

Tokamak Heating and Current Drive

Do we have enough plasma performance?

Can we sustain fusion reactor condition stably?

- Tokamak heating and current drive issues

Ion heating for ignition: NBI and ICRH (HW #3, Problem 1)

Sufficient ion heating without degrading confinement?

Need other means? Do we have alternatives?

Non-inductive current drive:(HW #3, Problems 2 & 3)

High bootstrap current to be feasible with high plasma current?

LHCD to be feasible for high density reactor-grade plasmas?

Sufficient current drive efficiency with wall-plugin power?

NBCD → NNBI technology, neutron damage

ECCD → availability of high and variable frequency gyrotron?

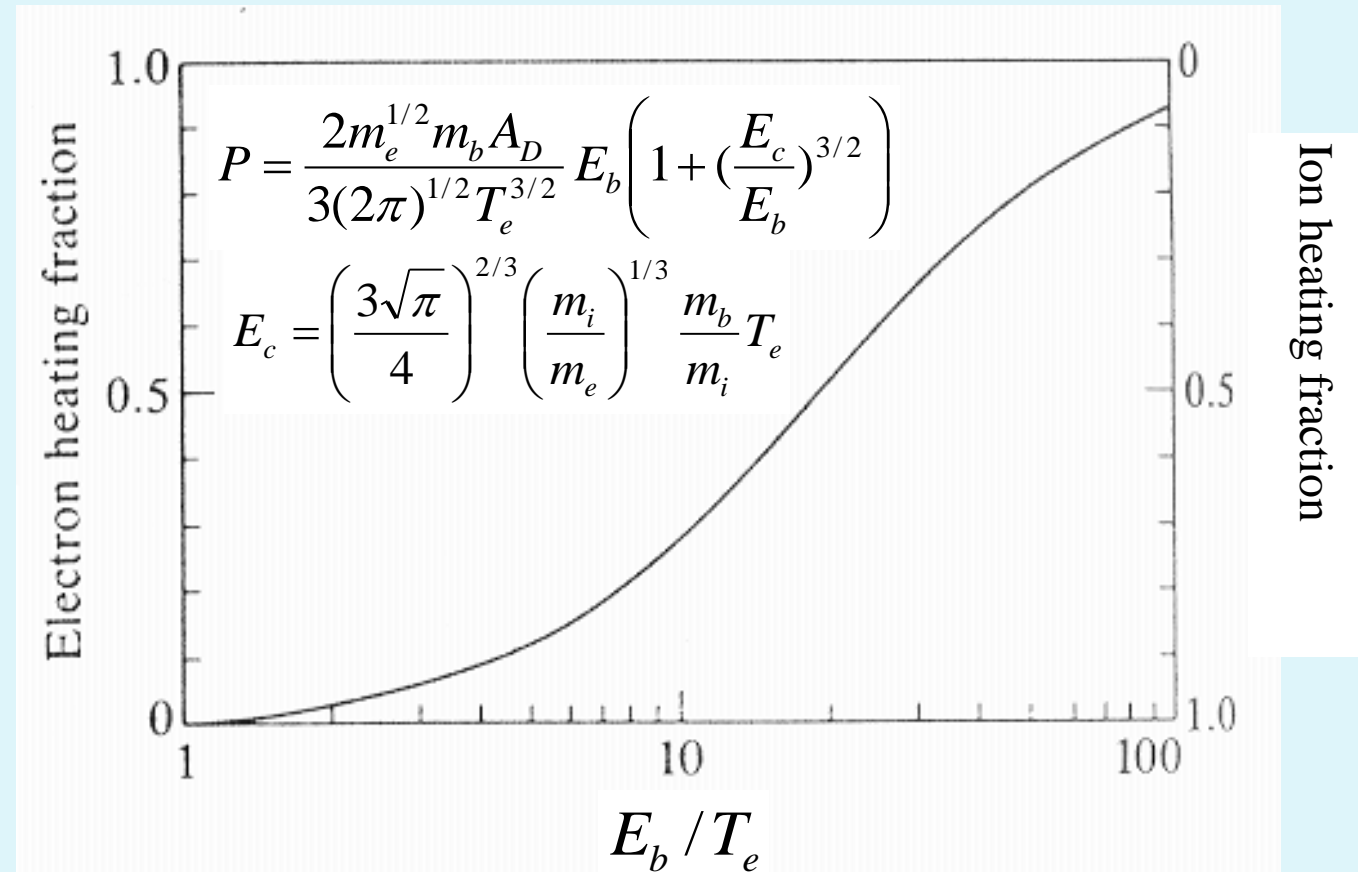
Issues of Ion Heating

High energy neutral beam may heat mostly electrons instead of ions.
Can electron heating result in sufficient ion heating eventually?



$$P = P_e + P_i = m_b A_D \left(\frac{2m_e^{1/2} E_b}{3(2\pi)^{1/2} T_e^{3/2}} + \frac{m_b^{3/2}}{2^{3/2} m_i E_b^{1/2}} \right)$$

$$E_b = \frac{1}{2} m_b v_b^2$$

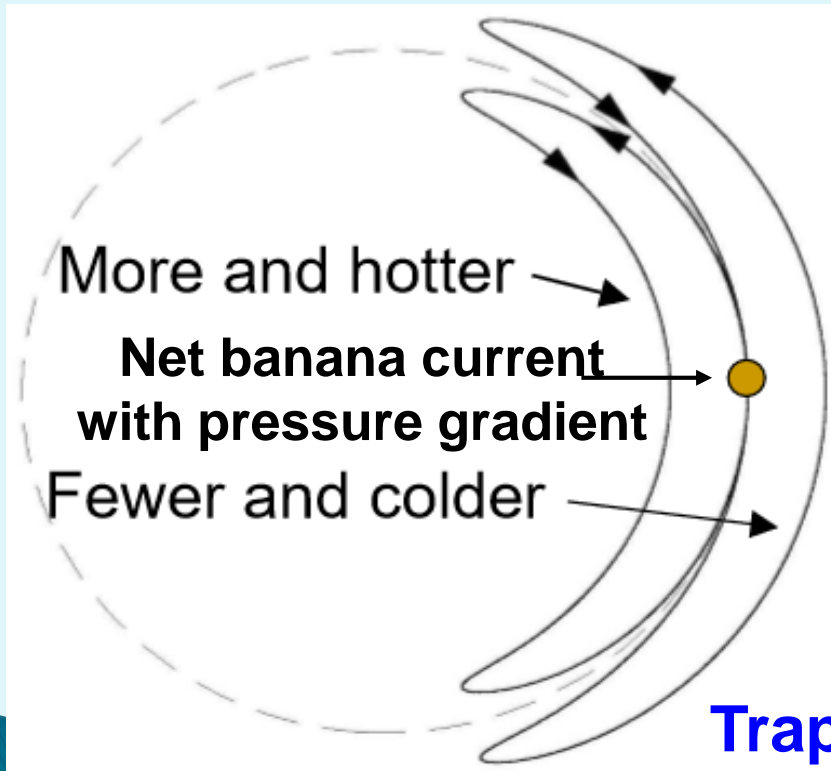


Is ion cyclotron resonance heating effective?

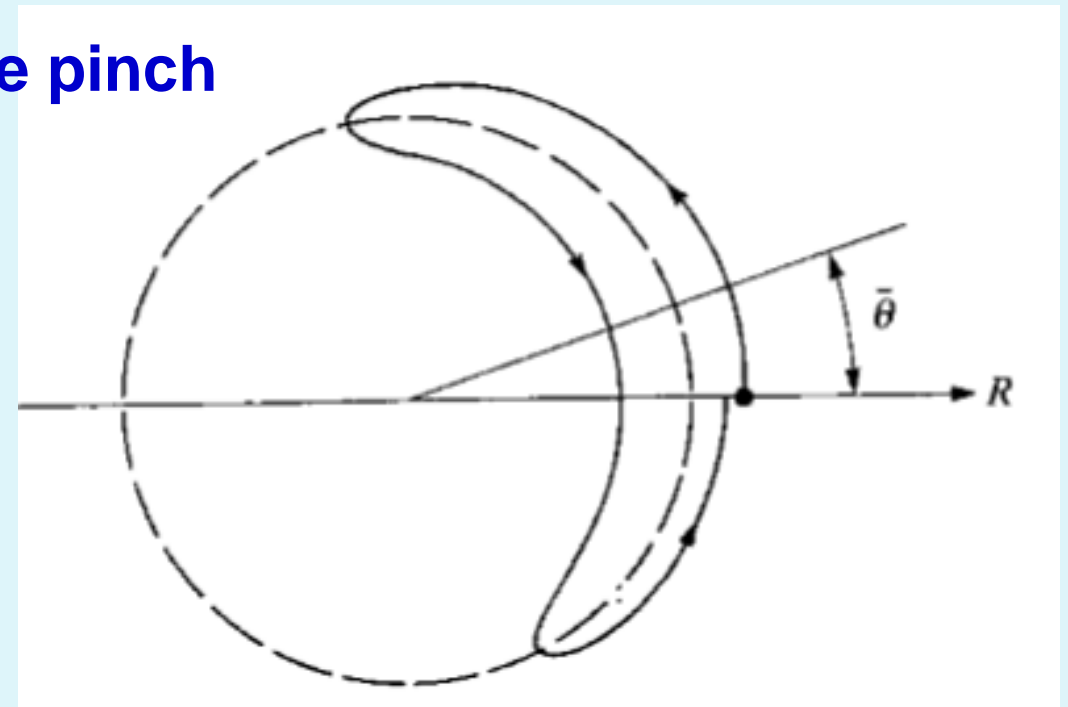
Physics Issues of Non-inductive Current Drive

High bootstrap current to be feasible with high plasma current?

- **Bootstrap currents with pressure gradient**
 - ✓ More kicks to one-directional passing particles preferentially
 - ✓ Ware pinch induce more de-trapping than trapping



Ware pinch



LHCD to be feasible for high density reactor-grade plasmas? Or Helicon?

Technical Issues of Non-inductive Current Drive

Overall Current Drive Efficiency

- **Conversion Efficiency:** power launched by the system per electric power used to operate the system
- **Coupling Efficiency:** power coupled to the plasma per power launched
- **Current Drive Efficiency:** plasma current driven per power coupled to the plasma
cf. engineering efficiency decreases with the major radius R and density n.

	Conversion [%]	Coupling [%]	Current Drive Efficiency [10^{20} A/m ² /W]	Overall Efficiency [10^{20} A/m ² /W]	Demonstrated Power [MW] [1]
NBI	<50	~100	0.50	0.25	25
ICRH	<57	<90	0.40	0.21	7.2
ECRH	<52	~100	0.20	0.10	2.4
LHCD	<36	<40	0.40	0.06	3