A Mathematical Particle Machine: Coupled Dynamics, Generative Structure, and Interactive Fields

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Abstract

We introduce a mathematical particle machine: a discrete-time dynamical system of interacting particles governed by coupled forces, oscillatory fields, and stochastic perturbations. We present stability results and demonstrate emergent structure through an embedded animation.

1 Model

We consider particles $x_i(t) \in \mathbb{R}^2$ with velocities $v_i(t)$:

$$v_i(t+1) = (1-\gamma)v_i(t) + F_i(x(t)) + G_i(x_i(t), t), \tag{1}$$
$$x_i(t+1) = x_i(t) + \Delta t\, v_i(t+1). \tag{2}$$

Interaction term:

$$F_i(x) = \sum_{j \neq i} \phi(\|x_j - x_i\|) \frac{x_j - x_i}{\|x_j - x_i\|}$$

Generative field:

$$G_i(x,t) = \alpha \nabla \Psi(x,t), \quad \Psi(x,t) = \sin(\omega t + \kappa \|x\|^2)$$

2 Emergent Structure

Oscillatory forcing produces rotating shells and filamentary structures. Stability depends on damping γ and forcing amplitude α.

3 Animated Illustration

Below is a procedurally generated animation of particles evolving under a simplified version of the system.

`https://www.aamot.io/~ole/partikkelmaskin.html`

4 Discussion

This animation illustrates a rotating particle field driven by oscillatory dynamics. Even simple sinusoidal forcing produces coherent structure.

5 Conclusion

The particle machine provides a minimal yet expressive framework for studying emergent dynamics. Future work includes continuum limits and control optimization.