Thermodynamics
Why, What & How

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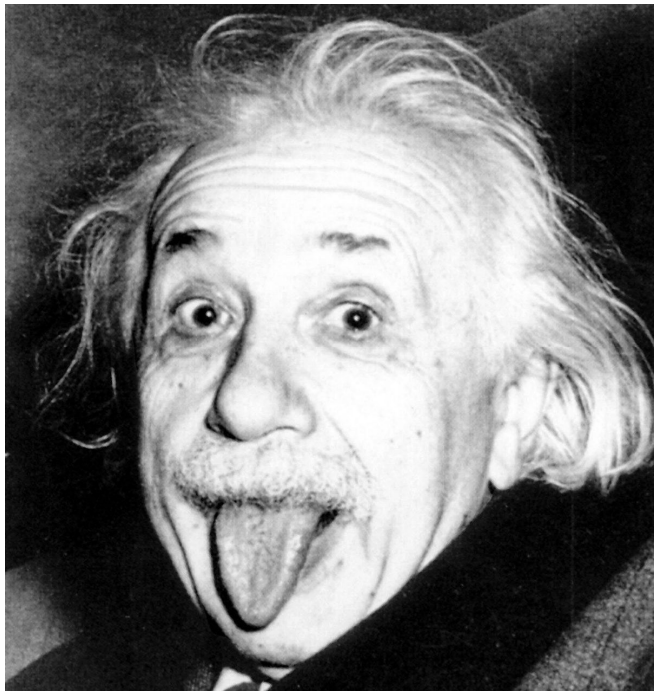
Thermodynamics (TD) in Social Media



" Thermodynamics is the only physical theory of universal content concerning which I am convinced that, within the framework of the applicability of its basic concepts, it will never be overthrown."

First course handout…

- Posted on Mookit

- Very many relevant information…but will not be repeated here

TD: Why & what?

- Mechanics: Particles, forces and energy, stress & strain, viscosity, modulus, relativity...Gravitational constant-*G*
- Electrostatics and electrodynamics: Fields, electric and magnetic field, scalar and vector potential...Speed of light-*C*
- Quantum mechanics: Wave function, Unobservable & measurement, ...Planck's constant-*h*
- Thermodynamics: "Macroscopic" variable "Temperature-T"

Macroscopic & Microscopic

- Relative, Absolute & Useful…
- Relative: Cosmology to elementary particles…
- Absolute: Planck length scale = $\sqrt{\frac{Gh}{c^3}}$ ~ $\mathbf{10^{-35}}$ $\boldsymbol{m}$
- Useful: Macroscopic scale~ human length & time scale accessible to human senses/experience, "macro" equipment (measuring cylinder, thermometer, manometer…)
- Macroscale can be "reasoned" from microscopic…but the strength of macroscopics/thermodynamic is in reproducible measurements! PV=nRT, **ΔE=mC ΔT…Phenomenological**

Macroscopic & Microscopic: Obvious?

- Familiarity brings in "pseudo-triviality", take it for granted...
- At the level of atom T, P & V are undefined...
- Macro-description ~ $\mathbf{10^{23}}$ $\boldsymbol{atoms}$
- Averages from microscopic can be related to macroscopics
- Equipartition theorem: T & average kinetic energy

Macroscopics: Economy in description

- Growth rate of a country...
- Tabulate the income of all people and keep track of it year to year...Present this data

- Present the data on the Per-Capita Income

- Averages provides an economy in description...also indicative of certain features of income distribution
- Macroscopic thermodynamic properties are averages over microscopic properties
- What kind of average? Weighted average...? Questions of statistical thermodynamics (ST)/statistical mechanics (SM)...

Microscopics: Power and limitations…

- Mechanism behind physical properties and phenomenon
- Mother of Big Data-$\mathbf{10^{23}}$ ***atoms***!
- Propagate the equation of motion for large number of atoms (~ $\mathbf{10^{23}}$!) in time to get averages… "sampling energies of different configuration" provide the *weight* for averages-ST/SM
- What & how to measure vs. What & how to compute…

Macroscopics & Human experience

- Thermal "equilibrium" and sense of hotness-Temperature
- Something for nothing is impossible- Energy conservation
- Directionality of "natural process"- Entropy increase

Thermodynamics: Two viewpoints

- Energy transformation (Greek: Therme-heat & dynamics-power; Lord Kelvin-1854 to emphasis "heat" as motion & not as a fluid!); Unification of "heat" & mechanics

- Theory underlying macroscopic measurements involving T; Arrow of time…

What we won't cover in this course…

- This course is about thermostatics-Systems under equilibrium
- Transformations occur via "quasi-static" processes
- Linear non-equilibrium TD: Fluxes because of forces (e.g. heat flux and temperature difference driving force)
- Entropy generation & Onsager's reciprocal relationship
- Non-linear TD: Order due to long-range coherence giving raise to dissipative structures (multiple ordered structures)
- Implications to biology (Prigogine)