PhD project outline

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How to build a swarm

Background

Understanding collective phenomenon in interacting particle systems is currently an extremely hot topic, both in thermodynamic systems (thermophoresis, diffusiophoresis etc) and in animal systems (flocks of birds, swarms of insects). As well as having having the eye of editors in the very highest profile journals the field also has numerous potential technological applications in, e.g. building out-of equilibrium materials or swarm computing, CGI graphics, crowd/pest control etc, respectively.

Project description

The student would work on developing a new model for collective motion in animal systems. This would involve analysing self-propelled particle model that include short term memory, i.e. an equation of motion that extends beyond one discrete timestep into the past. While a completely new development in the field these models will be relatively easy to write down and analyse. What has been missing is a good motivation for what the mathematical structure of this model should be, given the extremely large space of candidate models that would seem to exist *a priori*. Building on previous work from the group we believe that there is a good philosophy to select a structure for this model. This is based on building the simplest models that are consistent with the animal's vision, itself involving a projection of a 3D field of objects onto a 2D (black-and-white) pattern, e.g. on the retina of a bird.

The potential for impact is very substantial. Recently my group has published several papers, including one in *Proceedings of the National Academy of Sciences* just a few weeks ago [1], that have attracted much attention, both within the scientific community and in the wider public: I was recently told by one of our University PR staff that the publicity generated by this work represents one of the University's most successful news stories of 2014 with a value (assigned by them) of $\sim$ £ 250k.

Depending on the student's background and interests the project could either be purely theoretical/computational or could involve part theory and part experiment: we have been developing protocols to work on tethered insects within our lab for the last 18 months that offer the possibility of testing any models that we develop *in vivo*. Combinations of theory and experiment like this tend to have a better chance of publication in the very best journals. The co-supervisor on this project would be Dr Marco Polin, who would also contribute experimental expertise, if required.

References

[1] The Role of Projection in the Control of Bird Flocks, D. J. G. Pearce, A. M. Miller, G. Rowlands and M. S. Turner, Proc. Nat. Acad. Sci., 111, 10422 (2014).