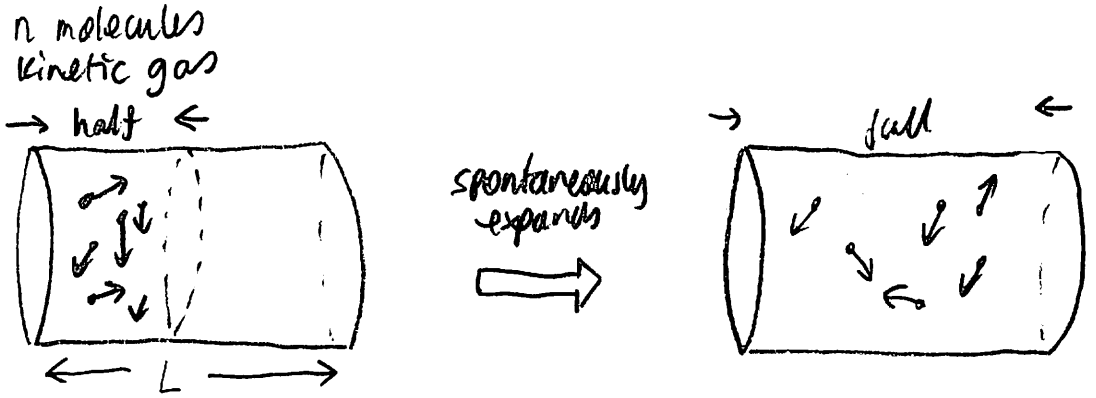
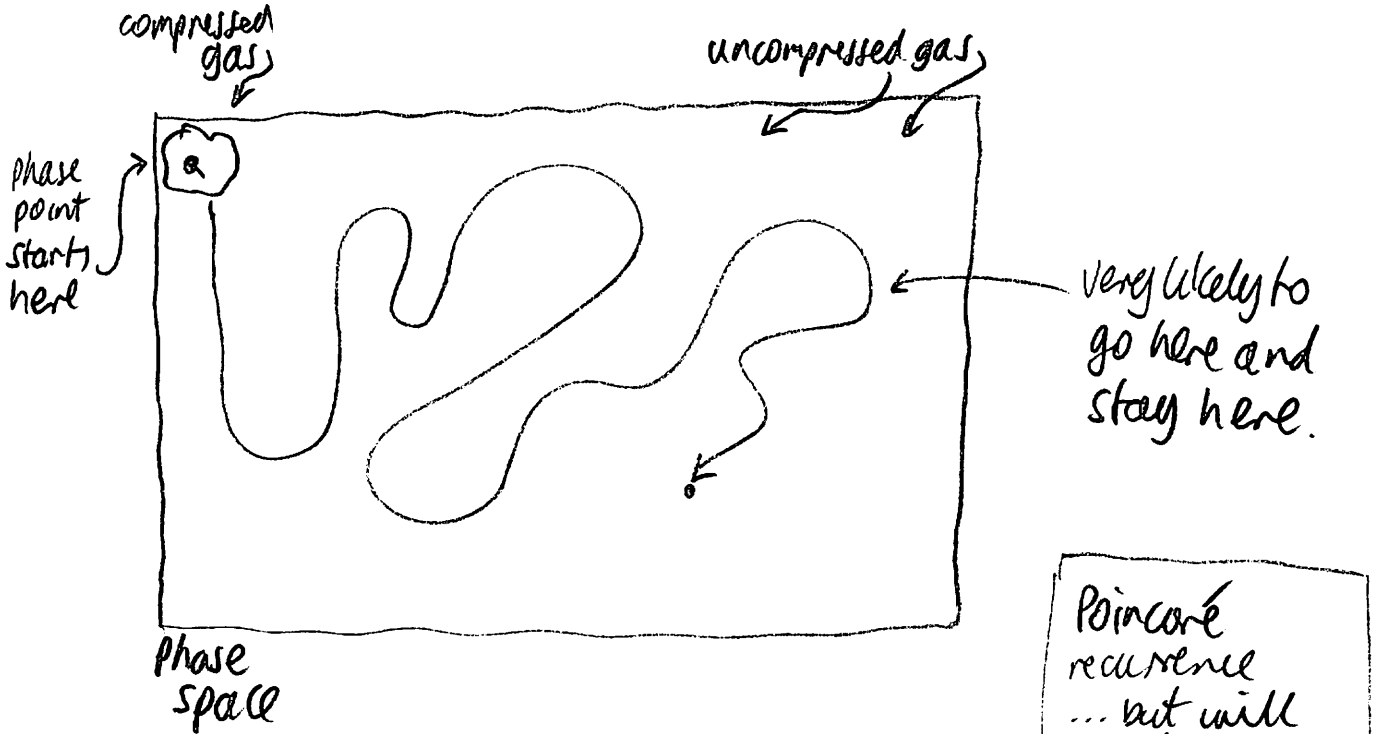
more on the approach to equilibrium



positions in $0-L/2$
momenta in $0-P$ ← same since no work extracted → positions in $0-L$, momenta in $0-P$

Volume in phase space $(PL/2)^{3n}$ = HUGE INCREASE Factor $(1/2)^{3n}$ ↑ Big! ⇒ Volume in phase space $(PL)^{3n}$

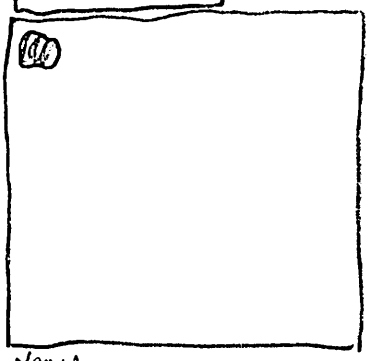


Poincaré recurrence ... but will eventually go back to phase volume of compressed gas

Fine & Coarse Graining

Expansion of the gas again:

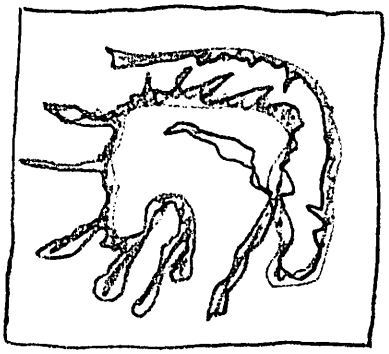
Fine Grain



phase space

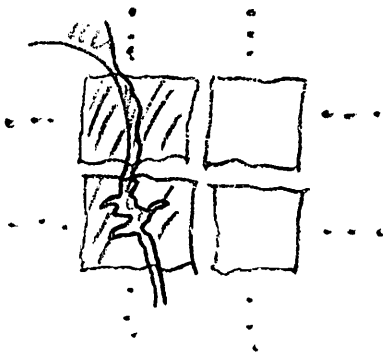
Liouville theorem → phase volume preserved

same volume stretched out into spidery filaments

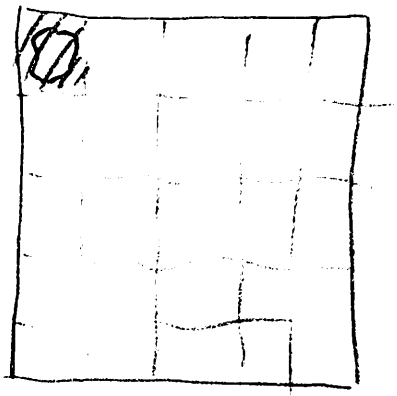


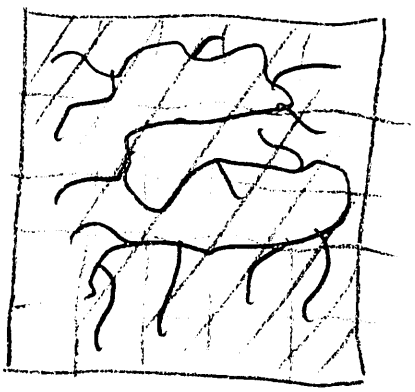
Entropy = k ln phase volume → NO INCREASE IN ENTROPY

"Coarse grain" = Divide phase space into cells. Cell is occupied if any point in it accepts migrating phase volume



Coarse Grain





Entropy = k ln volume $\underbrace{(PL/2)^{3n}}$ — increase by $k 3n \ln 2$ → Entropy = k ln volume $\underbrace{(PL)^{3n}}$