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LECTURE 3

THERMODYNAMIC PROCESSES

THERMODYNAMIC CONFIGURATION SPACE

All eqm states of a system
are described by ^{the} Fundamental Eqn

$$\text{either: } U(S, V, N_i)$$

$$\text{or } S(U, V, N_1, \dots, N_r)$$

either internal energy U or
Entropy S as fn of all other
extensive state variables.

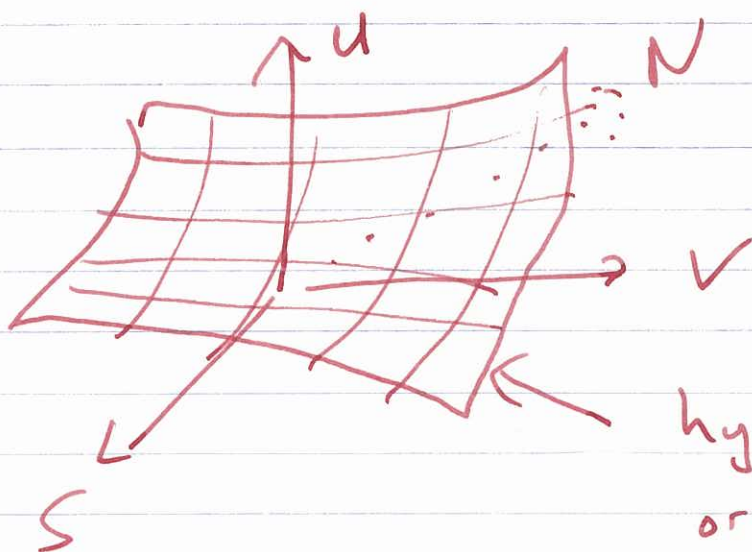
BECAUSE of this, all Eqm
states are described as points
in a Thermodynamic Configuration
Space - where Extensive
State variables are the coordinates

(2)

For single cpt system:

$$u = u(S, V, N)$$

\Rightarrow 4 dimensions



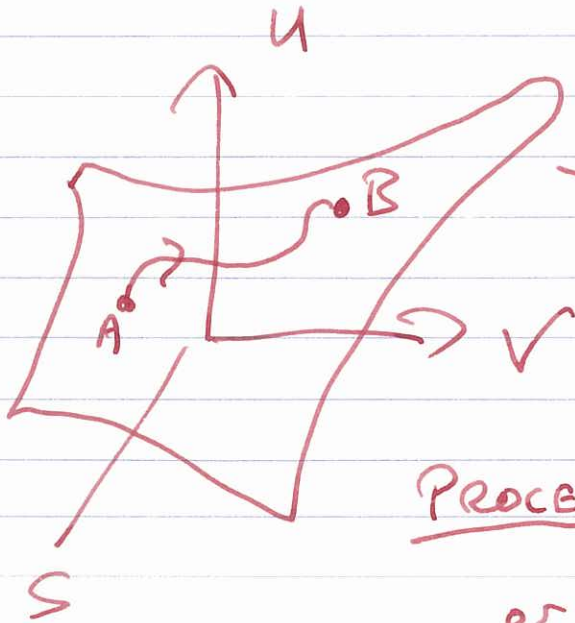
hyper-surface
or manifold
of Eqm states
(has 3 D, since
 $u(S, V, N)$)

NOTE: CANNOT Represent Non-EqM
States in Thermodynamic Config's
Space !

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~~NATURAL~~

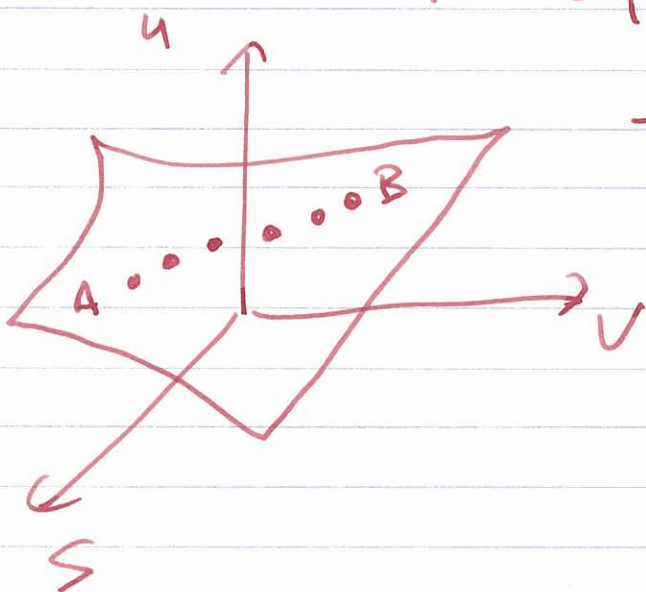
PATH on hypersurface of Eqm STATES



Path $A \rightarrow B$: represents
a series of Eqm
states from $A \rightarrow B$

Process : Change of state
or states. If Eqm
states \rightarrow path

If non eqm + Eqm states -
only see series of "dots"
for eqm states



- where path "disappears"
have non-eqm
process.

(4)

For a Closed, ^{isolated} system

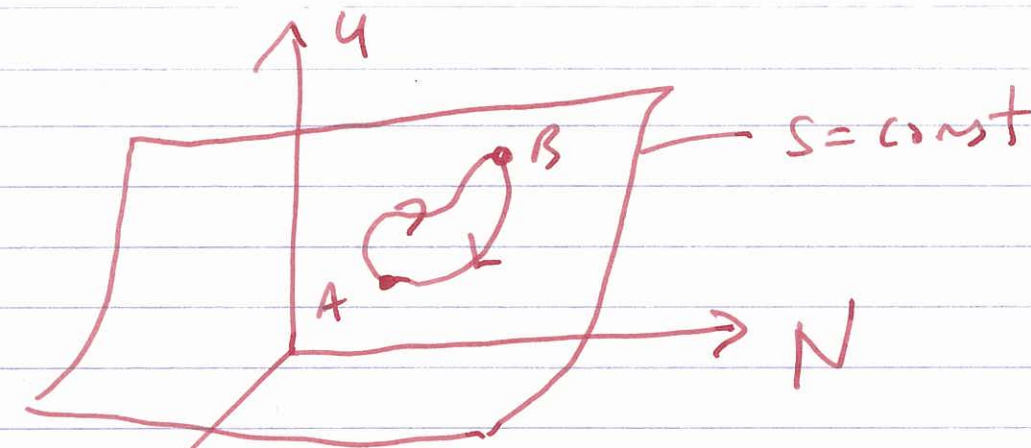
(1) all natural or spontaneous processes involve increase in Entropy $\Delta S > 0$

(2) for reversible processes, $\Delta S = 0$
- ideal, not real.

FOR SINGLE (pt) System

$$U(S, V, N)$$

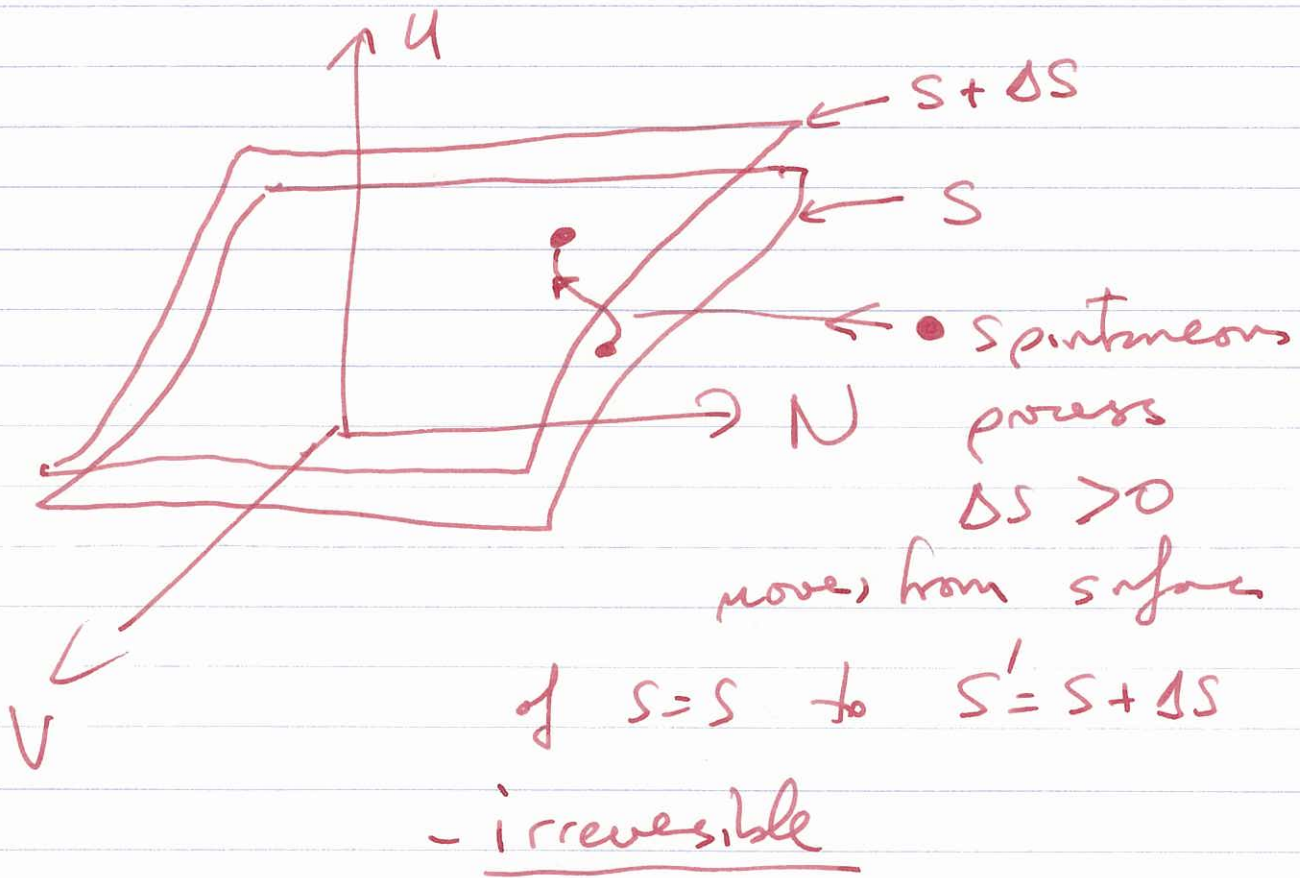
can draw surface with $S = \text{const}$



since $S = \text{const}$,
path on ~~the~~ surface is
reversible

(5)

CAN represent hypersurface
 $U(S, V, N)$ as a stack
of surfaces with constant S



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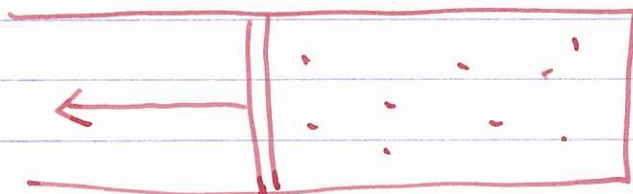
QUASI STATIC PROCESSES

Idea: try & keep system in Eqm state (or as close as possible) while changing state

⇒ very small changes in state & move slowly so that system reaches eqm before next step

→ CALLED "QUASI STATIC PROCESS"

Example: Expanding gas in cylinder:

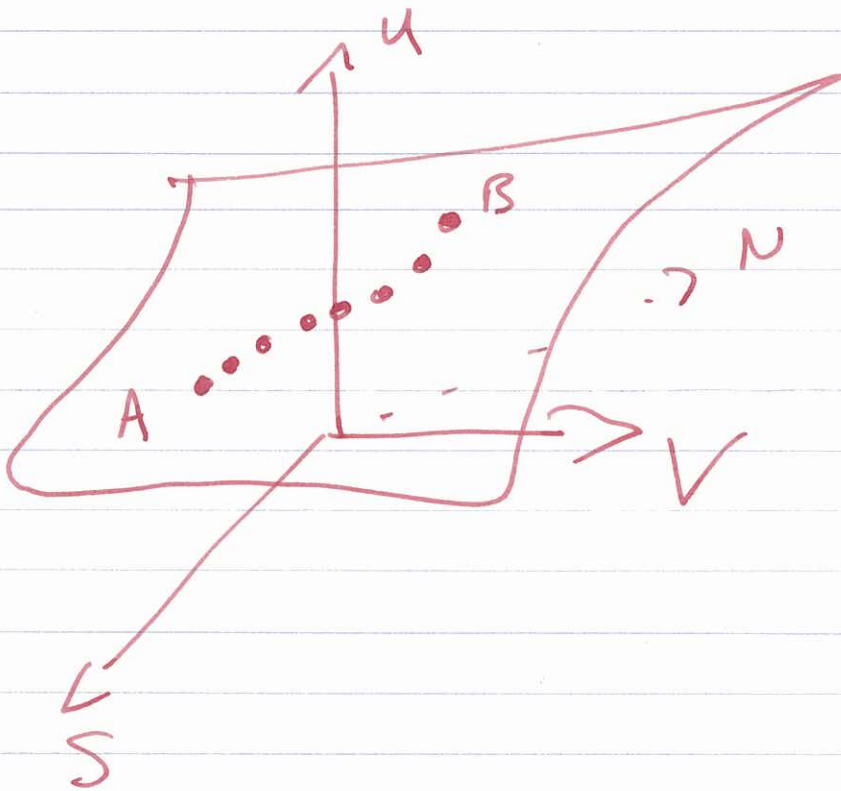


Move very slowly, or in small steps & allow gas to equilibrate

(7)

\exists a relaxation time τ
which tells how slow you need
to move.

If my QMC static process
is a set of steps:



- limit as
step size $\rightarrow 0$
 \rightarrow path
on $U(S, V, N)$
hypersurface

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REVERSIBLE PROCESSES

- Must be quasi static
- $\Delta S_{A \rightarrow B} = 0$
- real processes only approximate this.

IRREVERSIBLE PROCESSES

- could be quasi static
or not
- $\Delta S_{A \rightarrow B} > 0$
- All real processes are irreversible
- CAN still use thermodynamics since if end pts are Eqm States A, B & I know Fund eqn $U(S, V, N)$ I can calc all props of A & B indept of path!

(9)

CATEGORIES of Process

Isothermal

$$T = \text{const}$$

Iso baric

$$P = \text{const}$$

Iso choric

$$V = \text{const}$$

ADIABATIC :

$$\delta Q = 0$$

→ No exchange of heat, Q ,
with environment

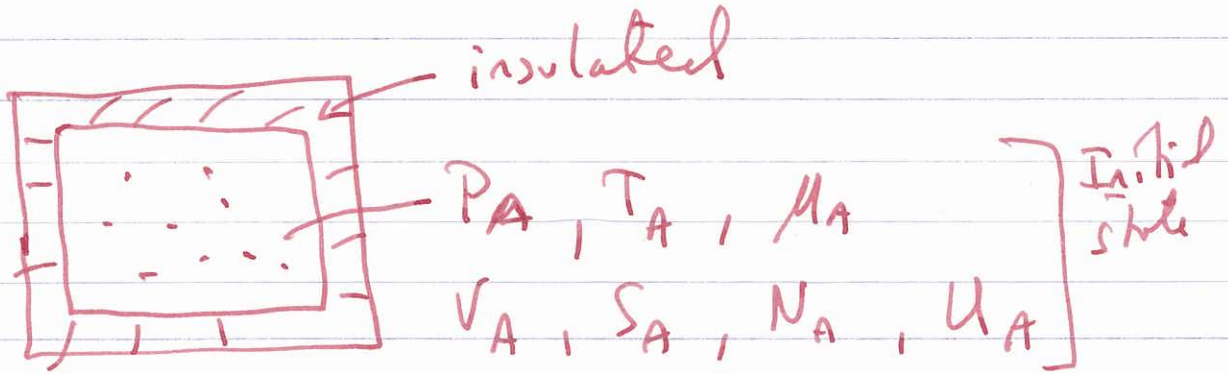
(wrapped in { insulation }
styrofoam)

FACILITATING or CONTROLLING THERMODYNAMIC PROCESSES

STATE A

- in EqM

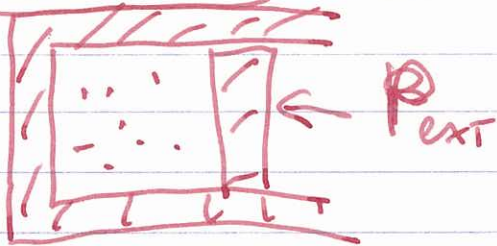
with set of constraints



Change some constraints:

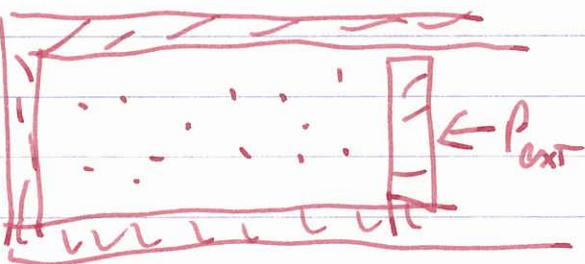
Non EqM

EXAMPLE 1



Allow V to change only

EqM



$V_A \rightarrow V_B$
 $P_A \rightarrow -P_{ext}$ (EqM)

STATE B - Final STATE

