핵융합 Plasma - I, 2019, 1st Midterm Exam

I. Adiabatic Compression of Toroidal Plasma

30pts.

One can displace the tokamak plama inward in major radius from R_0 to R_f by suddenly increasing the vertical magnetic field.

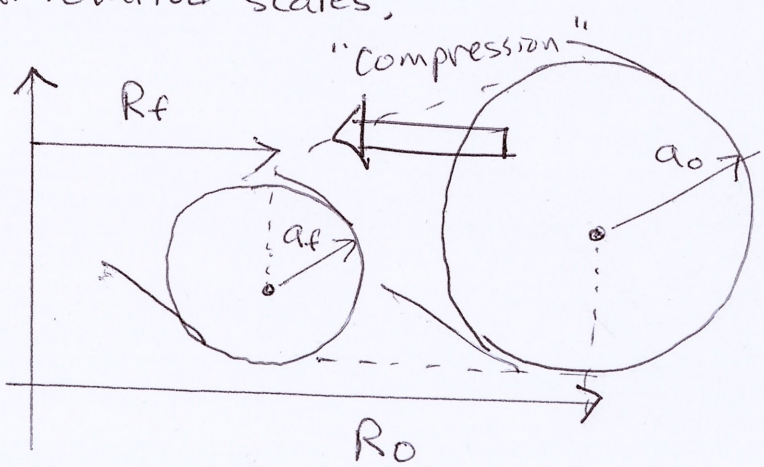
Express the ratio between the final value and the initial value for minor radius, density and temperature in terms of R_0/R_f.

* Show your derivation clearly.

(Using conservation laws relevant to this problem is almost essential for the derivation.)

a) $a_f/a_0 = ?$ b) $n_f/n_0 = ?$ c) $T_f/T_0 = ?$

$B_{toroidal}$ is kept constant. Figure may <u>not</u> be in real relative scales.



II.

40pts. In this problem, $f(x, \vec{v})$ is the distribution function of particles at x, $f_{gc}(x_{gc}, \vec{v})$ is the distribution function of guiding centers. $\vec{v}$ is the particle velocity in both quantities.

Consider a configuration described in Fig 7.3 on page 106 of Goldston and Rutherford.

Assume a uniform density "n", but $T = T(x)$ and $\vec{B} = B(x)\,\hat{z}$. (non uniform temperature),

a) The particles that are to be found at location "x" with velocity "v_y" are those that have guiding centers at a location "x_{gc}". Write the relation between x and x_{gc}.

b) "u_y", the mean fluid drift in y at location x is given by $u_y(x) = \frac{1}{n}\int v_y\, f(x, \vec{v})\, d^3v$.

Express this quantity in terms of an integral involving $f_{gc}(\underset{\sim}{x}, \vec{v})$. Both $B(x)$ and $T(x)$ vary over a distance much longer than the ion Larmor radius.

c) Show that one can obtain

$$u_y = \frac{1}{qB}\frac{d}{dx}\left(\frac{I}{B}\right)$$

for a Maxwellian $f_{gc}(x, \vec{v})$.

d) Discuss the relation (compatibility) of the expression in c) with the "diamagnetic drift" from the fluid picture and the "∇B-drift" from the guiding center drift analyses.