Long-time tails in sheared fluids

Hisao Hayakawa
collaboration with Michio Otsuki（YITP）
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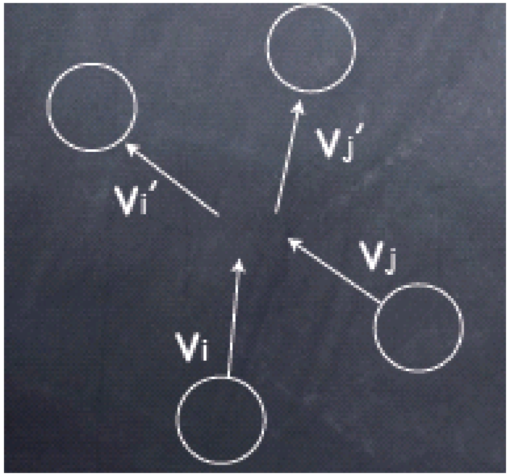
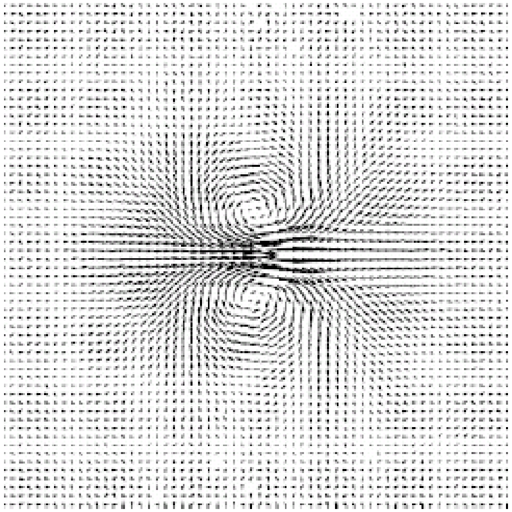
Systems we are considering

- Let us consider hard-spherical particles.
- Particles have the restitution constant e.
  - granular particles: e<1
  - elastic par





Back flow effect due to correlations observed in the simulation by M. Isobe (2007).

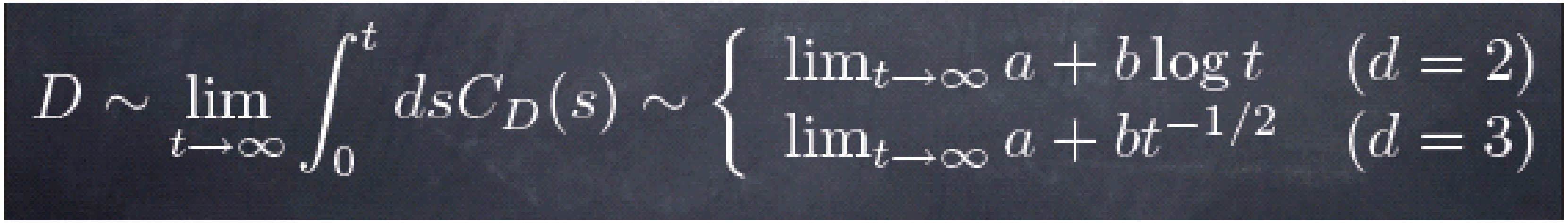
One-point lesson on long-tails

- The current correlation obeys a power law.
- The velocity autocorrelation obeys

$$C(t) =< v(0)v(t) >\propto t^{-d/2}$$

where d is the spatial dimension.

- Transport coefficient diverge for d<=2.

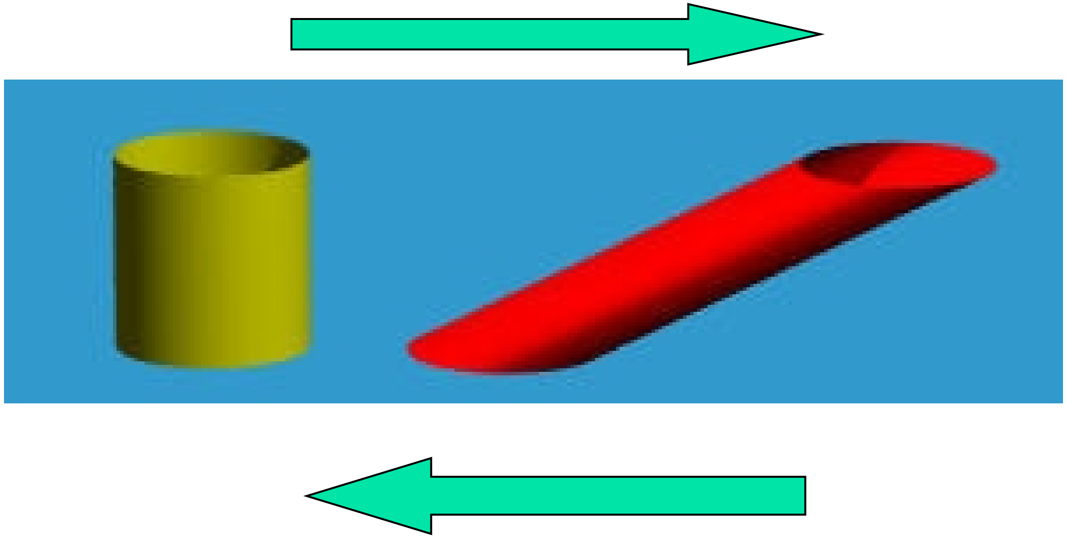


$$D \sim \lim_{t\to\infty}\int_0^t ds C_D(s) \sim \begin{cases} \lim_{t\to\infty} a + b\log t & (d=2) \\ \lim_{t\to\infty} a + bt^{-1/2} & (d=3) \end{cases}$$

Affine transformation in sheared fluids

- Wave number is transferred.

$$\boldsymbol{q}_t \equiv \boldsymbol{q}(t) = (q_x, q_y + \dot{\gamma} q_x t, q_z), \quad \tilde{t} = t$$



Long-tails in a sheared fluids

- Based on the phenomenological theory by using the linearized hydrodynamics, we obtain

$$C(t) \propto t^{-d/2} \quad \text{for } t < 1/\dot{\gamma}$$

$$C(t) \propto t^{-d} \quad \text{for } t > 1/\dot{\gamma}$$

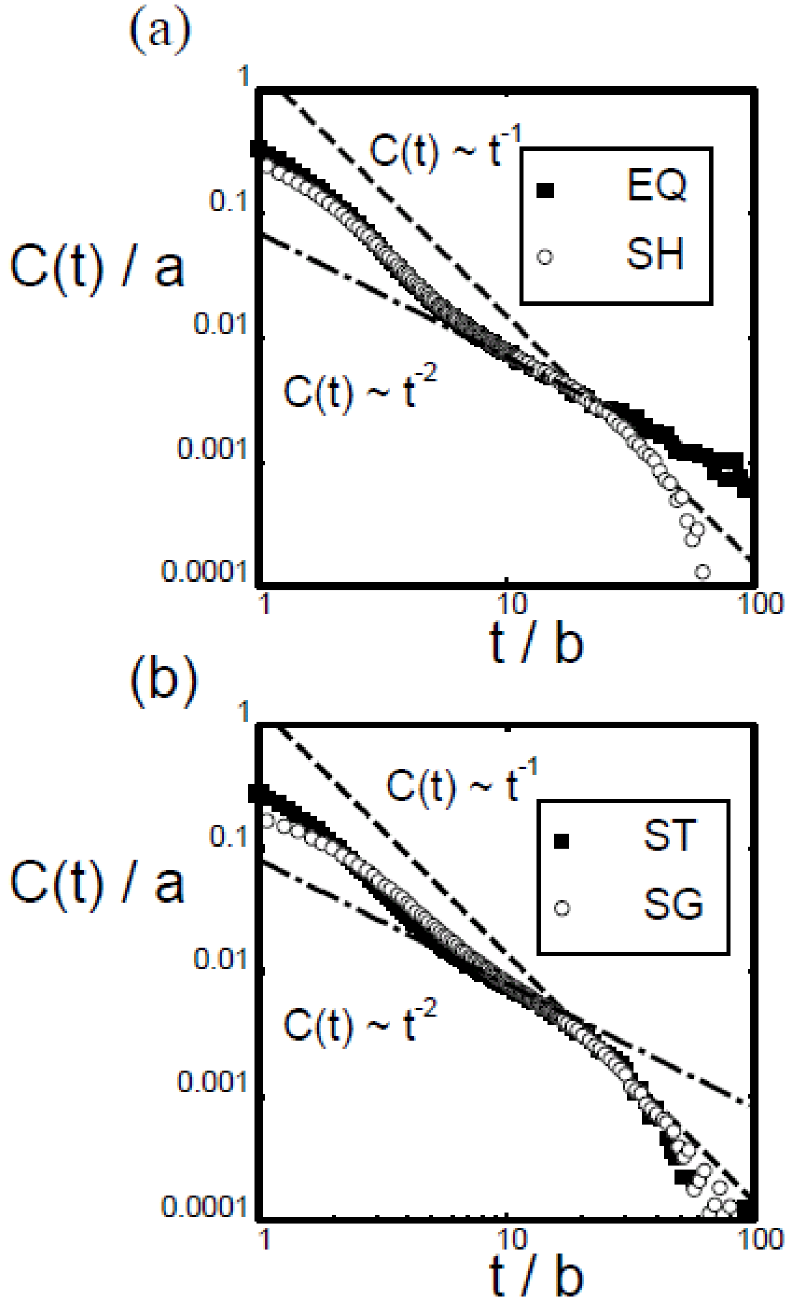
Sheared heating system

$$C(t) \propto t^{-(d+2)/2} \quad \text{for } t > 1/\dot{\gamma}$$

Isothermal fluids (thermostat & granular)

Simulation

- The results are consistent with the theoretical predictions.
- Sheared granular fluid are one of isothermal fluids.



$\dot{\gamma}$ dependence of D

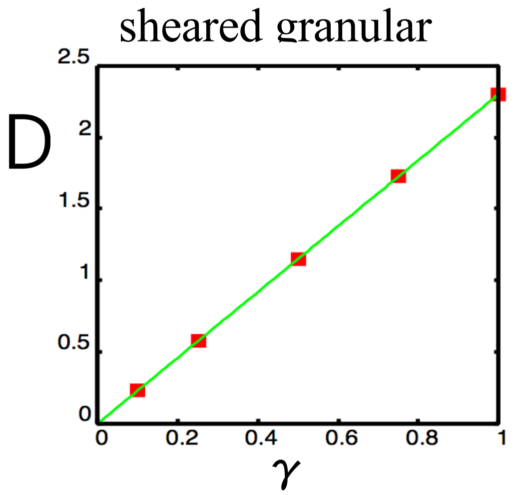
The system with thermostat

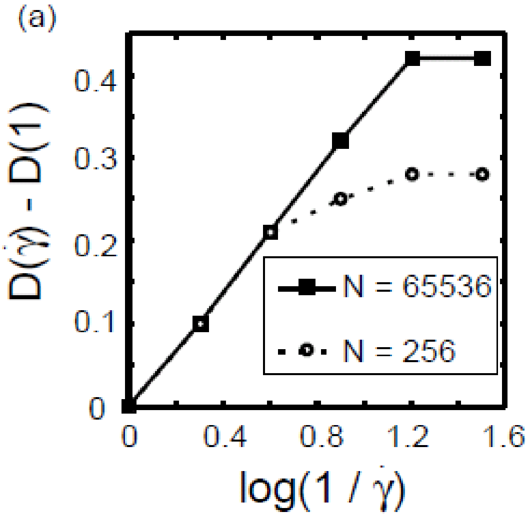
$$D \sim \begin{cases} a - b \log \dot{\gamma} & (d = 2) \\ a + b\dot{\gamma}^{1/2} & (d = 3) \end{cases}$$

Sheared granular system

$$D \sim \int dt C_D(t) \sim \dot{\gamma}$$

The relation is independent of d





The other transport coefficients also have similar relations.

Summary

- Heating system (without dissipation) may be in different universality class.
- Thermostat systems and granular systems may belong to the same universality class.
  - Temperature is determined by the shear rate in granular systems.