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Birds, magnets, soap, and sandblasting: surprising connections in the theory of incompressible flocks

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In this talk Ill describe the hydrodynamic theory of the motion of incompressible flocks: that is, collections of self-propelled entities (birds) that are packed so tightly together that their density cannot change as they move. In two dimensions, this problem can be mapped onto an equilibrium magnet with a peculiar constraint. This problem, in turn, can be shown to be equivalent to a 2d smectic (soap), with the flow lines of the flock playing the role of the smectic layers. Finally, this smectic problem can be mapped onto the 1+1 dimensional KPZ equation, which describes the growth or corrosion (sandblasting) of a one dimensional interface. The scaling properties of this last system, which have been known exactly for a long time, can thereby be used to determine those of incompressible 2d flocks. One important implication of the resulting scaling laws is that such flocks can exhibit long-ranged order in two dimensions, unlike their equilibrium counterparts.