Massive Particle Systems, Wasserstein Brownian Motions, and the Dean--Kawasaki SPDE

Lorenzo Dello Schiavo

ISTA

Host: Jan Maas

Let W be a conservative, ergodic Markov diffusion on some arbitrary state space M, converging exponentially fast to equilibrium. We consider: (1) Systems of up to countably many massive particles in M, with finite total mass. Each particle is subject to an independent instance of the noise W, with volatility the inverse mass carried by the particle. We prove that the corresponding infinite system of SDEs has a unique solution, for every starting configuration and every distribution of the masses in the infinite simplex. (2) Solutions to the Dean--Kawasaki SPDE with singular drift, driven by the generator L of W. We prove that the equation may be given rigorous meaning on M, and that it has a unique distributional solution. This extends Konarovskyi--Lehmann--von Renesse's ill-posedness vs. triviality' to the case of infinitely many massive particles.(3) Diffusions with values in the space P of all probability measures on M, driven by the geometry induced by L.(4) In the case when M is a manifold, differential-geometric and metric-measure Brownian motions on P induced by the geometry of optimal transportation and reversible for a normalized completely random measure.We show that all these objects coincide.

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