K-branching random walk with noisy selection: large population limits and phase transitions

C. Desmarais[a], *E. Schertzer*[b], *and Z. Talyigás*[c]

[a] TU Wien.

[b] University of Vienna.

[c] BOKU University.

Branching particle systems with selection have recently received significant attention as models for understanding the interplay between reproduction, competition, and evolutionary dynamics. In this talk, I will present results on a K-particle branching random walk with noisy selection. At each generation, K particles lie on the real line with their position representing fitness. The particles first undergo a reproduction phase, in which each particle gives birth to a fixed number of children whose positions are independent and identically distributed random displacements from their parent's position. This is followed by a noisy selection phase whereby K particles are randomly selected from the offspring population with selection probabilities favouring fitter individuals.

For a general class of reproduction distributions, we provide an asymptotic description of how the population distribution evolves from one generation to the next. For displacement probabilities with exponential tails we prove the existence of asymptotic travelling wave solutions for the population distributions. These solutions undergoees a phase transition as the selection pressures vary. In what we call the *survival of the fittest* regime, with high probability all of the fittest individuals past a certain threshold are selected. In the other regime, with high probability none of the fittest individuals past a certain threshold are selected, what we call *survival of the luckiest*.

This is joint work with Emmanuel Schertzer and Zsófia Talyigás, and is available on arXiv [1].

References:

[1] C. Desmarais, E. Schertzer, and Z. Talyigás, K-Branching Random Walk with Noisy Selection: Large Population Limits and Phase Transitions, *available online at* `https://arxiv.org/abs/2509.26254`, (2025).