PhD Projects in Solid/Structural Mechanics and Mathematical Biology

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My expertise lies at the interface between mathematics on one hand, and solid/structural mechanics and biology on the other hand. Current projects include adaptive structures, wound healing and electroreception in bees.

1 Adaptive Structures

An adaptive structure is one which can change its external shape, internal connectivity or the stiffness of its structural elements in response to changing structural loads, with minimal external control. For example, consider an aerofoil whose shape can change in response to changing aerodynamic loads. Such an aerofoil could continually adapt its shape to surrounding atmospheric conditions (e.g. air pressure, wind velocity) and as the flight regime changes (e.g. from take-off to cruising). It could thus take on optimal—or closer to optimal—shape throughout the flight, with consequent economic and environmental benefits.
The mathematical study of adaptive structures is a young field with much yet to be explored. Possible research questions include:

- Designing structural elements such as beams, plates and shells with bespoke elastic properties. See articles 1 and 3 for related work.
- Characterising the stable states of trusses and frameworks with multistable elements. See article 2 for related work.

Sample Publications

1. I. V. Chenchiah, *Bespoke two-dimensional elasticity and the nonlinear analogue of Cauchy's relations*, Mathematics and Mechanics of Solids. doi: 10.1177/10812865231198204
2. M. P. O'Donnell, M. Towes, R. M. J. Groh, I. V. Chenchiah, *Exploring adaptive behaviour of non-linear hexagonal frameworks*, Frontiers in Materials, 7, 64, 2020 doi: 10.3389/fmats.2020.00064
3. M. D. X. Dixon, M. P. O'Donnell, A. Pirrera, I. V. Chenchiah *Bespoke extensional elasticity through helical lattice systems*, Proceedings of the Royal Society of London A, 475 (2232), 20190547, 2019 doi: 10.1098/rspa.2019.0547

2 Electroreception in Arthropods

Bees (and other arthropods) can sense electric fields in the environment, and it is conjectured that they use this sense, known as electroreception, to interact with their environment. For an introduction to this topic, watch a recent research talk by me on TouTube: https://www.youtube.com/watch?v=K-NJLybn8Qs.
Mathematical models help us understand the possibilities and limits of this recently-discovered sensory modality. Possible research questions include:

- *Modelling of electric memory*: How could bees remember an electric environment and determine if a location has already been visited?
- *Electroreception and vision:* How is electroreception integrated with vision?

Sample Publications

1. R. A. Palmer, I. V. Chenchiah, D. Robert, *Passive electrolocation in terrestrial arthropods: Theoretical modelling of location detection.* Journal of Theoretical Biology, 558, 111357, 2023. doi:10.1016/j.jtbi.2022.111357.

2. R. Palmer, I. V. Chenchiah, D. Robert, *The mechanics and interactions of electrically-sensitive mechanoreceptive hair arrays of arthropods.* Journal of the Royal Society Interface,19, 20220053, 2022. doi:10.1098/rsif.2022.0053.