Damping of Josephson oscillations in strongly correlated one-dimensional atomic gases

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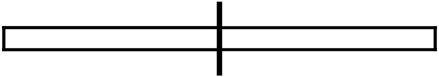
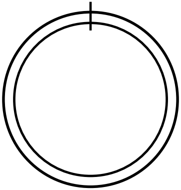
Coupled finite wires and ring





Wires

Infinite 1D coupled wires have been previously investigated showing dissipation [1]

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Closed loops present new possibilities, especially for studying current dynamics and superfluidity [2]

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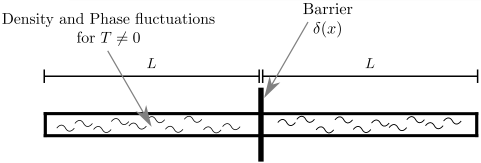

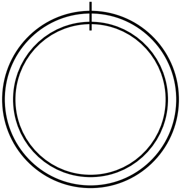

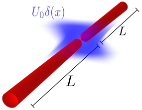

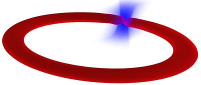

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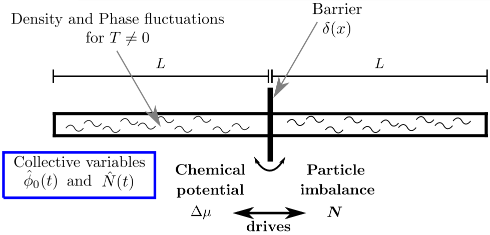

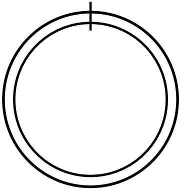

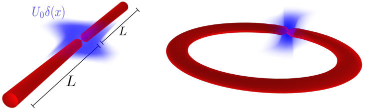

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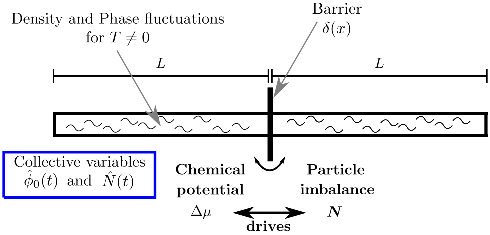

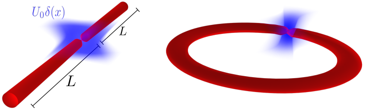

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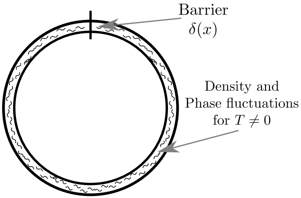

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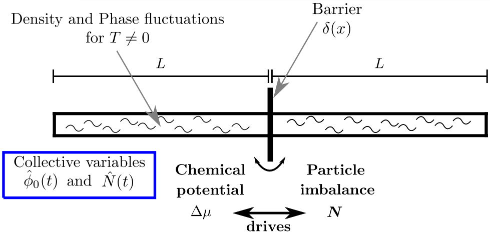

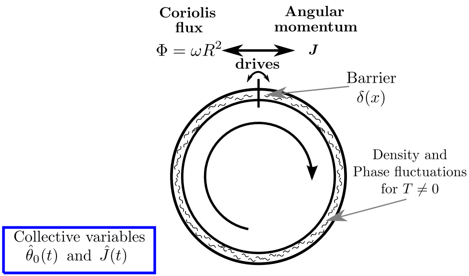

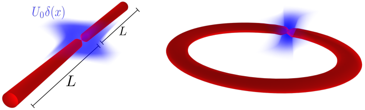

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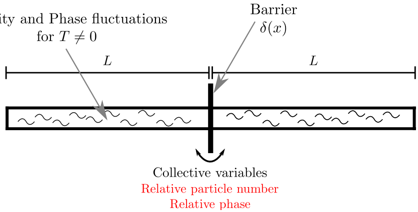
1D Finite wires with strong barrier

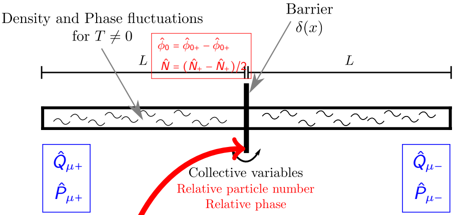


Luttinger Hamiltonian

$$H_{LL\pm} = \frac{\hbar v K}{2} \int_0^{\pm L} dx \left[\left(\partial_x \phi_\pm(x,t) \right)^2 + \frac{1}{K^2} \left(\partial_x \theta_\pm(x,t) \right)^2 \right]$$

$$H_b = E_J \cos\left(\phi_+(0) - \phi_-(0) \right)$$

1D Finite wires with strong barrier



Effective Hamiltonian

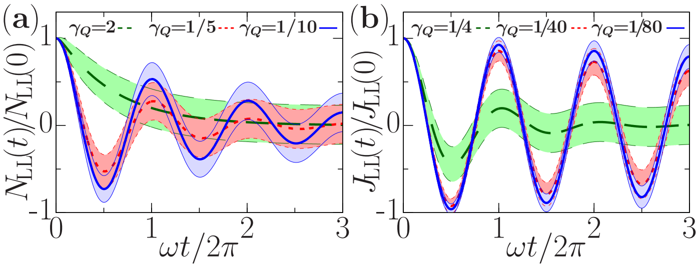
$$\hat H = \overbrace{\underbrace{\frac{\hbar^2}{2ML^2}\hat N^2}_{\text{“Potential term”}} - \underbrace{E_J \cos\left(\hat\phi_0\right)}_{\text{“Nonlinear Kinetic term”}}}^{\text{Quantum particle}} + \sum_{\mu\geq 1}\left[\overbrace{\underbrace{\frac{\hat P_\mu^2}{2M} + \frac{1}{2}M\Omega_\mu^2\hat Q_\mu^2}_{\text{“Harmonic bath”}}}^{\text{Bath}} + \overbrace{\underbrace{\frac{\sqrt{2}\hbar}{ML}\hat N\hat P_\mu}_{\text{“Coupling”}}}^{\text{Interaction}} + \underbrace{\frac{\hbar^2}{ML^2}\hat N^2}_{\text{“Renormalization”}}\right]$$

$$M = \frac{\hbar K}{2\pi v L} = \frac{K^2}{2\pi^2 N_0} m \qquad \Omega_\mu = v k_\mu$$

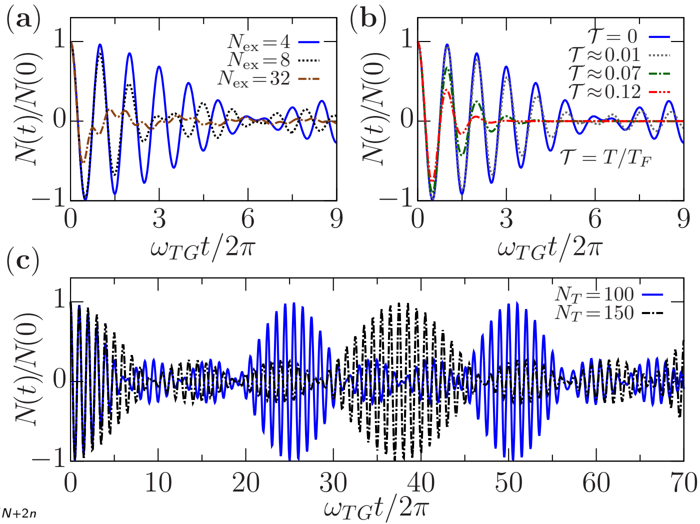
Classical limit results within the Luttinger liquid approach

Quantum particle coupled to a bath $\Longrightarrow$ **Quantum Langevin equation of motion**

Classical limit shows the main dynamical features



Exact Tonks-Girardeau method



$$\omega_{TG} = \frac{1}{N_{ex}} \sum_{n=-N_{ex}/2+1}^{N_{ex}/2} \omega_{N+2n}$$