Entanglement dynamics → understanding Non equilibrium quantum many body systems?

Why study the dynamics of entanglement in a non-equilibrium quantum many body isolated system of Rydberg atoms

1. Gives us insights to how information spreads in our system (how fast does information spread, can quantum transports protocols be creates)
2. Gives us insights to what extent our system thermalises (how does quantum statical mechanics emerge? do we get strong ergodicity breaking phenomena (MBLs), weak ergodicity break phenomena (scars), where on the scale are we)

Both help with developing an understanding of the phenomena governing our system. Useful for quantum control.

Thermalisation

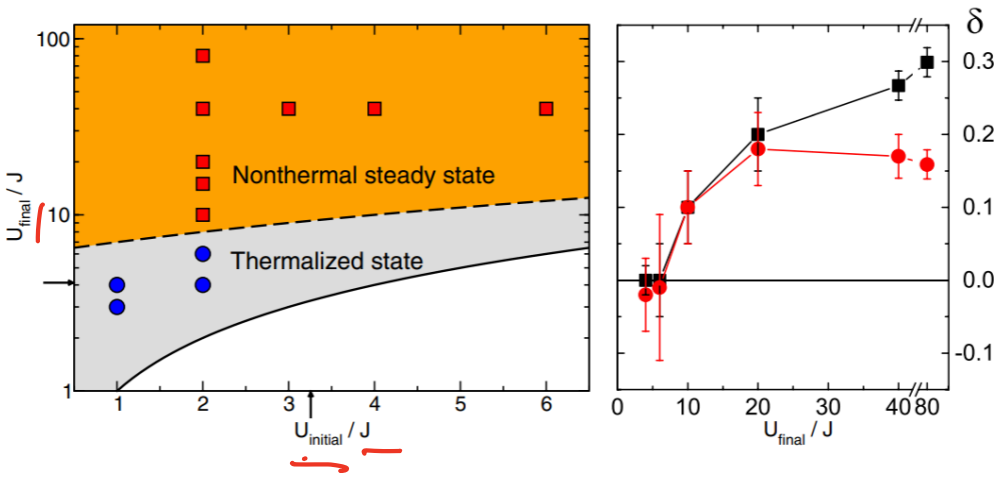
→ global observables reach a steady state value

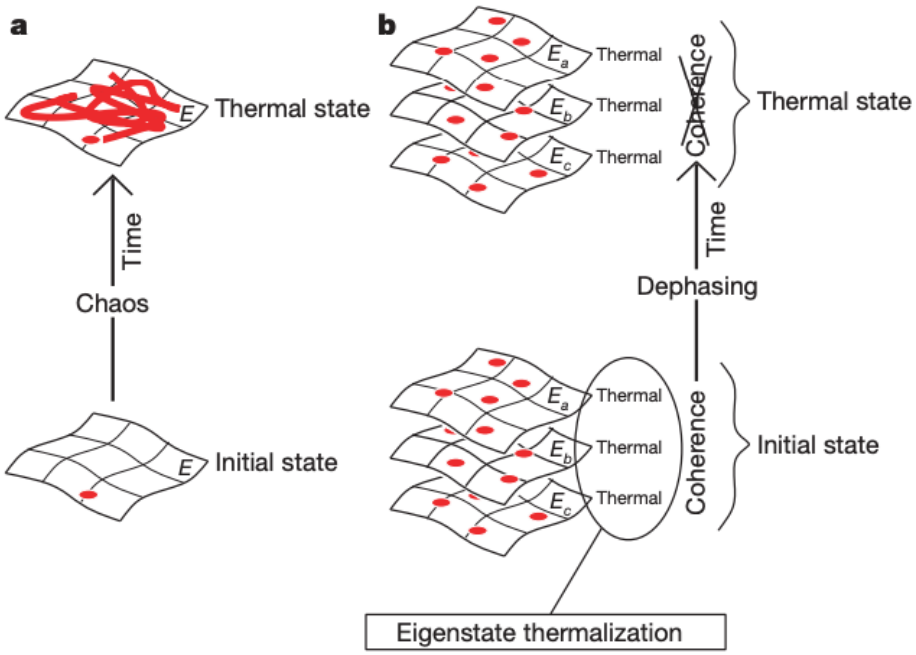
- Quantum chaotic systems — volume law
- weak ergodicity breaking
- Strong ergodicity breaking
- Many Body Localisation — Area law

↳ where does our system lie on this scale

↳ how does different quenches effect where we are (initial states, power of the quench ...)

$$H = -J\sum_{\langle i,j\rangle}(b_i^\dagger b_j + \text{H.c.}) + \frac{U}{2}\sum_i n_i(n_i - 1).$$

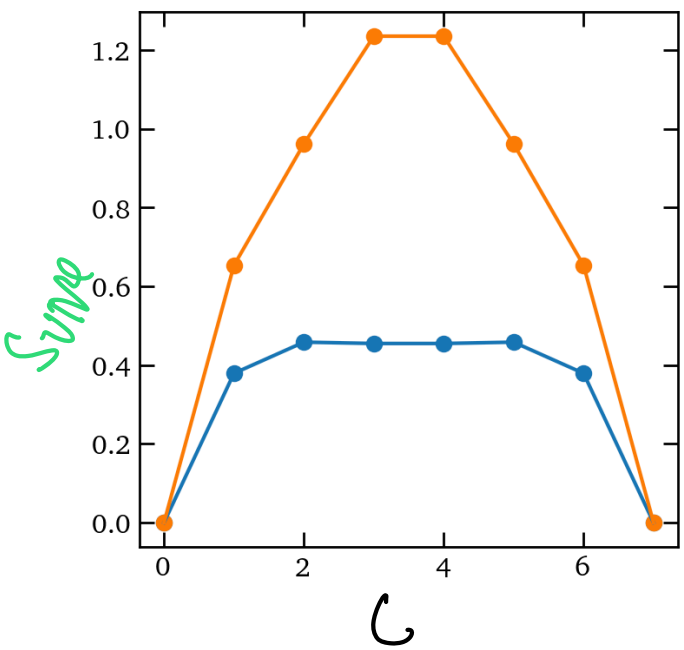




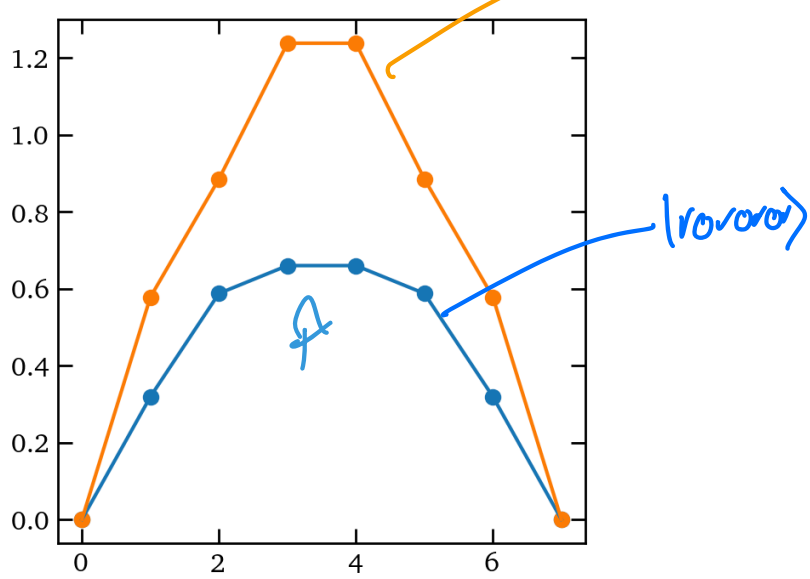
Our 7 atom System

global quench

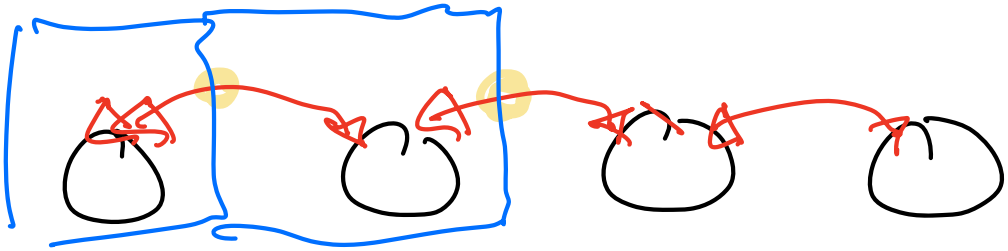
$\epsilon = 0.4\mu s$



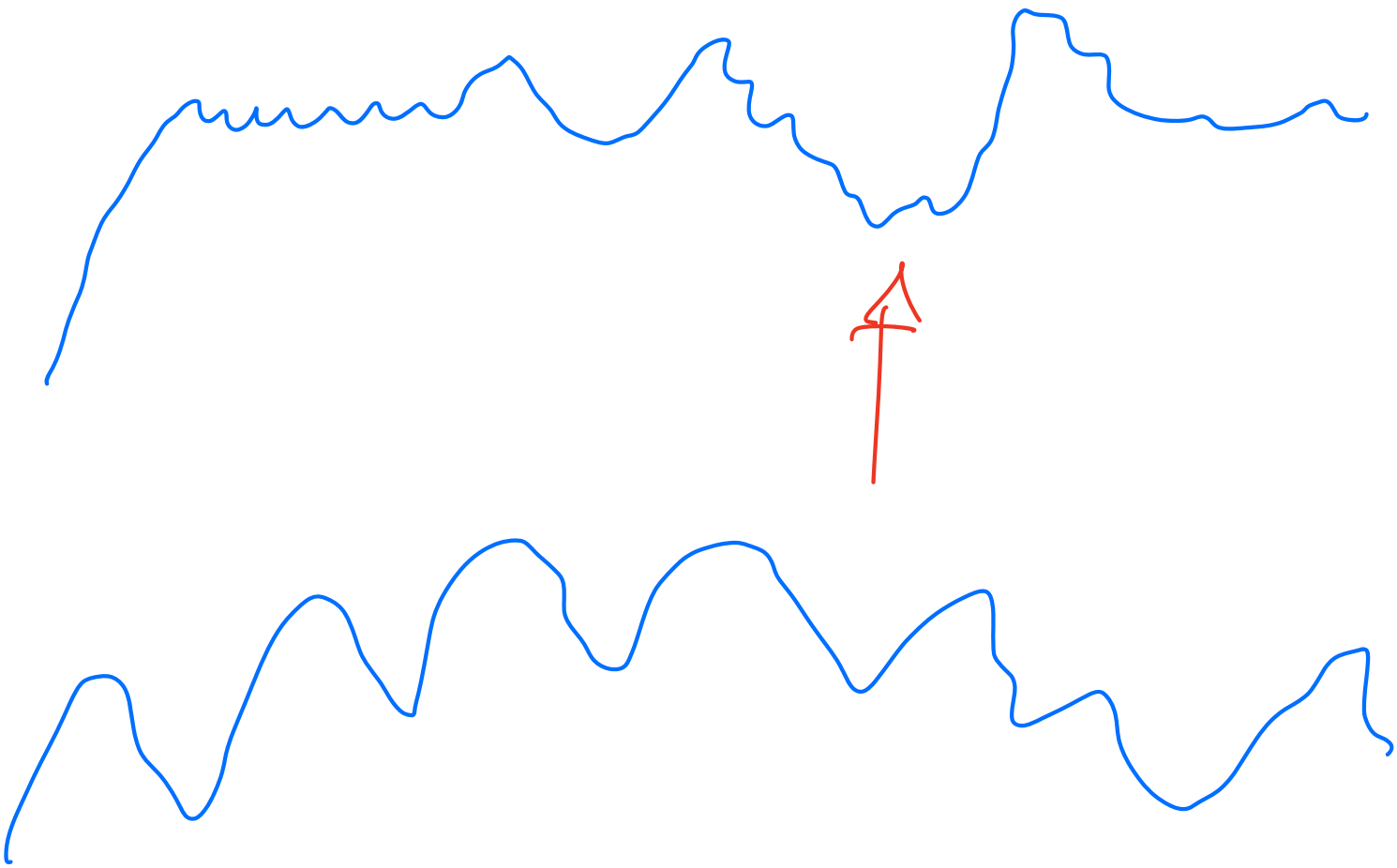
$\epsilon = 0.6\mu s$



once low breaks down with time what happens at revivals

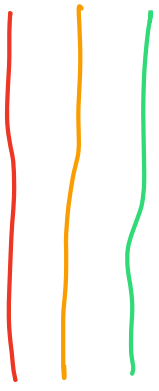


Avec



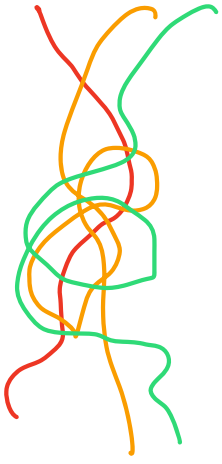
Scrambling

unscrambled



local information at site 1 (i.e initial state)

scrambled

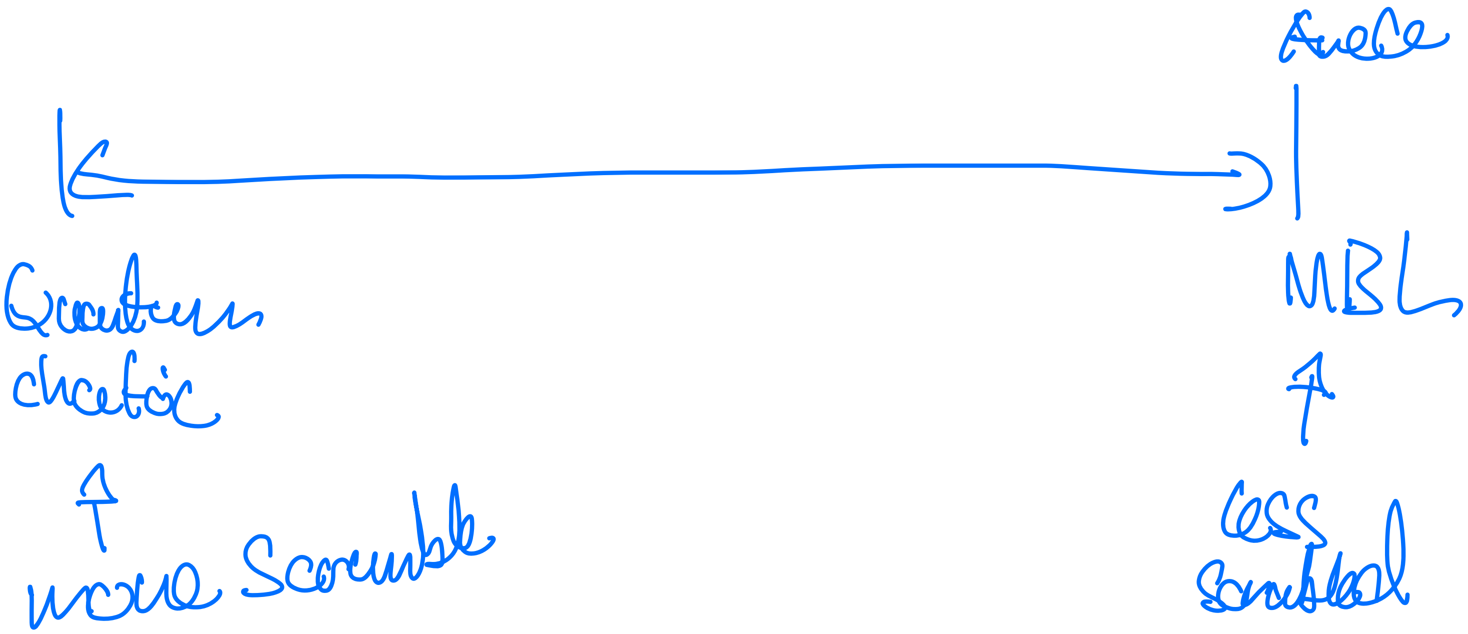


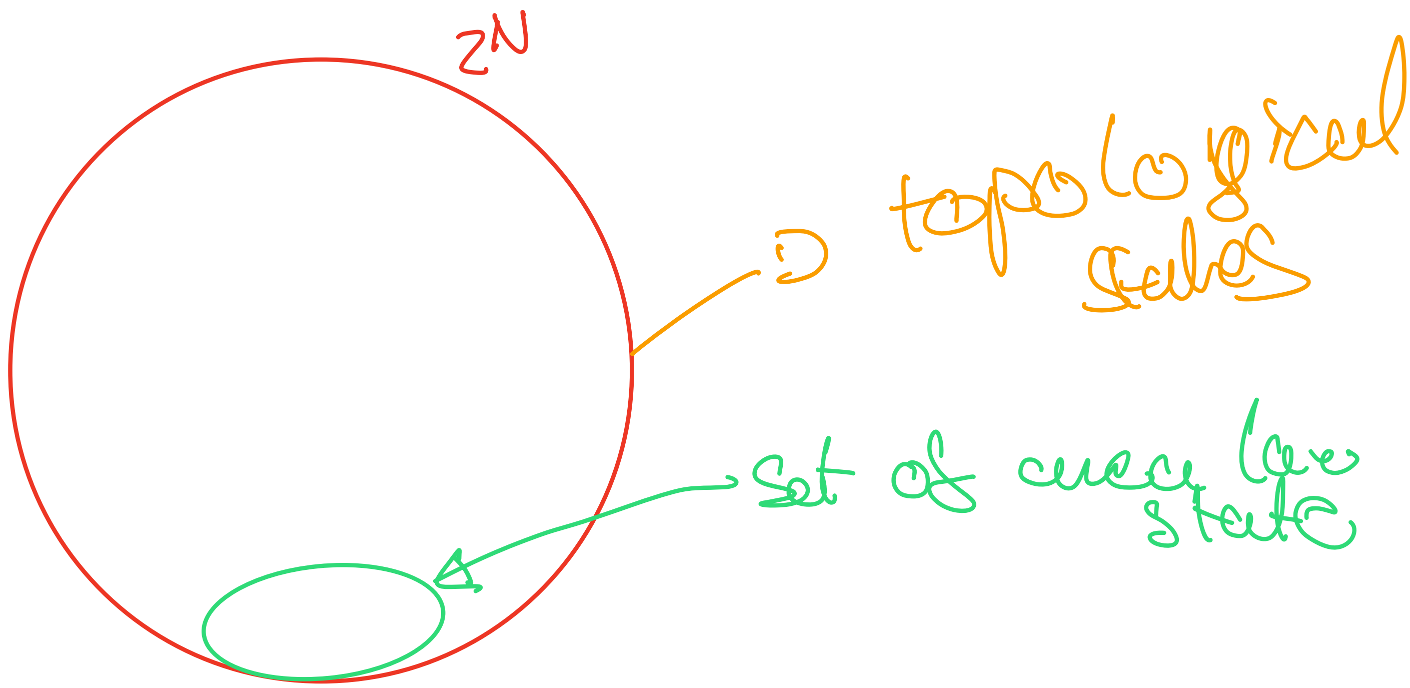
Non local

information scramble through system (now need all atoms to recover information)

How fast entanglement spreads a group in a system has a large effect on how efficiently information is scrambled

Initial quantum info matters spread of degrees of freedom

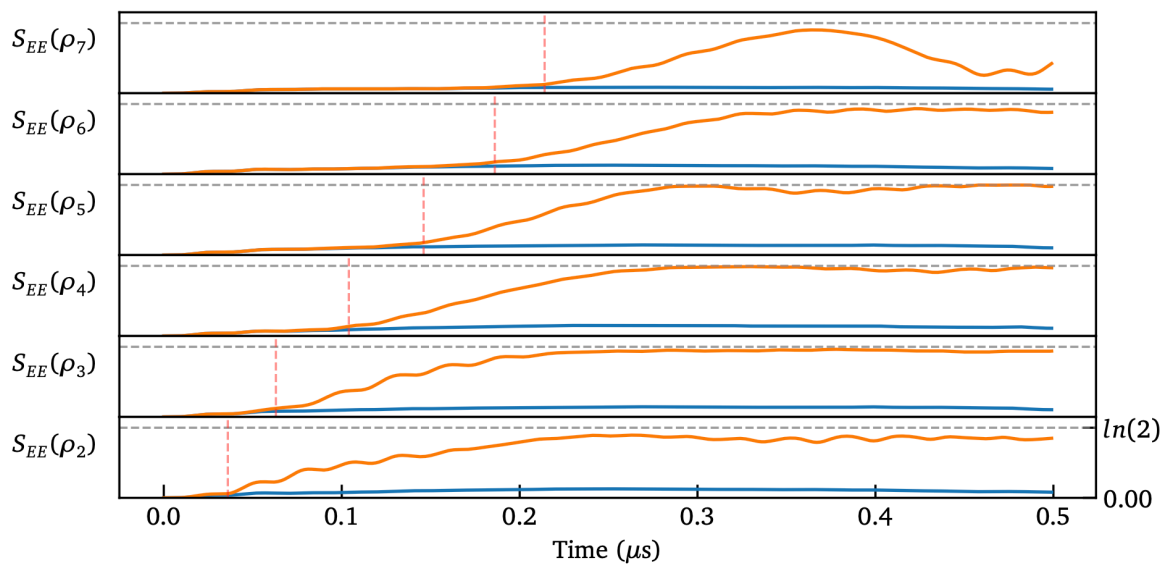




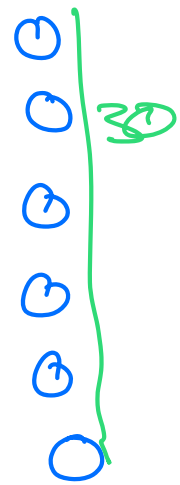
→ more robust quantum systems less prone to scrambling

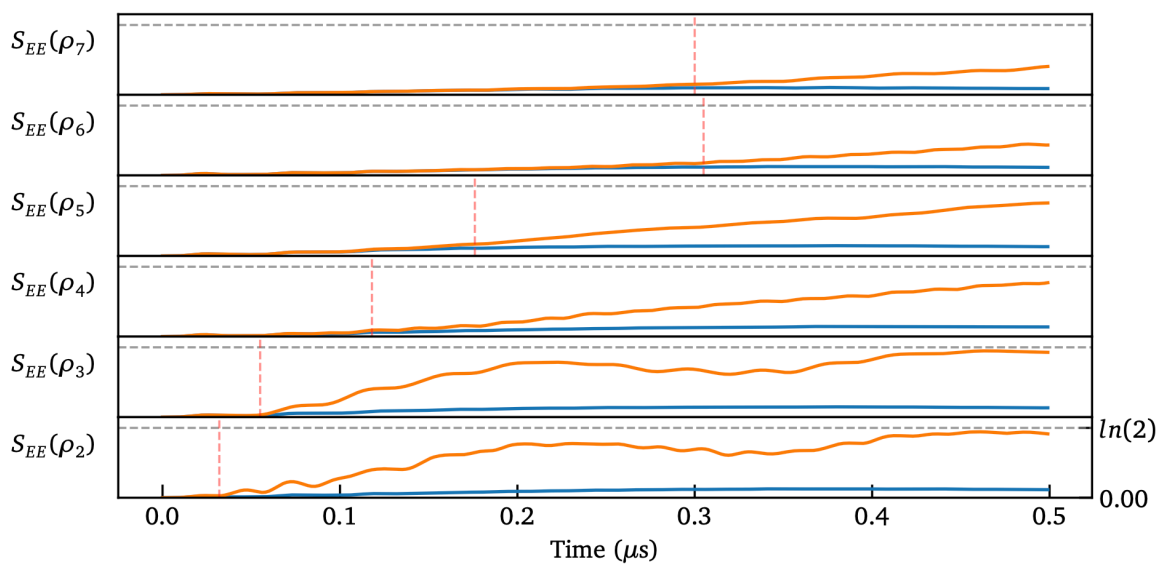
Analysis of prop of EE

Propagating through different boundaries is how does entanglement propagate out different rate for different detunings

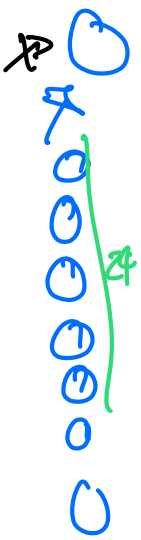


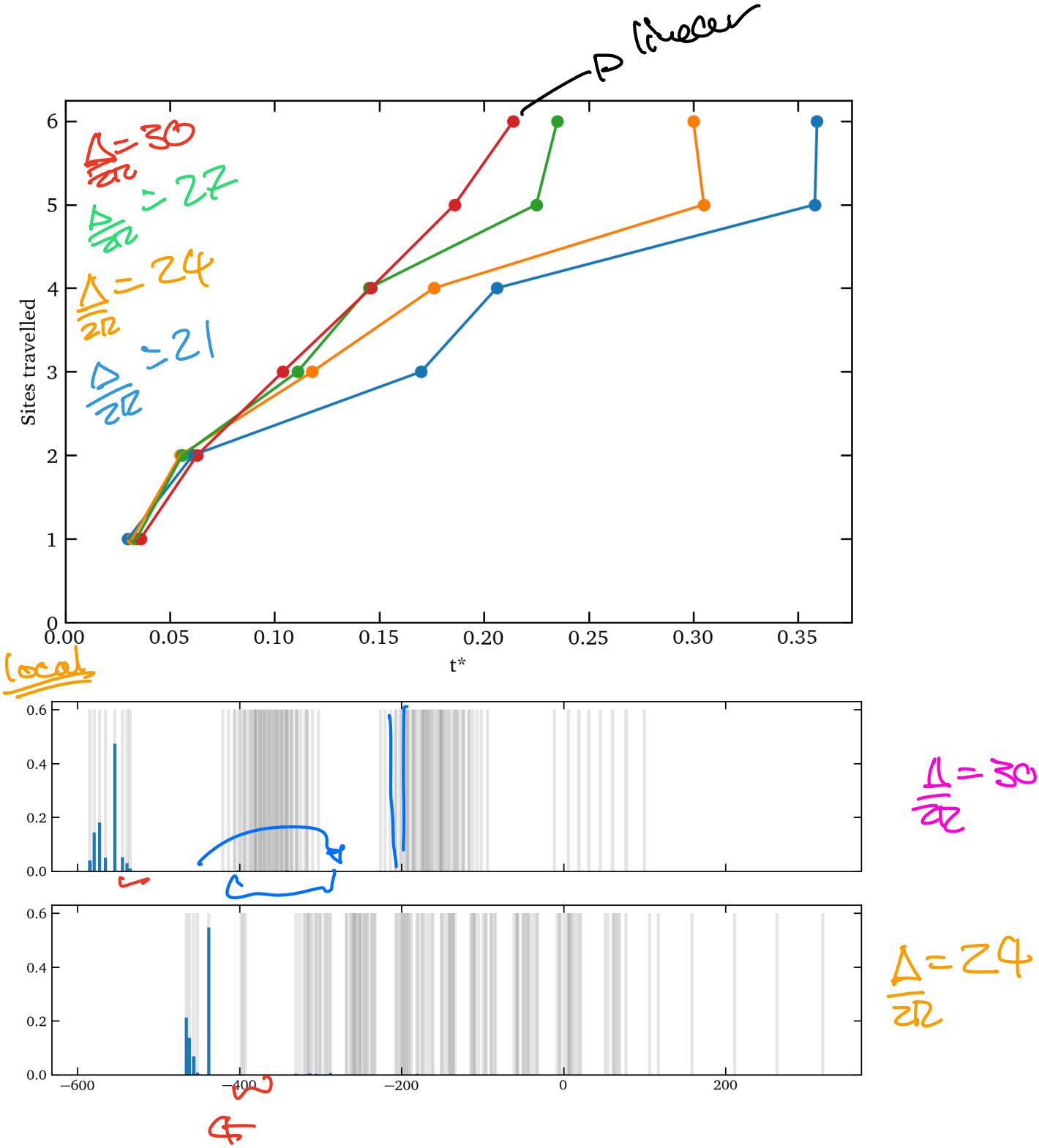
$\Delta = \frac{30}{2\pi}$

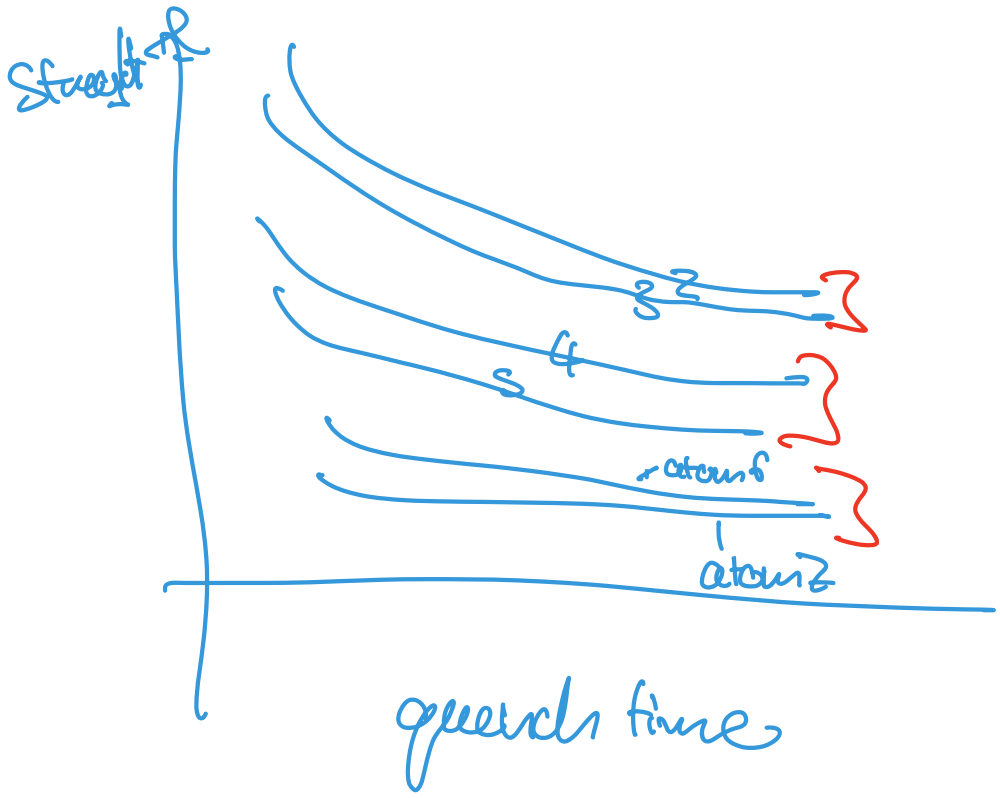




$\Delta = \frac{24}{2\pi}$




Sites travelled
t*
0.00
0.05
0.10
0.15
0.20
0.25
0.30
0.35
0
1
2
3
4
5
6
0.0
0.2
0.4
0.6
−600
−400
−200
0
200


Strength
3
4
5
atoms
atom
quench time