Lecture: Fndns Thermo & SM - Reduc/Emerg SM/Thermo (Butterfield) [date] Jan 2018 (0)

Begin by discussing all the issues we won't discuss - nitty gritty details of real calculations and args that attempt to demonstrate the reduction or derivation of one from the other (e.g., Sommerfeld's args to show how to "derive" the Navier-Stokes eq'ns from the Boltzmann collision eq'n)

- problems about mismatch of quantities, concepts, processes (heat and work in thermo, not in SM? diff't entropies, probabilities at the lower level (not higher one), ...)

- Skeptical insightful remarks about the role of thermo in framing content of SM - so how can it be any reduct? And all the cards one puts in hand by one that cards in SM to get "better" behavior right (e.g. [illegible], 2nd Law) - they are motivated and justified by our thermo knowledge, not any thing idio or peculiar or internal to SM - so, again, how a reduct?

- original Butterman Fandango on "necessity, indispensability" of limits, idealization - for explanatory purposes

Butterfield

Lecture: Fndns Thermo of Stat – Reduction/Emerg SM/Thermo

09 Jan 2018

①

- Nagelian reduction (definitional extension: "F ≡ F(x,y,z)" where x,y,z are part of lower theory and F is 'new name') loose
- Supervenience in standard form ("no change at one level w/o change at other")

p. 1067
- → compare to Butterfield's more formal characterization (definitional extension), the 2 versions, ∞ and finite, show how they capture loose view, show rel'n of ∞ vs finite to Nagelian reduction (in which def'ns are always finite)
- ⇒ why has been thought emergence & reduction are mutually exclusive
  - but need not be when "deductions" include "taking ∞ limits"
- → resolves problem of how logical implication can create "new content" (emergence)

p. [illegible]

raises point: Butterfield is ambiguous about "deduction" – after limit is taken? limit part of it? Either way, is it really – strictly like Nagel? does that matter

Butterfield

- reduction is "Nagelian reduction"
- emergence is "appearance of novel & robust behavior (relative to some comparison class)", not traditional "supervenience"

§3.8 limits not defin'g [illegible] – [illegible] (for [illegible]) [illegible]

- comparison class:
  1) composites – props/behavior of emergent sys are novel robust compared to those of its components
  2) limits – properties/behavior of limit sys are novel/robust compared to those of sequence generated by letting some parameter → ∞
- ⇒ strong vs weak emergence:
  - strong – robust/novel at N=∞
  - weak – weaker, but still vivid 'novel & robust' behavior (finite N), appears before limit is reached and that behavior is physically real
- → emergence not always associated w/ actual singular limit, or even of any limit

Pragmatism: need not be single, canonical, rigid, universal def'n/characterization of 'reduction' and 'emerg' (p. 1068)

- ⇒ pragmatic pluralism on applications of notion (p. 1068)

that this is not traditional Nagel – and in particular that not all concepts, methods, justification, comes internally from lower theory – good or bad thing? bad: not 'real' reduct'n; good: shows complexity of real sci, how theories interrelate

Lecture: Fndns Therm & SM — Reduct/Emerg SM/Thermo [Butterfield] 09 Jan 2018 ②

Butterfield's 4 Theses

1: Deduce emerg compatible w/ reduct, on strong understanding of 'emerg' ('novel & robust') and of 'reduct' (Nagelian reduction, definitional extension)

2: Before emerg in weaker but still vivid sense appears before limit achieved (finite N)

3: Herring supervenience, while true in several senses in interesting exs, is pretty worthless — gives no insight — gives no control on why certain [lower-level] combinations realize higher-level phenomena; no connection is made w/ physics of the situation, the why and how of the limiting procedure

4: Unreal examples become 'unreal' in catastrophic way for increasing N, well before ∞ (atomism, cosmology, even more subtle stuff like Newton vs SR)

[and they become unreal b/c of facts about the world, not for phil reasons] ⇒ 2 questions:
1) can emerg really then be characterized by limits?
2) can the 'singular limit' be in any sense 'real' (not just epistemically indispensable, or something like that)? If not, then how does it do "explanatory" work? (or other phil)

— Aside: what role does purported 'explanatory indispensability' and other such epistemic criteria play in determining what ought to count as "true" emergence and reduction?
→ Batterman vs Belot, e.g.

4: unreal (cont.): subtlety of 'cross-over' behavior, where limiting sequences can oscillate between 2: Before and 4: Unreal!
↳ [it blows my fucking mind that phils have ignored this for so long — but it does not surprise me]

– why 4: unreal is benign: even when relevant limits are singular (and so $N \to \infty$ is somehow 'not well behaved' or otherwise prima facie one learns nothing from looking only at finite N), then broadly instrumentalist justification works: mathematical convenience and empirical correctness

⇒ is this too quick? can we really "see" thermodynamical behavior at the 3,652nd moment of the partition function? can we use it to explain or describe? can we use it to provide epistemic warrant? } ppr topic ⊛

diff't limits } see my probs listed in marginal notes of ppr: equivocation on
1) sloppy vacillation of σ as 'phys sys' and 'math'l entity'
2) seq of gs: is it 'eng, eng, ...' but no 'eng'?? confus for their non-[illegible], if we don't [illegible] a dichotomy?

– systems
– properties
– values of properties   of properties of systems in sequence

distinguish limit of values from value of property of system at limit

⇒ only when these don't equal is there real explanatory work to do, otherwise we can make do w/ pragmatic, 'instrumentalist' considerations of mathematical tractability and empirical success

example of sequence of continuous funcs → discont

limit of characteristic func "is continuous"
versus
limit of vals individual values of funcs of each g_n itself; continuous everywhere but at zero (though zero itself is continuous) (value of)

Lecture: Fndns Thermo & SM – Reduc / Emerg   Butterfield SM / Thermo   15 Jan 2018

(4)

define "phase transition", briefly discuss phys'l meaning

in thermo discontinuity in derivatives of the free energy: disc. change of pressure, volume, capacity to absorb heat and change temp with density; particle density

(change of 'states of matter': liquid/gas/solid, some trans plasma; magnetization; communication networks; traffic; →)

⇓

in SM, one provably does not "nonanalyticities" in free energy until # of constituents is ∞" (happens for no finite N – all phys'ly signif funcs of distribution/partition funcs are analytic)

⇓

take "thermo limit": $\lim_{N \to \infty} N/V$, scale V so that $\rho = N/V$ is const

(consistency phys'y of this limit? in phase transitions, almost always the case that particle density ρ changes discont!)

⇒ reduction: "force" discont in SM qs corresponding to thermo qs to reproduce thermo 'discont'

But taking thermo limit "introduces new math struc"
(Butterfield p. 1126)
⇒ this is not Nagelian reduct no matter how broadly and charitably construed, it's not a definitional extension + deduction
⇒ in what sense a reduc?

1: Deduce: in order to do properly, Butterfield would have to (p. 1128)
a) define actual novel, robust behavior of a phase trans that appear at finite vals of N; b) actual thms, real calcs, showing 'strong' emergence of that stuff when N → ∞
– similar for other claims

Question: is there anything like this actually available to and known by physicists?
I don't think so (see Sommerfeld's 'derivation' of Navier-Stokes from Boltzmann collision eqn for typical probs)