Preprint **Bearon R and Lynch S, Microswimmers and Computing at Leicester British Science Festival 2022, IMA Mathematics Today 58(6), p184**

Microswimmers and Computing at Leicester BSF

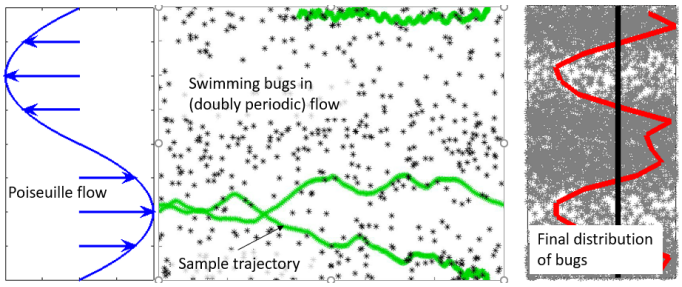
The British Science Festival (BSF) 2022 was held in Leicester, hosted by De Montfort University (DMU), 13–17 September. The two speakers proposed by the Mathematical Sciences Section (run by Tony Mann and Peter Giblin) were Rachel Bearon (University of Liverpool, President of the Section) and Stephen Lynch (Manchester Metropolitan University, National Teaching Fellow).

The maths of microswimmers

The location had particular personal significance as my late father was a principal lecturer in Engineering at DMU, and I was delighted to have a strong contingent of family and friends in the audience.

As a passionate ambassador of mathematics, I began by highlighting why I love the subject – in terms of breadth of applications but also from the perspective of intrinsic human curiosity. The main focus of my talk was *The Maths of Microswimmers*, and I aimed to give a taste of my research, whilst also making connections to the mathematics of A-level mechanics.

Beginning with calculating the optimal initial angle for maximum range of a cannonball, I spoke about ordinary differential equations, trigonometry and Newton's laws, before progressing onto low Reynolds number hydrodynamics and the collective dynamics of microswimmers using the modelling tools of partial and stochastic differential equations.



Swimming rod-shaped bugs accumulate in high shear regions

I highlighted research from two specific projects I am actively working on. Firstly, on the role that elongation, or chain-forming, has in the vertical migration of swimming algae in the turbulent ocean – this is a collaboration with William (Mack) Durham at the University of Sheffield. Secondly, a project looking at the effect of shape and shear on bacterial transport in confined geometries [1], which has implication on biofilm formation. This project is in collaboration with Bakhti Vasiev and Smitha Maretvadakethope at the University of Liverpool, and Andrew Hazel at the University of Manchester, and is supported by EPSRC EP/S033211/1.

Rachel Bearon FIMA
University of Liverpool, President of the Section

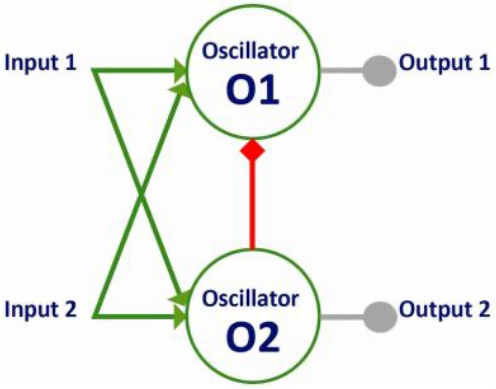
Brain-inspired computing

The campus was rather quiet when I arrived early, so I was pleasantly surprised when over 50 people turned up for my talk, which was entitled *Brain-Inspired Computing*. This is a talk that I regularly deliver to school children aged 13–18 in the North-West of England as part of widening participation. I am attempting to turn school pupils onto mathematics by showing them how a simple idea in maths can lead to big applications in the real world.

In my talk, I described how neurones work in the brain. I then proceeded to explain about binary threshold logic and memory, and indicated how our invention could lead to important applications in both computing and medicine.

… showing them how a simple idea in maths can lead to big applications …

For those interested in the invention, in a recent development, our logic circuits have been implemented using memristors [2]. A memristor has only recently been discovered, it is the fourth fundamental component in electronics and acts like a resistor with memory.



A binary threshold oscillator half-adder.

We have also recently obtained some exciting results with Josephson junctions and expect to have some research papers published in the coming months. Like biological neurones, Josephson junctions are also threshold oscillators, however, they consume far less energy, can be built one thousand times smaller, and oscillate 100 million times faster!

Stephen Lynch FIMA
Manchester Metropolitan University, National Teaching Fellow

References

1 Maretvadakethope, S. et al. (2022) The interplay between bulk flow and boundary conditions on the distribution of microswimmers in channel flow, arXiv preprint, arXiv:2209.05973.

2 Fang X., Duan S. and Wang L. (2022) Memristive FHN spiking neuron model and brain-inspired threshold logic computing, *Neurocomputing* (in press), doi:10.1016/j.neucom.2022.08.056.