**Space Plates for Acoustics**

DLA Summer Studentship Project Outline

R. Jansen-Van Rensburg\*, G.J. Chaplain, T.A. Starkey

\*rj429@exeter.ac.uk

Space plates are devices that effectively shrink space between a source and an observer. The space plate is a novel application of metamaterials, artificial materials that are engineered for certain properties by exploiting periodic relationships in their structure. Metamaterials have seen a rise in exploration over the past few years and are an actively evolving field. Space plates have so far only been applied to electromagnetic wave propagation, specifically in the optical and in the microwave regime [citation1,citation2]. The aim of this project would be to extend this work out to acoustics, both in air and underwater.

Transformation optics is the application of metamaterials tailored to manipulate electromagnetic waves in space in a particular way. The tailored space plates in Mrnka et al., are designed using Fabry-Pérot cavities. These work by essentially reflecting the waves back and forth within the cavity, the separation of the two plates determines the allowed frequencies within the cavity, and the accumulated phase difference due to the propagation within the space plate creates the illusion of having travelled much further in free space – essentially compressing space for an observer on the other side. In optics this has uses in shrinking optical equipment such as telescopes and cameras, as lenses can be brought closer together. In acoustics (**what is the benefit of making something sound further away as opposed to cancelling it out all together** + what specific industrial applications do we have in mind? Similar applications – in audio applications concert halls, home theatre, etc you may want your loudspeaker to sound like it is further away – or at least be able to change its apparent location)(will we be using acoustic Fabry-Pérot cavities or something else? – yes FP cavities for the airborne case, potentially Lamb-modes in elastic plates underwater).

Diagram of a diagram showing the lens and spaceplate

AI-generated content may be incorrect.

Figure 1 - add caption

As an extension to the project, we hope to model underwater space plates for acoustics. This presents further complexity in the acoustic-metamaterial coupling in the form of fluid–structure interactions, but also benefits, since regular bulk materials can have refractive indices that can be larger or smaller than surrounding water medium.

This project will take a multifaceted approach, employing analytical theory in the form of the transfer matrix method, model matching, numerical analysis using Multiphysics codes, and experimental validation using bespoke field-mapping equipment.

The ultimate goal of this project is to produce a working space plate for the acoustic domain, to function in air at audible frequencies. Time permitting these concepts will be translated to the underwater domain. The work done over the course of the project will hopefully form the basis of a publication in an appropriate journal.

Project would be hosted by Centre for Metamaterials Research and Innovation.

Project duration: 8 weeks, tentatively beginning [whenever we agreed]

References – either do classic references e.g. [1] and then collect the references here or do something like [Phys. Rev. Lett. 131, 176101 (2023)] within the text.

I had a few more questions too~~. First what's the title going to be – above~~. Then I did wonder how we are hoping to make this work for a wider range of frequencies [let’s not worry about that just yet], in the APL paper they talk about how compression factor and the "sharpness" of the resonance is linked meaning a narrower frequency band where the space plate is effective, if I understand that right [yes the q-factor of the resonance is a factor in the compression factor. We will determine the frequency of the FP-mode using a cavity and tune the Q of that cavity by tuning the partial mirrors that form the cavity]. How are we going to overcome that problem?