

Problem 1

Nagaoka bags

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Let's use Caldeira-Leggett equation:

$$\frac{d}{dt}\rho_S(t) = -\frac{i}{\hbar} [H_S, \rho_S(t)] - \frac{i\Gamma}{2\hbar} [x, \{p, \rho_S(t)\}] - \Lambda [x, [x, \rho_S(t)]] \quad (1)$$

Where

$$\Lambda = \frac{2m\Gamma k_B T}{\hbar^2} \quad (2)$$

$$[x, [x, \rho_S]] = [x, x\rho_S - \rho_S x] = xx\rho_S - x\rho_S x - x\rho_S x + \rho_S x x = x^2\rho_S - 2xx'\rho_S + x'^2\rho_S = (x - x')^2\rho_S \quad (3)$$

In a first approximation, we can solve eq (1) using part of hamiltonian

$$\rho_S(t, x, x') \simeq \exp [-\Lambda(x - x')^2 t] \rho_S(0, x, x') \quad (4)$$

$$\tau_D = \frac{1}{\Lambda \Delta x^2}, \Delta x = |x - x'| \simeq L \quad (5)$$

Finally,

$$\tau_D = \frac{\hbar^2}{2m\Gamma k_B T} \quad (6)$$