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Well-posedness of aggregation-diffusion equations and systems with irregular kernels

In this talk, I will discuss some recent progress towards understanding properties of solutions to the aggregation-diffusion equation

$$\partial_t u = \Delta u + \nabla \cdot (u \nabla (W * u)),$$

where $W * \cdot$ denotes a spatial convolution with a kernel W on either $\mathbb{R}^d$ or $\mathbb{T}^d$. When W is sufficiently regular (e.g., $\nabla W \in L^\infty$), spatial derivatives can be transferred to W , and the existence and uniqueness of solutions follows from standard parabolic theory; in practice, kernels need not be differentiable, and one must use the regularity of u to deduce further information on the potential $W * u$. I will present some recent results regarding the existence and uniqueness of weak (and sometimes classical) solutions for merely bounded kernels (i.e., $W \in L^\infty$) under two regimes: a **small mass** regime, and an **arbitrary mass** regime with some additional structural requirements. I will then discuss how these results translate to the multi-species system with a matrix of bounded interaction kernels, highlighting what is known and where gaps remain. This is joint work with José Carrillo and Jakub Skrzeczkowski.