

CHEASE/NEOART Interface

Y. Camenen

November 11, 2009

Documents the addition of a small module in CHEASE to compute the quantities required for NEOART and of another module in NEOART to read the CHEASE outputs.

1 CHEASE modification

A new subroutine `neoart.f90` (based on `hamada.f90`) is added to output the quantities required for NEOART. All the quantities in the output file are in SI units. The names of the various quantities in the output file are chosen to be the same than the ones in the subroutine `geom.f` of NEOART. New quantities are calculated in `surface.f90`

1.1 Conventions

1.2 Outputs

Scalars

NPSI: number of points for the radial grid

R0EXP: reference major radius used in CHEASE, generally taken to be close to the magnetic axis radius for faster convergence (but the actual position is not necessarily known beforehand)

B0EXP: reference magnetic field in CHEASE defined as the magnetic field at R0EXP

Raxis: magnetic axis radius as calculated by CHEASE

Grid

PSI: Ψ , the poloidal flux, zero at the magnetic axis, increasing towards the edge

1D arrays

Rgeom: major radius of the flux surface centre, defined as $(R_{\max} + R_{\min})/2$

amin: minor radius of the flux surface, defined as $(R_{\max} - R_{\min})/2$

damindpsi: $\partial \text{amin} / \partial \Psi$

bmax: maximum of the magnetic field strength on the flux surface

bmin: minimum of the magnetic field strength on the flux surface

q: safety factor

dqpsi: $\partial q / \partial \Psi$

p: plasma pressure

dpsi: $\partial p / \partial \Psi$

f: $F = RB_t = R^2 |\mathbf{B} \cdot \nabla \phi|$ (always positive by convention)

dfpsi: $\partial F / \partial \Psi$

bav: flux surface average of the magnetic field strength $\langle B \rangle$

b2av: $\langle B^2 \rangle$

bi2av: $\langle 1/B^2 \rangle$

r2av: $\langle R^2 \rangle$

ri2av: $\langle 1/R^2 \rangle$

gclass: $\langle R^2 B_p^2 / B^2 \rangle = \langle R^2 \rangle - F^2 \langle 1/B^2 \rangle$

bgradp: $\mathbf{b} \cdot \nabla \Theta$, as defined in Houlberg's paper PoP 4 3230 (1997)

fm1 to fm6: F_M coefficients for the Pfirsch-Schluter contribution to the viscosity integral, equation B9 in Houlberg PoP 4 3230 (1997)

1.3 Checks

The quantities calculated in CHEASE for an equilibrium with circular flux surfaces are compared to the analytical expressions (extracted from the `geom.f` module of NEOART). The reference radius is $R_N = R_{\text{axis}}$, the reference magnetic field is $B_N = B(R_{\text{geom}})$ and the inverse aspect ratio $\epsilon = \frac{R_{\text{max}} - R_{\text{min}}}{2R_N}$. The following expressions are used for the comparison:

$$\text{BAV} = \langle B \rangle = B_N$$

$$\text{B2AV} = \langle B^2 \rangle = \frac{B_N^2}{\sqrt{1 - \epsilon^2}}$$

$$\text{BI2AV} = \langle 1/B^2 \rangle = \frac{1 + 1.5\epsilon^2}{B_N^2}$$

$$\text{RBT} = F = R_N B_N \frac{\sqrt{1 - \epsilon^2}}{\sqrt{1 + \epsilon^2(1/q^2 - 1)}}$$

$$\text{BGRADP} = \mathbf{b} \cdot \nabla \Theta = \frac{1}{R_N \sqrt{\epsilon^2 + q^2(1 - \epsilon^2)}}$$

$$\text{DPSIDR} = \frac{\partial \Psi}{\partial \rho} = \frac{R_N B_N}{\sqrt{1 + q^2(1/\epsilon^2 - 1)}}$$

$$\text{RNQ} = R_N q$$

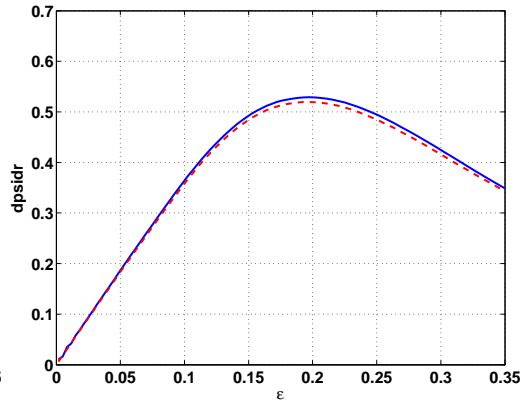
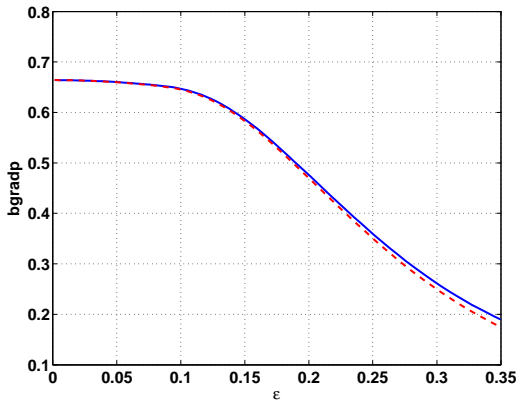
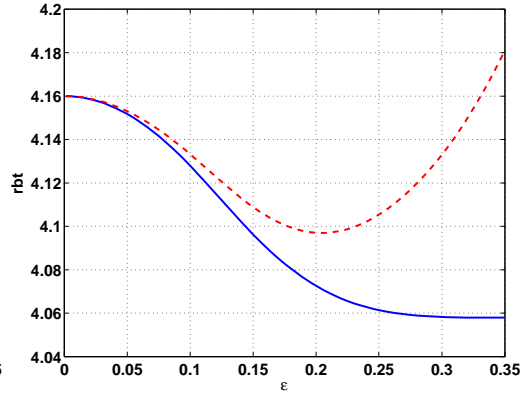
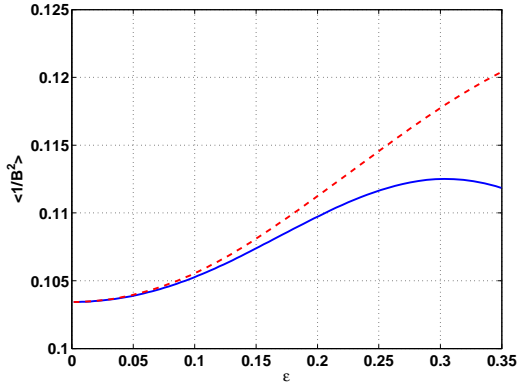
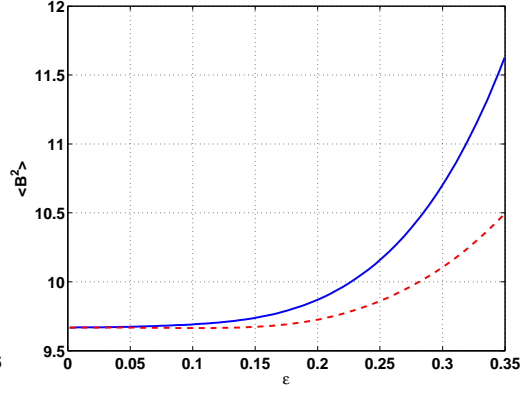
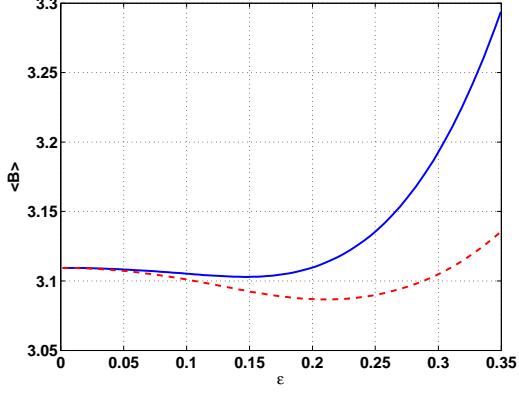
$$\text{FC} = (1 - \epsilon) \sum_{i=0}^5 a_i \epsilon^{i/2}$$

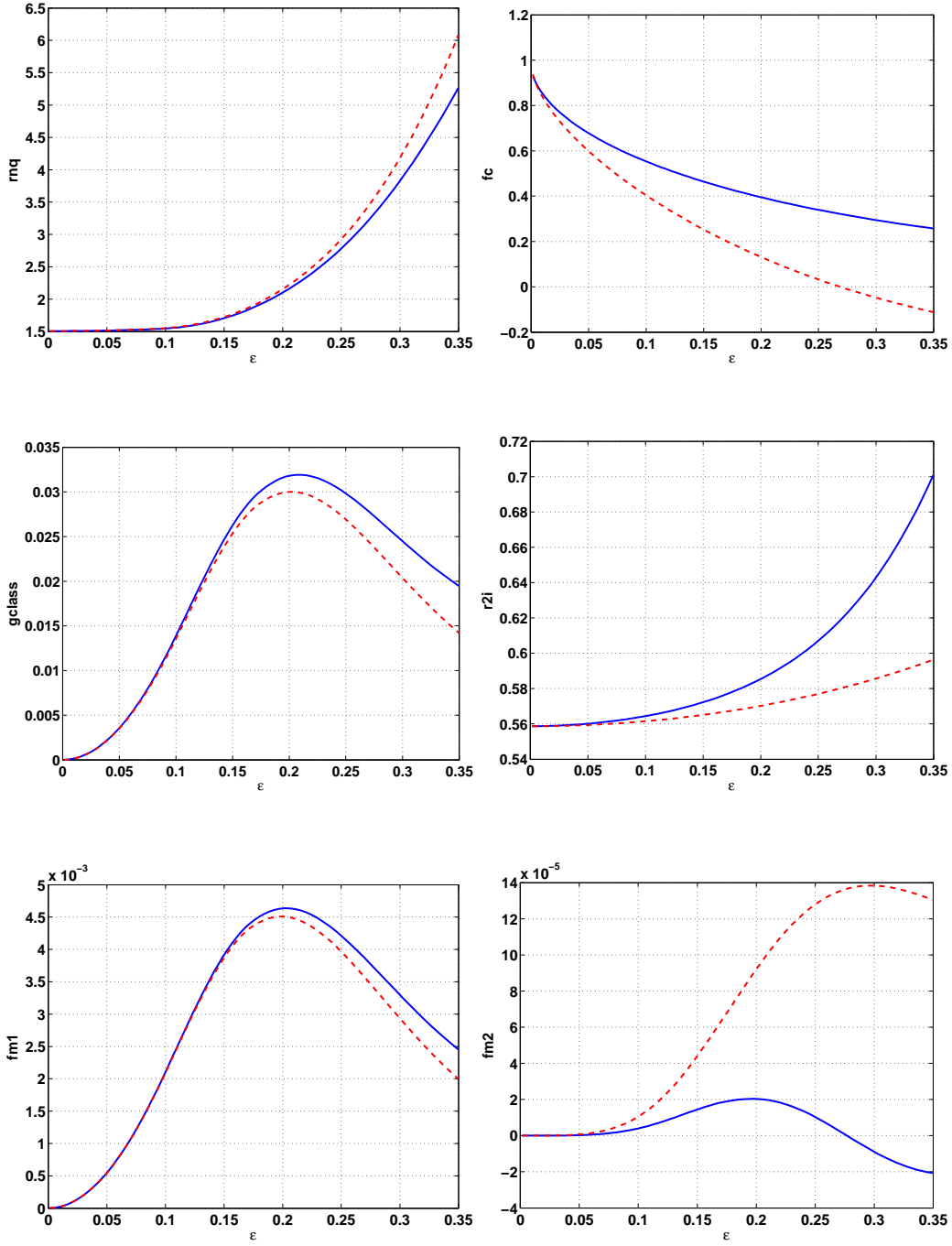
with the coefficients taken to be $a_0 = 1$, $a_1 = -1.46655$, $a_2 = 1.0241$, $a_3 = -1.20107$, $a_4 = 1.356234$, $a_5 = -0.662881$

$$\text{GCLASS} = \frac{\epsilon^2 R_N^2 (1 + 1.5\epsilon^2)}{q^2 + \epsilon^2(1 - q^2)}$$

$$\text{FM}(i) = 2i(\mathbf{b} \cdot \nabla \Theta)^2 \left[\frac{-1 + \sqrt{1 - \epsilon^2}}{\epsilon} \right]^{2i}$$

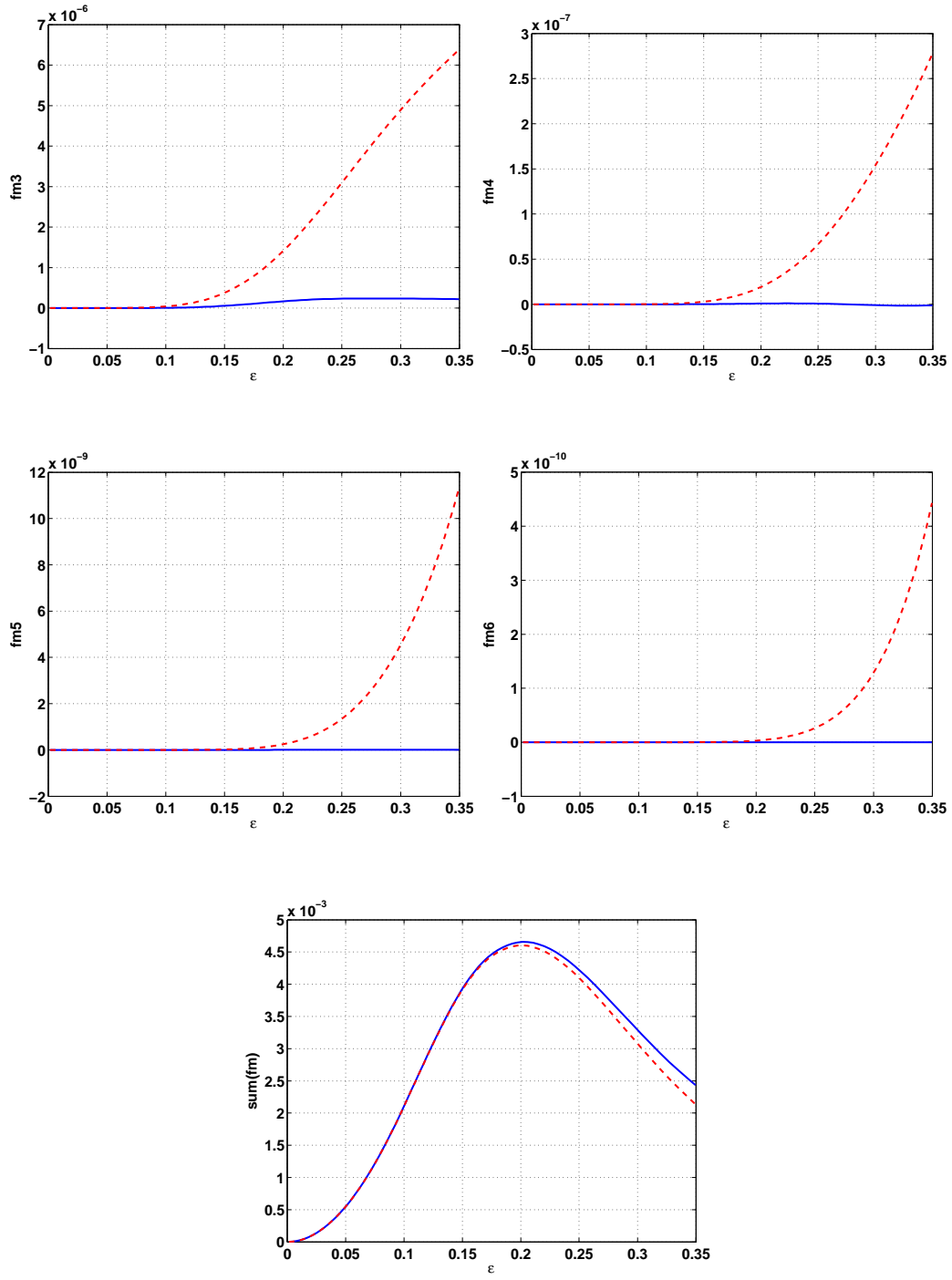
$$\text{R2I} = \langle 1/R^2 \rangle = \frac{1}{R_N^2 \sqrt{1 - \epsilon^2}}$$





2 NEOART modification

The main change done in NEOART is the addition of a module `get_geom.ch.f` to load the data from the output file generated by CHEASE. The full radial profiles are loaded and interpolated at the input radial value specified in NEOART. The parameters related to the MHD equilibrium are read from the CHEASE output when NEOART is called with `ISEL = 4`. The CHEASE output file has to be called `neoart_geom.dat`



and be located in the directory where NEOART is run.