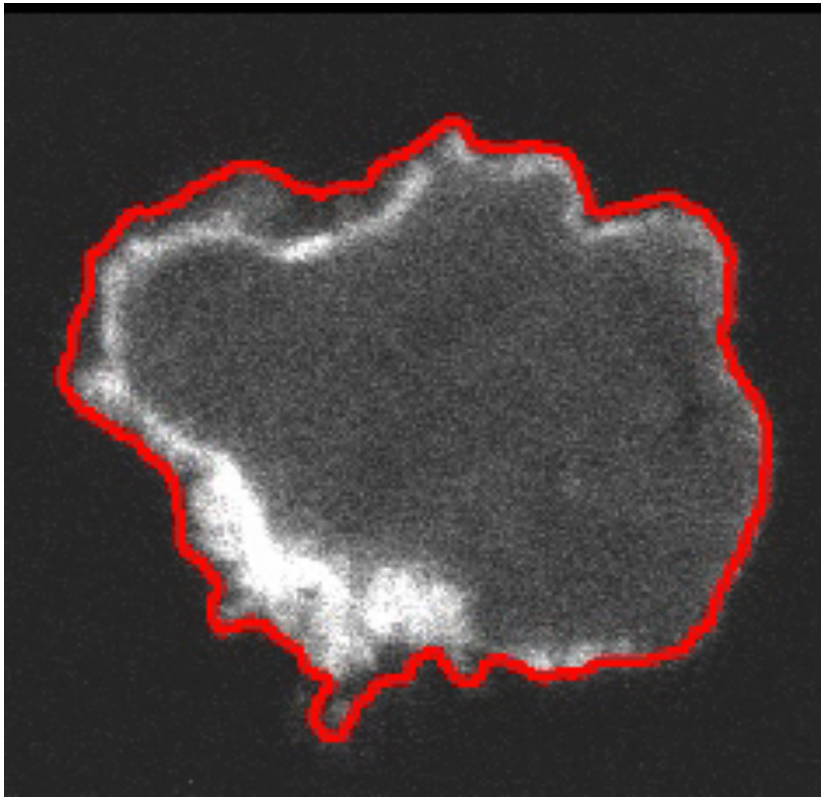
Outline

- Entropy
- Second Law of Thermodynamics

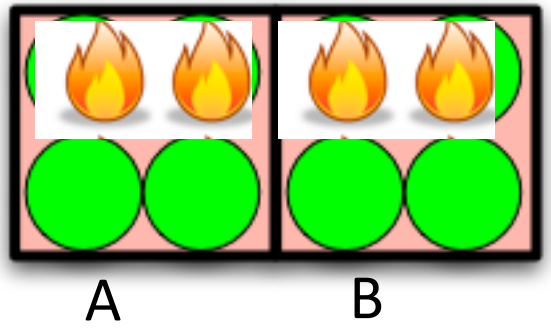


Example of an active cell
(from Jacobsen UNC (2013))

Losert Office hours next week:
THURSDAY 1-2pm Rm 0208 (Course Center)

Suppose I have two blocks of matter A and B touching each other. Suppose each block has 4 “Degrees of Freedom” (bins in which to place energy)

I have 4 packets of thermal energy.



How many ways are there to distribute 4 packets to either block A or B?

1. 1
2. 2
3. 3
4. 4
5. 5
6. 6
7. 7
8. 8
9. More than 8

- The number of ways to distribute 4 packets into 8 bins can be calculated.
- Need the number – you can google it:

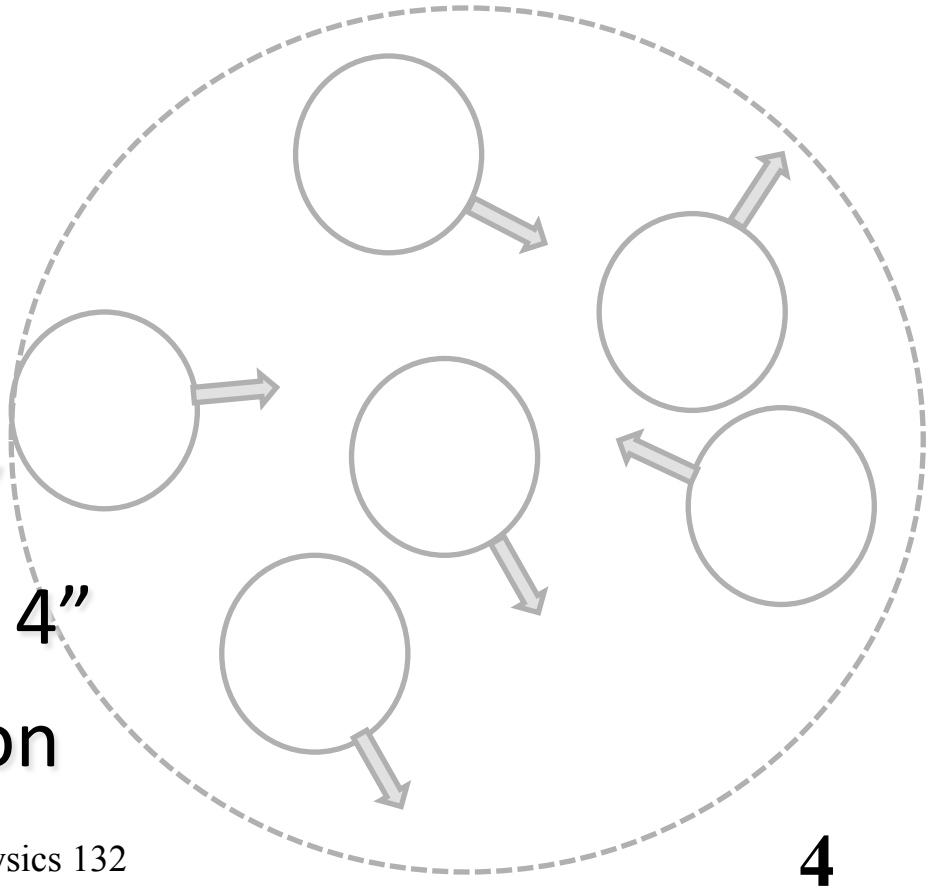
"8 choose 4"

Number of bins Number of packets

Simple System: A 6 atom gas

How many ways to spread 4 packets of thermal energy

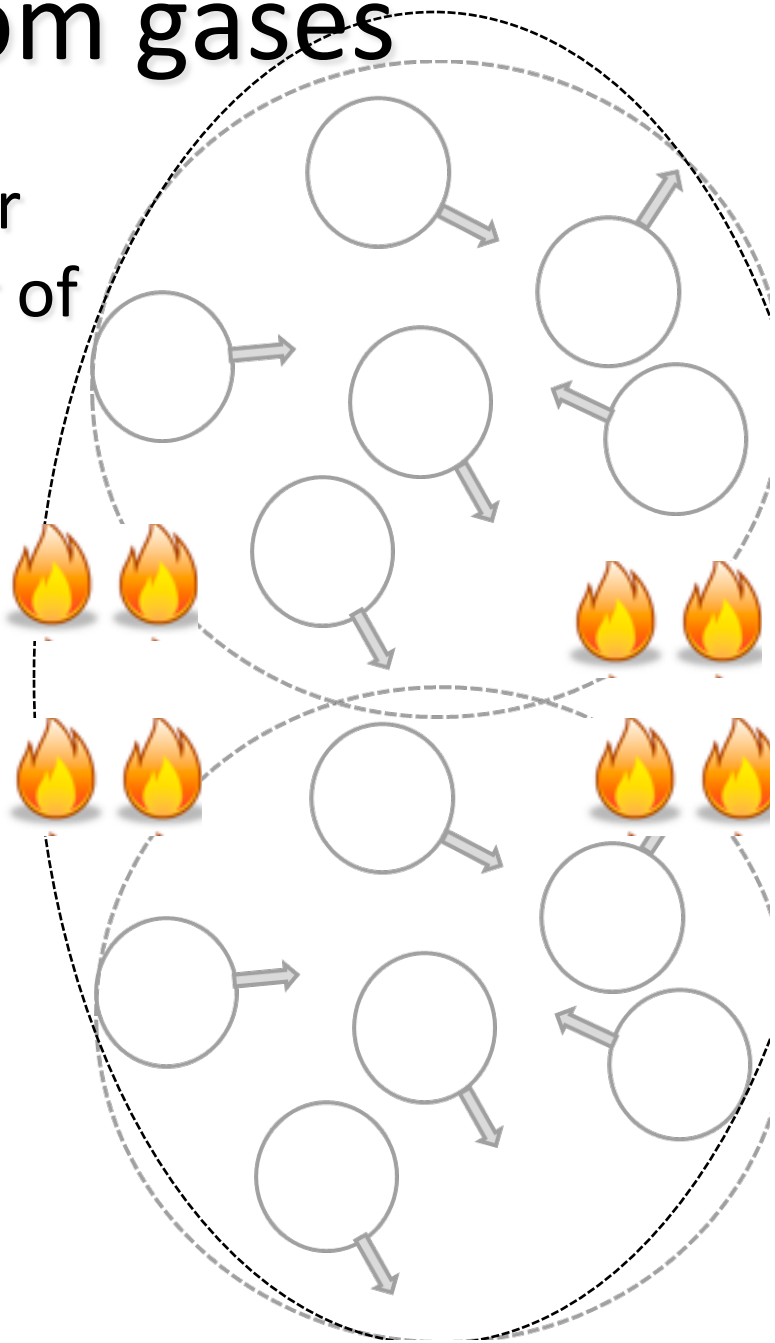
1. "6 choose 4"
2. "12 choose 4"
3. "18 choose 4"
4. Less than "6 choose 4"
5. More than "18 choose 4"
6. Not enough information



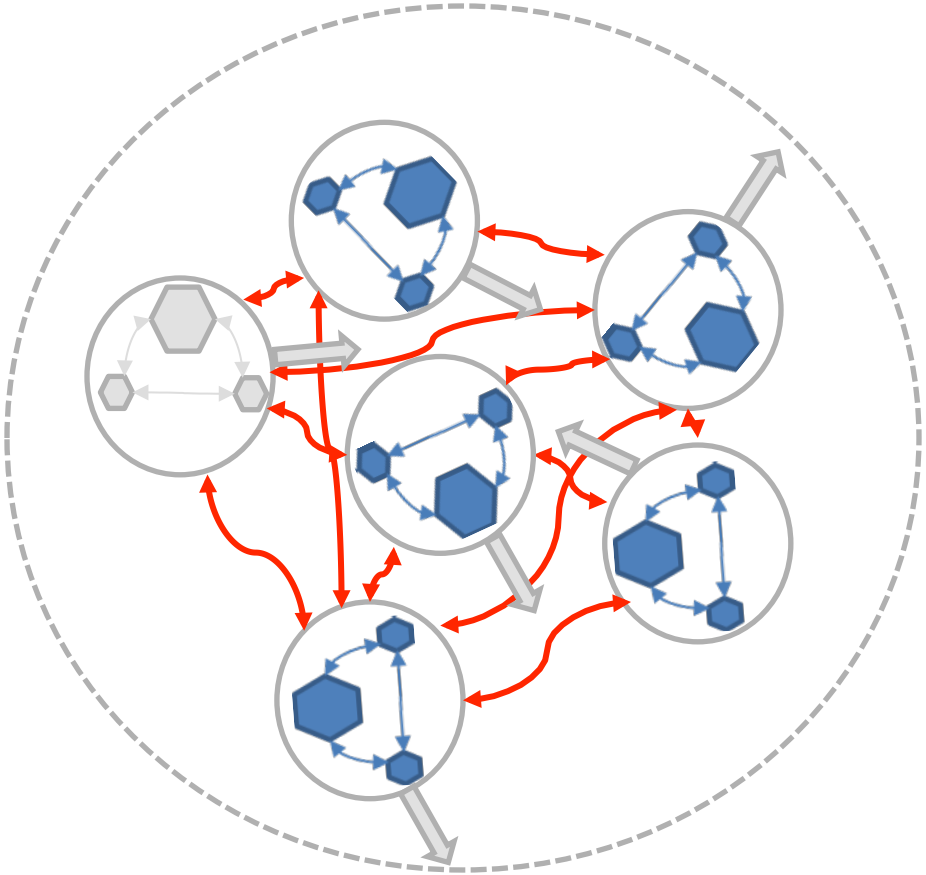
Two touching 6 atom gases

Again, 4 packets of thermal energy for EACH so 8 packets total. The number of possible microstates compared to a single 6 atom gas is

1. Twice as high
2. Four times as high
3. Eight times as high
4. More than eight times as high
5. Not enough information



A more complicated system: Droplet with 6 water molecules



Macroscale energy of droplet

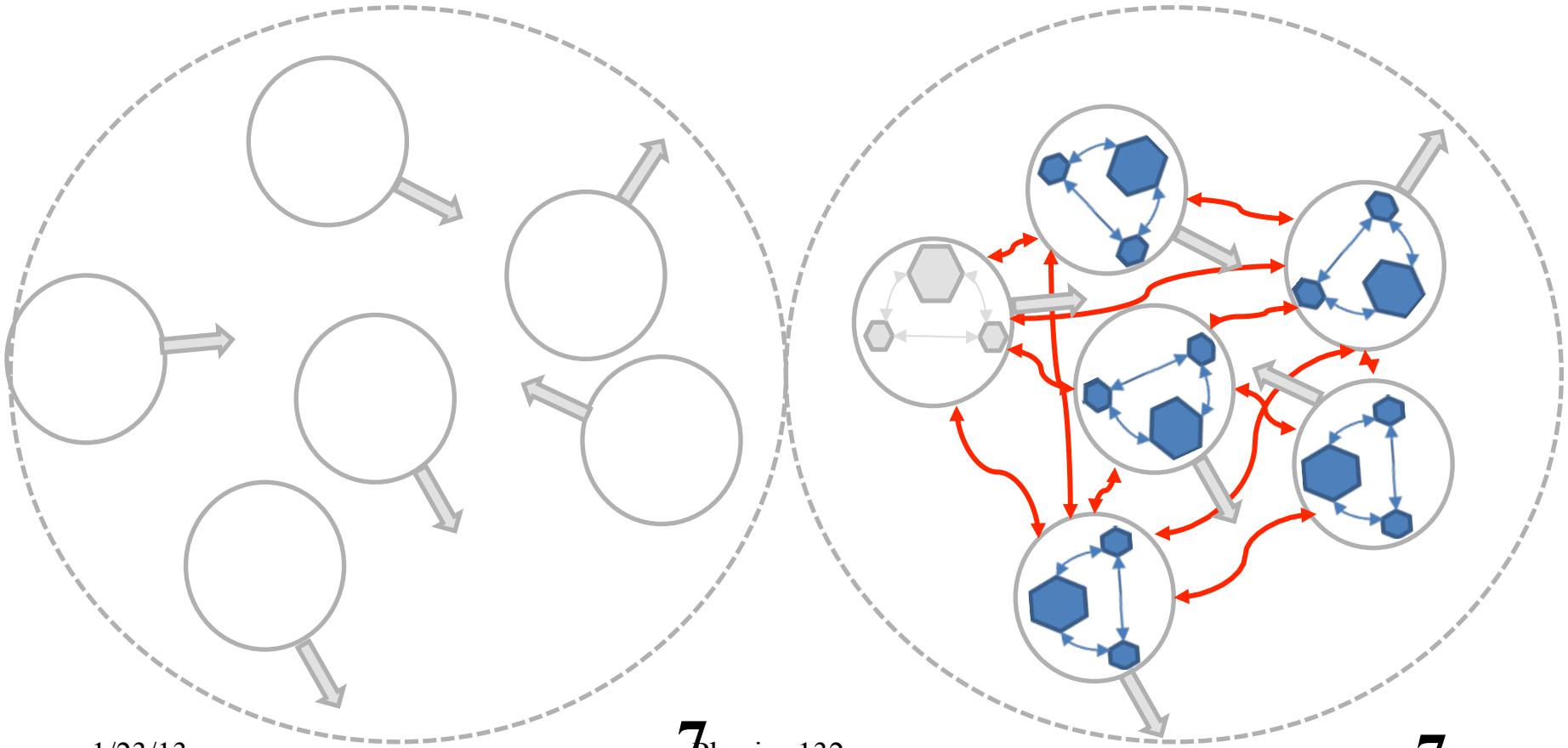
- KE of droplet motion
- PE (gravity)

Internal energy of droplet

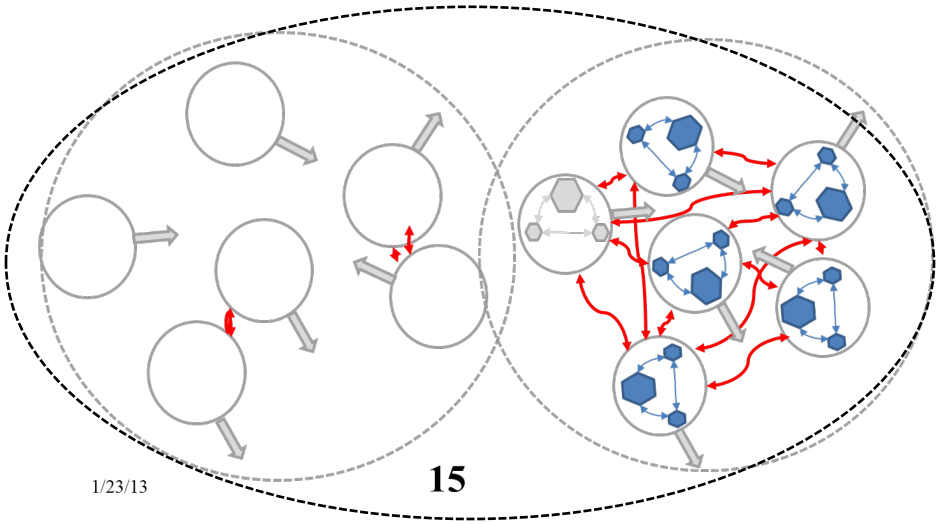
- Thermal:
  - KE of each H_20 (incoherent motion)
  - PE of H_20 interaction
  - Internal energy of each molecule
    - KE of each atom
    - PE of atomic interactions
- Chemical
  - PE due to electron-electron and electron nucleus interactions in molecule
  - KE of electrons

Two systems touch and exchange heat – they come into thermal equilibrium

- Six atoms
- six water molecules



Now consider the "joint" system with 6 atoms and 6 water molecules. We put in 8 packets of thermal energy



1. They are more likely to be in "gas"
2. They are more likely to be in water
3. They are equally likely to be in any atom/ molecule

More thermal energy packets are in the water molecules

1. Water is hotter than gas
2. Water is colder than gas
3. Water is at the same temperature as gas