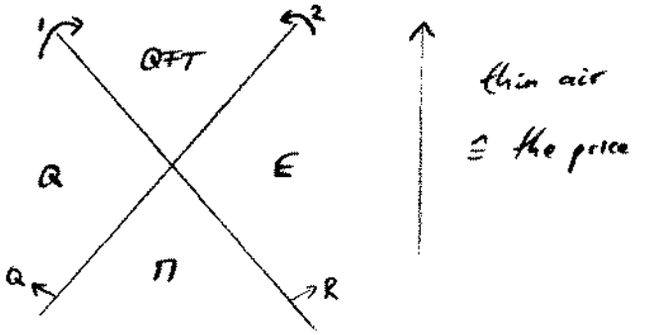
Today's plan
- Motivation
- sketch contents / program

- (review of) Stat Mech
- (— " —) Quantum Field Theory

Motivation

- what happens if matter is compressed / heated ??
  → machinery: QFT, Stat } FTFT

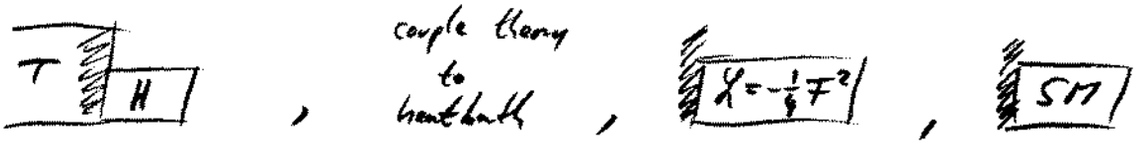
- what is QFT ?



1) Dirac eq., spectrum $\pm\sqrt{\ }$, 
   sea filled (vac!)
   ⇒ many (∞) body theory !

2) known from thermodynamic in blackbody rad.
   (‘standing wave $\vec{k}_{ij}$ carries n(tick)’s’)
   → must/can be derived.

• Statistics (no first principle)



$\beta = \frac{1}{T} = \partial_E S(E,V,N)$

QED$|_{\text{no e}}$

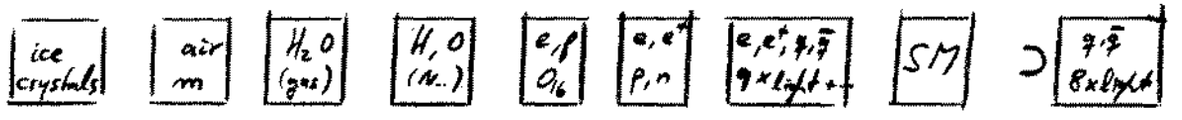
↝ blackbody rad. $E \sim T^4$

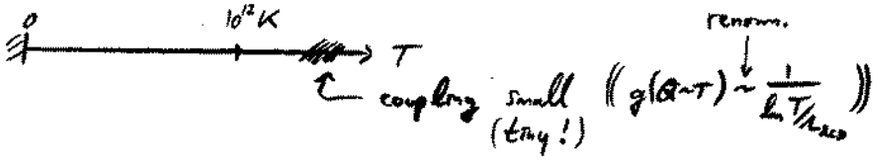
- statistics can prove a theory wrong (→ ED)

"any healthy physics can be heated up"

• why ~~FTFT~~ ?

→ understand theory ! (("heat simplifies", $\bigcup \to \bigcup_{SSB}$))

ex 



⇒ T is the parameter for which ∃ solvable limit !!!

here SM → QCD , because QCD ...

...is well established theory of strong interactions

...is non-Abelian (YM) , (color) gauge group SU(3) → SU(N), # gauge bosons (gluons) = N^2-1 (=8)

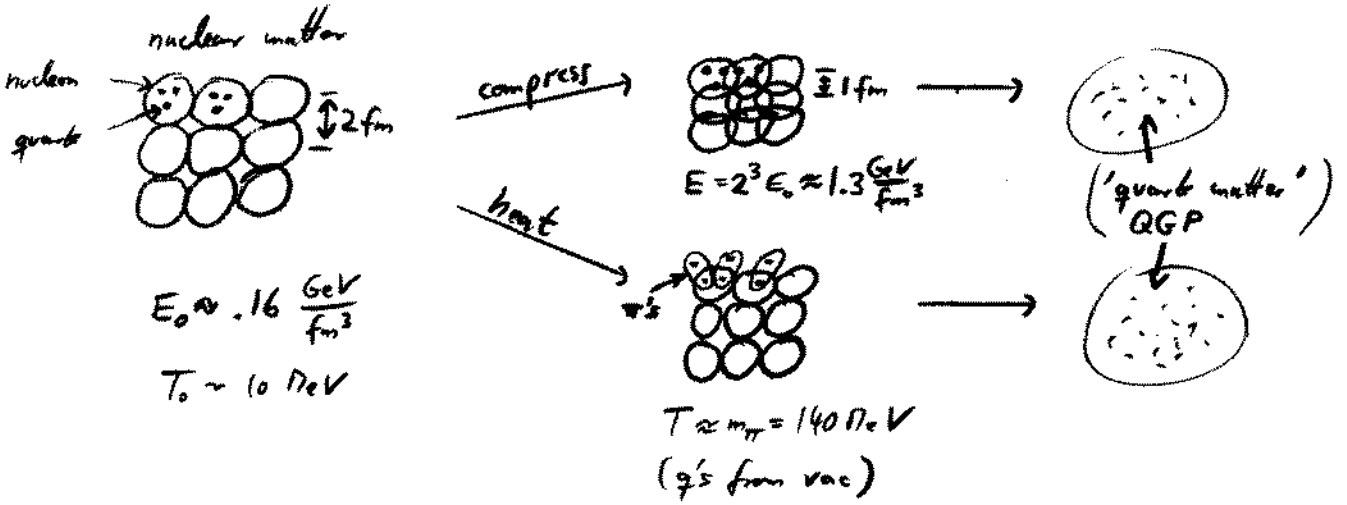
... has quarks as matter content ;

six flavours u c t / d s b → N_f flavours

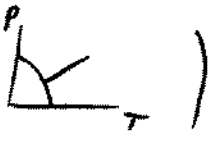
... is renormalizable ~ $g(Q) \xrightarrow{Q\to\infty} 0$ asy. freedom !

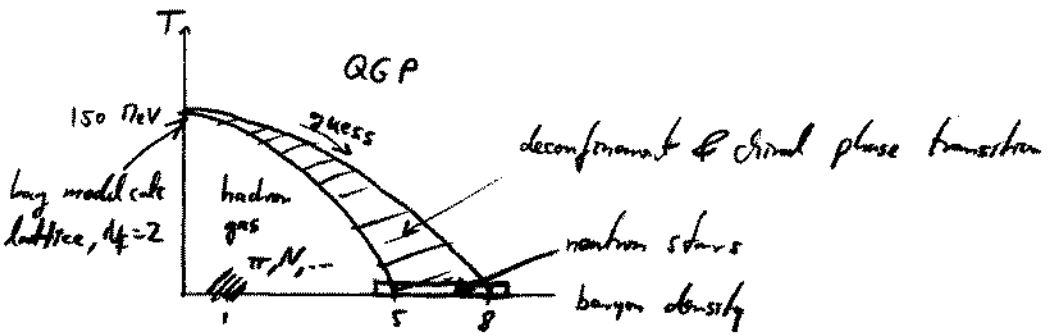
• why FTFT now ?

- unsolved problem of baryon asymmetry
  early universe ($T \gtrsim 150$ MeV, 10^{-6}–10^{-5} s after big bang)
  huge system, but long ago ..
- production of 'quark matter' in lab-experiments (?)
  ultrarel. heavy-ion (Pb+Pb, Au+Au) collisions
  (10+10 GeV : CERN/SPS 1994–1998 ** sign (yet)
  100+100 GeV : Brookhaven/RHIC May 2000 – ?
  2700+2700 GeV : CERN(LHC)/Alice 2006 (?) –)
  tiny, short-lived system; any equilibrium reached ?



⇒ QGP ∃ in nature !
⇝ want to understand phase diagram !

(you know.. water..  ⇝ )



Contents (planned; to be updated if necessary..)

1) Intro / Motivation ✓done
2) (review of) Stat Mech
3) (review of) Qu Field Theory
4) Greens ∂ T
   Path Integral
5) perturbative expansion
6) $\lambda\phi^4$; Fy rules
7) $\lambda\phi^4$; first terms of pressure ($\to \lambda^{3/2}$)
8) QCD; Fy rules
9) QCD; collective excitations
   plasma frequency
10) linear response
11) HTL's; eff. action
12) Outlook

comments
- 4): Matsubara (ITF)
  also RTF, Thermofield ...
- 7): 3-loop vac diag's 
  renorm., IR resu
- 9): 1-loop self E's  etc
  HTL, 'true zeroth order'
- 12): → dim red.
  2+1 D YM solvable ?!

Inhalt (1st approx)

Intro / Motiv / T≠0 → Cobe CMB plot

(review of) Stat Mech

(↘) QM

Greens ∂ T

Pfadintegral, ITF / RTF / Thermo Field

Störungstheorie

$\lambda\phi^4$, Diagrammar

QED, Hohlraumstrahlung

weiße Zwerge → Chandra (h1504, Sirius, Mira)

QCD, HTL's

kollektive Anregungen, Plasmafrequenz

Phasenübergang

ultrarel. Kernstöße → RHIC movies

"seltsame" Sterne → Kandidat

schwache WW

frühes Universum → thermal history

dichte Kernmaterie

Neutronensterne → (Crab, 3c58)

Ausblick

dünn real; 2+1 D YM lösbar?!