EPSRC DTP PhD Research Project

Project Title: Metamaterials for Wave Power

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PhD Programme: PhD Physics

Project Description:

Metamaterials have allowed unprecedented control of wave propagation across almost all wave regimes, from electromagnetism to elasticity. They comprise strategically placed building blocks (meta-atoms) that endow a material with exotic effective material properties, determining for example the wave speed, or energy absorption, that aren't usually possible to achieve naturally.

The harvesting of wave energy by metamaterials has emerged as a disruptive technology that requires input from physicists, mathematicians, and engineers. Given the inexorability of offshore ocean waves, metamaterials for wave power offer a potential for enhancing the efficiency of renewable energy sources.

This project will develop a new collaboration between the Centre for Metamaterial Research and Innovation (CMRI) at the University of Exeter, and the Supergen Offshore Renewable Energy (ORE) Hub at the University of Plymouth. the University of Plymouth's Centre for Decarbonisation and Offshore Renewable Energy (ORE), which hosts the Supergen ORE Hub – a £16.5M EPSRC funded programme which provides research leadership to connect academia, industry, policymakers and the public, inspire innovation and maximise societal value of offshore renewables.

The goal of this project is to adapt established design techniques to explore a range of submerged metamaterials for applications in offshore renewable wave power. Wave-energy harvesting will

feature, although other application areas may emerge as the research develops. The project will involve mathematical modelling, simulation, and experimentation.

The project takes advantage of the complementary expertise in the two institutions, with Exeter leading the design and simulation, with experimental realisation and a deep knowledge of fluid dynamics provided by Plymouth, using their state-of-the-art Coastal, Ocean and Sediment Transport (COAST) laboratory [2] (Fig. 1).

Initial aims of the project shall focus on applying the principles of metamaterial design and optimisation (e.g. effective medium theory, adjoint methods, and multipole expansions) to the governing equations of shallow and deep-water waves. Our design process will be split into three parts.

Firstly, periodic arrays shall be considered, predicting established phenomena such as band gaps and local resonance. Extensions to graded and disordered arrays [3,4] and experimental verification of dispersion engineering shall be explored via mathematical models and large-scale flume experiments. Secondly, optimisation of the array geometry shall be investigated in the waver wave system by applying the semi-analytical adjoint method, familiar in the context of electromagnetism [1], for the concentration of wave energy at harvester locations, where we shall explore the possibility of designing a concentrator that is robust to changes in wave conditions. Finally, the design methods shall also be applied to scatterer design, optimizing a variety of realistic power take-off mechanisms.

The PhD researcher will benefit from the soft-skill and scientific training associated with CMRI's hugely successful doctoral programme (100+ recruited), thus ensuring that they benefit with a broad skill set, for a career in academia or industry. They will also benefit from membership of the UoP COAST Engineering research group and CDORE research seminars as well as the Supergen ORE Hub network and Early career researcher training and masterclasses, including the UoP Masterclass on Advanced Experimental Fluid Mechanics for Offshore Renewable Energy (ORE).

Project specific enquiries:

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