

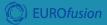


KDMC development in Eiron

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DiPICITiation Consortium, Fanden by the European Usion via the European Research and Training Programme Scant Agreement No. 191522200 – EVORvisein V. New and epinions represent a provime those of the authority only and de ant necessarily when the European Usion nor the European Commission. Neither the European Usion nor the European Commission can be hild reported for them







Kinetic equations

- Individual particles in position-velocity phase space (X_t, V_t, t)
- Evolution of distribution follows kinetic equation

$$\partial_t f(x,v,t) + \frac{v}{\epsilon} \partial_x f(x,v,t) = \frac{1}{\epsilon^2} Q(f(x,v,t))$$

Velocity jump process



$$dX_t = \frac{V_t}{\epsilon} dt, \quad V_t = \mathcal{V}^n, \quad t \in [t^n, t^{n+1}),$$
$$\mathcal{V}^n \sim \mathcal{M}(v), \quad t^{n+1} - t^n \sim \mathcal{E}(1/\epsilon^2)$$



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Kinetic equations

Velocity jump process

$$dX_t = \frac{V_t}{\epsilon} dt, \quad V_t = \mathcal{V}^n, \quad t \in [t^n, t^{n+1})$$

• $\epsilon \to 0$: Time between collisions $t^{n+1} - t^n \to 0$

Brownian motion

$$X^{n+1} = X^n + \sqrt{2\Delta t}\sqrt{D}\xi^n, \quad \xi^n \sim \mathcal{N}(0,1)$$

Output: Plasma source terms

$$S(x,t) = \int \Psi(x,v,t) f(x,v,t) dv$$



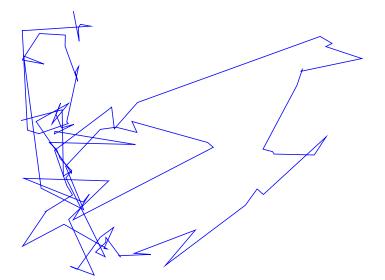
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Kinetic trajectory





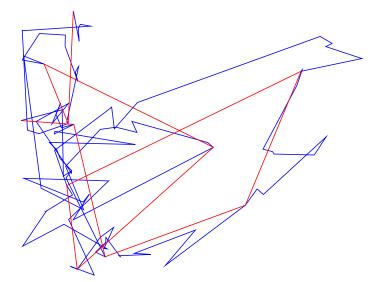
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Kinetic-diffusion trajectory





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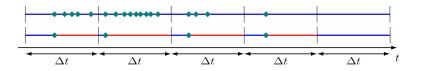




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Kinetic-diffusion

- General idea: replace many kinetic steps with a diffusive step
- Advantage:
 - Less computational work
- Issues:
 - Different particle timestepping behavior
 - Loss of intermediate path information



B. Mortier, M. Baelmans, G. Samaey, A Kinetic-Diffusion Asymptotic-Preserving Monte Carlo Algorithm for the Boltzmann-BGK Model in the Diffusive Scaling. SIAM Journal on Scientific Computing 44(2) pp. A720–A744 (2022)



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Current status

- KDMC timestepping added to code base
- Developed comparison test-case
- Consistency test: Kinetic and KDMC should match as
 - $\Delta t \to 0$
 - Collision rate $\rightarrow \infty$
- Estimators for diffusive simulation
- Multilevel extension
 - Many trajectories with Δt large
 - Correction with fewer correlated pairs



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