Lectures on alignment models of collective behavior
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In this series of lectures we present basic principles of emergent dynamics in systems governed by laws of self-organization. Such systems arise in a variety of applications including biological (swarming behavior of animals), social (opinion dynamics, social networks) and technological contexts (cosmology, robotics, etc). A particular focus will be placed on the so-called Cucker-Smale models, which encode one of the simplest communication protocols that lead to two fundamental phenomena of collective action: alignment and flocking. We will start with elementary proofs of alignment in various scenarios involving local and global communications kernels, address the issues of collision between agents. Mean-field limit and hydrodynamic models will be presented in the second part of the lectures, and we address the problems of global well-posendess, long time behavior, and stability of flocks on the macroscopic (large crowd) level. Finally, we discuss singular and topological kernels within the same Cucker-Smale context, which have been recently introduced to demonstrate how global collective phenomena emerge from purely local communication. These models present many new challenges to the regularity theory of fractional parabolic PDEs, which we will also discuss if time permits.