Dynamics in social fluids

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Bird flocks, insect swarms and fish shoals resemble fluids made up of many individuals where the controlling interactions are social rather than physical in character [1]. Some progress has been made reverse-engineering candidates for these interactions that are local in space, either in a metric-based [2] or topological sense [3, 4]. A question that has been largely overlooked is whether the interactions should be expected to be local at all. We discuss the evidence for them having a non-local character and, furthermore, that there is a natural choice for this that is consistent with the cognitive limitations of a bird's vision. This leads us to propose a non-local *hybrid-projection* model. We study the global character of the flocks that emerge from this model and their various phenotypes. Most significantly, an emergent state arises in which the probability that a typical bird can see out (sky) in any direction divided by the probability that its view is blocked by other bird(s) is O(1). We refer to this as *marginally opaque*, see Fig. 1. We present experimental data on bird flocks that confirm this prediction. Finally, we discuss how these models may naturally be associated with evolutionary fitness, as well as being physiologically plausible.

Figure 1: The centre panel is an image of a real flock of Starlings. It is *marginally opaque*. The left and right panels show the same image artificially doctored so as to resemble states that would have a very low (≪1) or a very high (≈1) opacity, respectively.

References

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