Emergent hydrodynamics in integrable quantum systems out of equilibrium

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TQFT2016, Riken, August, 2016

Based on **arXiv:1605.07331**

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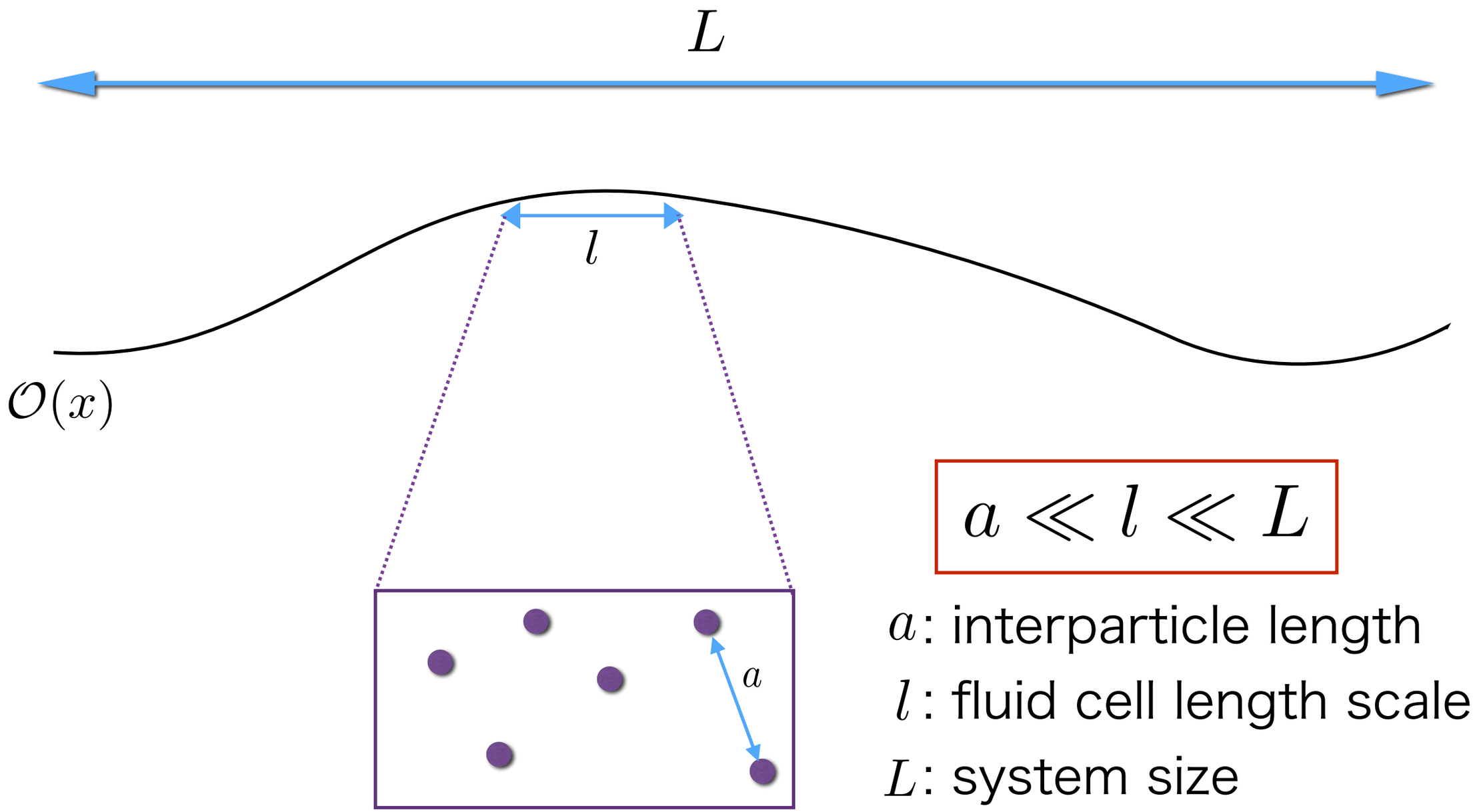
Separation of scale



$$a \ll l \ll L$$

a: interparticle length

l: fluid cell length scale

L: system size

Locally thermal!

We propose a novel hydrodynamic theory for integrable systems

Conventional hydrodynamics

Conserved charges:

Energy, momentum, U(1) charge, etc.

Dynamics:

$$\partial_t n + \partial_x (nv) = 0$$

$$\partial_t v + v\partial_x v = -\frac{1}{mn}\partial_x \mathcal{P}$$

Locally Gibbs ensemble

Generalized hydrodynamics

Conserved charges:

Infinitely many!

Dynamics:

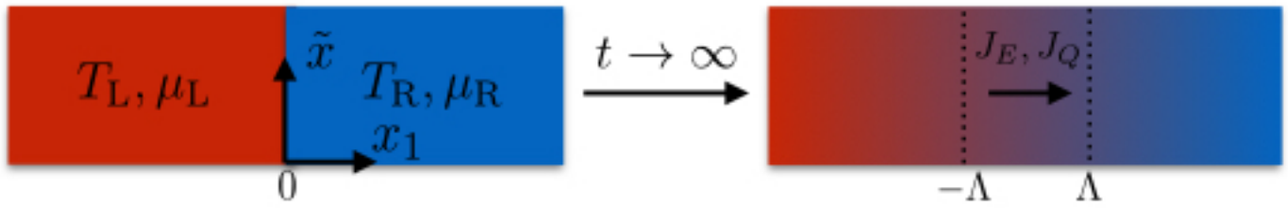
$$\partial_t \rho_{\rm p}(\theta) + \partial_x (v^{\rm dr}(\theta)\rho_{\rm p}(\theta)) = 0$$

$$\partial_t n(\theta) + v^{\rm dr}(\theta)\partial_x n(\theta) = 0$$

Locally GGE

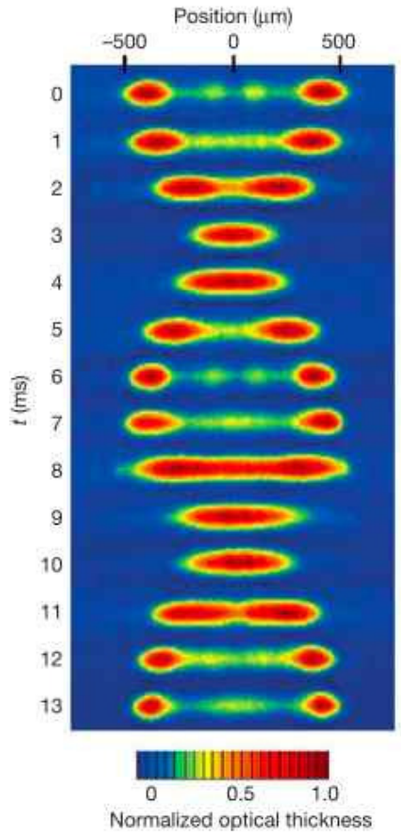
Applications

- Local quench ✓



- Quantum explosion of the Lieb-Linger gas ✓

- Quantum Newton's cradle ✓



- Transports in quantum dots

- Many possible applications!