Your project will benefit from a generous budget that will support external training activities, as well as funding small items of equipment, consumables and travel and subsistence for attending meetings and conferences.

More information

The successful candidate must be able to achieve full SC (Security Clearance).

How to apply

Please forward your CV and a covering letter explaining why you are suitable for this opportunity to Recruitment@uk.atlas-elektronik.com by the closing date and state the PhD Title in the subject line.

Due to the nature of our work and the projects you will be working on, all candidates must be eligible to gain security clearance. ATLAS ELEKTRONIK UK Ltd is an Equal Opportunities employer and welcomes applications for all posts from suitably qualified people regardless of age, disability, ethnicity, gender, marital status, sexual orientation, religion or belief.

Only successful applicants will be contacted.

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[1] SA Cummer, J Christensen, A Alu, Controlling sound with acoustic metamaterials, Nature Material Reviews, 1 (16001) 2016

[2] TJ Graham, AP Hibbins, JR Sambles, TA Starkey Underwater acoustic surface waves on a periodically perforated metal plate The Journal of the Acoustical Society of America 146 (6), 4569-4575, 2019

[3] TJ Graham, JD Smith, AP Hibbins, JR Sambles, TA Starkey Experimental characterization of acoustic beaming from an elastic plate by coupled symmetric leaky Lamb modes, Physical Review B 104 (4), 045105, 2021

[4] GJ Chaplain, RV Craster, N Cole, AP Hibbins, TA Starkey Underwater Focusing of Sound by Umklapp Diffraction, Physical Review Applied 16 (6), 064029, 2021