421 Class Notes

3-30

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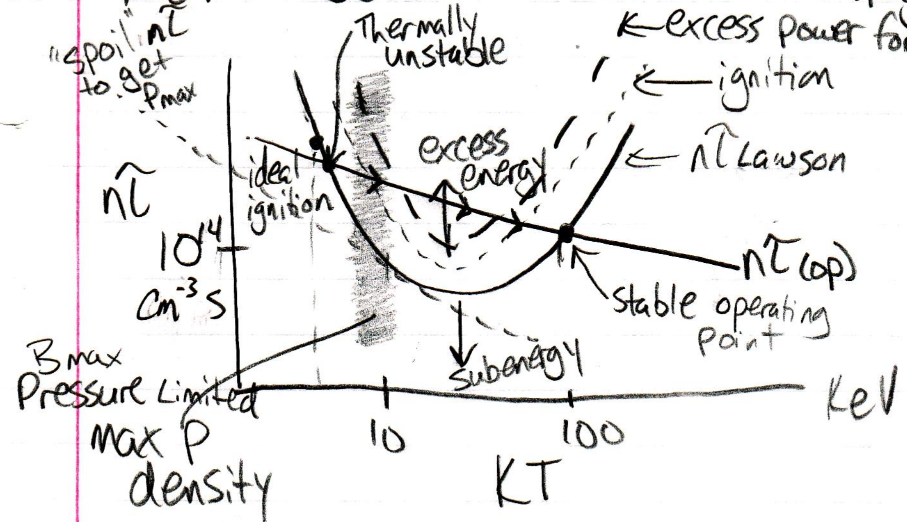
→ 2^{nd} exam: April 13 in class
→ Take Home problem: April 27 - due May 6
→ No final

Reading
6.3 Global leakage
10.3 Tordial particle trapping
p158 Safety factor q.
4.5 ICF (Review)
9.3-9.5 mirror

Not in book: Global Leakage and operating regions



Energy Balance Lines (can derive)

We want to be on the line
Above ⇒ too much & it will heat up
Below ⇒ too little energy

$n\tau$ (op)
operational Line
Thermal stability

Max P

$$\beta = \frac{P \leftarrow 2nKT}{B_{max}^2/2\mu}$$

$$P_{DT} = \frac{n^2}{4}\langle \sigma v\rangle E_f \sim \frac{\langle \sigma v\rangle}{(KT)^2}$$

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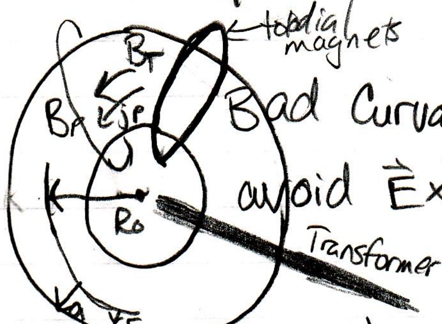
Tokamak

name of game: calculate $n\tau$ for your system

① Stable system



Bad Curvature } Shear
avoid $\vec{E}\times\vec{B}$ drift } Rotational Transform

$q(r) \equiv$ safety factor $= \frac{2\pi}{\iota} = \frac{1}{A_s}\frac{B_T(r)}{B_P(r)}$

ι ← angle, $A_s = \frac{R_0}{a} \sim 3$

$$\boxed{\begin{matrix} q(0) > 1 \\ q(a) > \sim 2.5-3 \end{matrix}}$$

B_T is fixed by external coils
Change B_P to get desired $q(r)$

q discussed on page 158 in book

should find profile
$\nabla^2 n = S$
$\rightarrow n(r)$
$\int n(r)\, d^3r$

$n\tau = n\frac{N_{tot}}{J_{tot}}$

$N_{tot} = \bar{n}V \sim \frac{2}{3}n_0(2\pi R_0 \pi a^2) = \frac{4\pi^2}{3}n_0 A_s a^3$ (Volume)

Assume A_s = constant = 3

Aspect Ratio Considerations, $A_s = \frac{R_0}{a}$

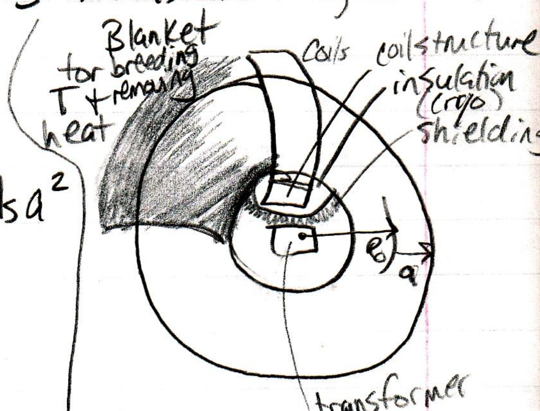
$J_{Tot} = -D_\perp \int \nabla n\, dA$

estimate $\nabla n \sim n_0/a$, $dA = 2\pi R_0 2\pi a = 4\pi^2 A_s a^2$

$\Rightarrow n\tau = \dfrac{\frac{4\pi^2}{3} n_0 A_s a^{3\,2}}{D_\perp \frac{n_0}{a} 4\pi^2 A_s a^2}$

$n\tau = \dfrac{a^2}{3D_\perp}$, $D_\perp \sim \dfrac{1}{B_0^2\sqrt{kT}}$

$\Rightarrow n\tau = \underset{\text{constant}}{k}\, a^2 B_0^2 \sqrt{kT}$



Hole size is crucial to contain all this structure

$\Rightarrow A_s = R_0/a \sim 3$ or more

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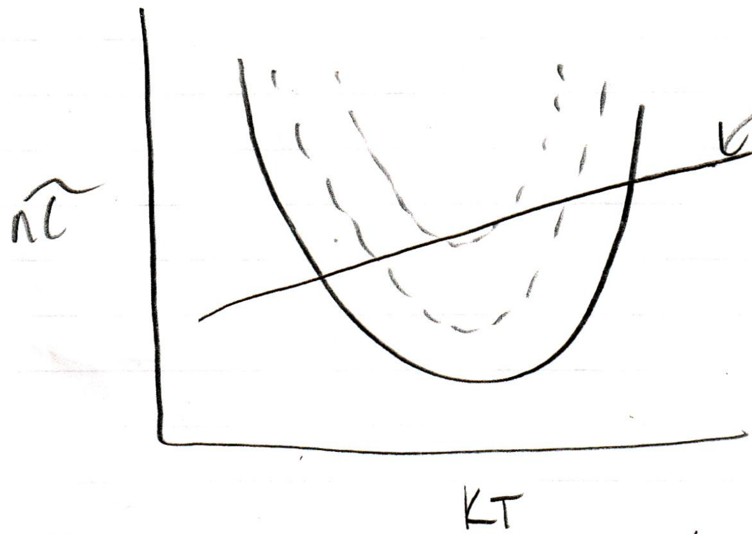
$$\beta = \frac{2 n_0 KT}{B_0^2/2\mu} \Rightarrow B_0^2 = \frac{2 n_0 KT \, 2\mu}{\beta}$$

$$\Rightarrow n\tau = \frac{\boxed{K' a^2 n_0}\,(KT)^{3/2}}{\boxed{\beta}_{\text{fix}}}$$

This gives the operating line for Tokamak



You can change a (increase) to achieve stability