Contents

Part I
Profiles NF2008

1 Normalized poloidal magnetic flux ψ_N

Normalized polidal magnetic flux ψ_N (1, Fig.1):

$$\psi_N(a_N) = \frac{\int\limits_0^{a_N} \mu(a')a'da'}{\int\limits_0^{1} \mu(a')a'da'} \tag{1}$$

where $\mu = 1/q$, $q(a_N) = 1 + 3.6a_N^{5.6}$ is safety factor.

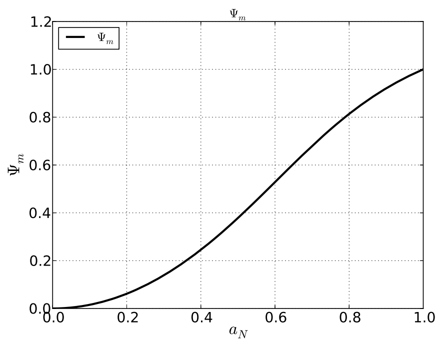

Figure 1: ψ_N - normalized poloidal magnetic flux (NF2008)

2 Density n_e and temperature $T_{e,i}$

Profiles of electron density $n_e(\psi_N)$ and electron and ion temperature $T_{e,i}(\psi_N)$ (2,3):

$$\begin{aligned} n_e(\psi_N) = n_{sep} + a_{n0}\left[tanh\left(2\frac{1-\psi_{mod}}{\Delta}\right) - tanh\left(2\frac{\psi_N-\psi_{mod}}{\Delta}\right)\right] + \\ + a_{n1}H\left(1-\frac{\psi_N}{\psi_{ped}}\right)\left[1-(\frac{\psi_N}{\psi_{ped}})^{\alpha_{n1}}\right]^{\alpha_{n2}}, \end{aligned} \tag{2}$$

$$\begin{aligned} T_{e,i}(\psi_N) = T_{sep} + a_{T0}\left[tanh\left(2\frac{1-\psi_{mod}}{\Delta}\right) - tanh\left(2\frac{\psi_N-\psi_{mod}}{\Delta}\right)\right] \\ + a_{T1}H\left(1-\frac{\psi_N}{\psi_{ped}}\right)\left[1-(\frac{\psi_N}{\psi_{ped}})^{\alpha_{T1}}\right]^{\alpha_{T2}}, \end{aligned} \tag{3}$$

where Δ is pedestal width, $\psi_{ped} = 1 - \Delta, \psi_{mid} = 1 - \Delta/2$, parameters a_{n0}, a_{t0} and Δ affect the pedestal profiles, parameters $a_{n1}, a_{T1}, \alpha_{n1}, \alpha_{n2}, \alpha_{T1}$ and α_{T2} affect the core plasma profiles, $H(x)$ - Heaviside function. These profiles are shown as function of normalized radius at Fig.2 and Fig.3.

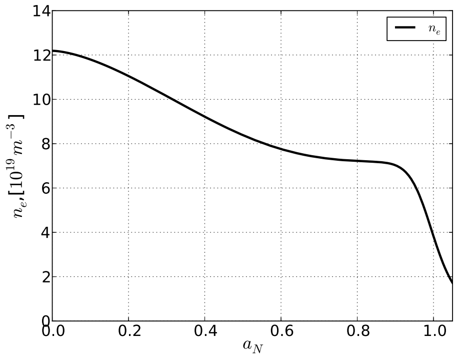

Figure 2: Electron density, $10^{19}m^{-3}$ (NF2008)

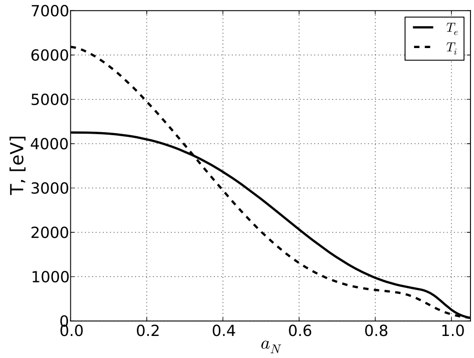

Figure 3: Electron and ion temperature, eV (NF2008)

3 Plasma pressure and pressure gradients

Electron, ion and total plasma pressure (Fig.4) are estimated as (4):

$$P_{e,i}[Pa] = 1.6 \times n_e[10^{19}m^{-3}] \times T_{e,i}[eV] \tag{4}$$

Pressure gradients are shown at Fig.24.

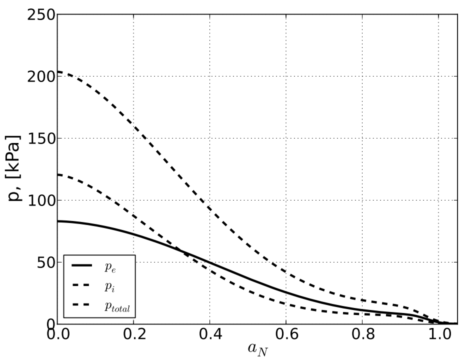

Figure 4: Electron, ion and total pressure, kPa (NF2008)

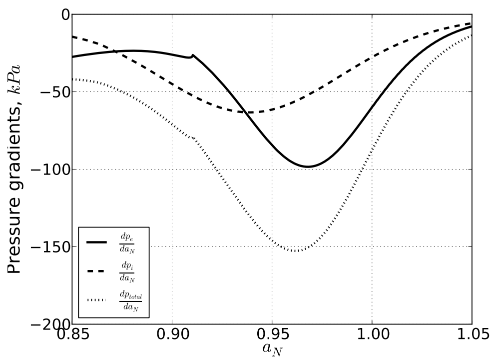

Figure 5: Pressure gradients, kPa (NF2008)

4 Radial electric field $E_{0r}(a_N)$

Radial electric field $E_{0r}(a_N)$ (Fig.6) is aproximated as (5):

$$E_{0r}(a_N) = d_1 + r_1 a_N \, exp\left(b_1 + c_1 a_N^{exp(-a_1 x^2)} \right) [\frac{V}{m}]. \tag{5}$$

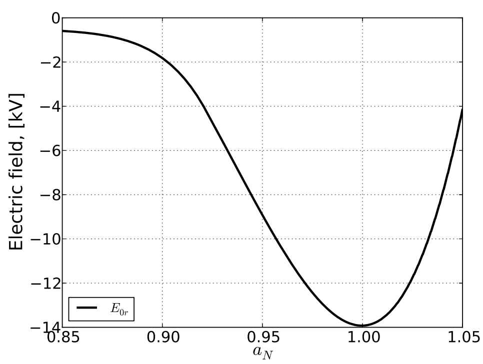

Figure 6: Radial electric field, kV (NF2008)

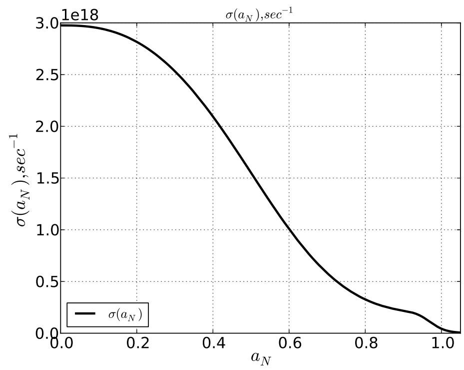

Figure 7: Plasma conductivity, sec^{-1} (NF2008)

5 Plasma conductivity $\sigma(a_N)$

Plasma conductivity $\sigma(a_N)$ (7, Fig.7):

$$\sigma(a_N)[sec^{-1}] = 1.2 \times 10^{17} \left(\frac{T_e[keV]}{500} \right)^{3/2} \tag{6}$$

6 Equation

Our equation (7):

$$\begin{aligned} &\frac{1}{a_N} \frac{d}{da_N} \left(a_N \frac{d}{da_N} (a_N B_m^a) \right) - \frac{m^2}{a_N^2} (a_N B_m^a) - \frac{m}{a_N^2} Q_m(a_N)(a_N B_m^a) - \\ &- \frac{4\pi m^2}{cB_{0\zeta}} \frac{R}{a} \frac{dj_b}{da_N} Q_{1m}(a_N)(a_N B_m^a) = 0 \end{aligned} \tag{7}$$

7 $K_m(a_N), A(a_N)$

Quantities $K_m(a_N)$ (Eq.8, Fig.8) and $A(a_N)$ (Eq.8, Fig.9):

$$K_m(a_N) = F_m(a_N)\frac{a}{R}\frac{V_{0||}}{mc} + \frac{1}{B_0}\left(\frac{1}{p_{0i}}\frac{dp_{0i}}{da_N}\frac{T_i(a_N)}{ea_{pl}} - E_{0a}(a_N)\right) \tag{8}$$

$$A(a_N) = \frac{8\pi}{B_{0\zeta}^2}a_N\frac{dp_0}{da_N}m^2(\mu^2 - 1 - \frac{R}{a}S\xi'), \quad \boxed{-1 - \tfrac{R}{a}S\xi' \approx -9} \tag{9}$$

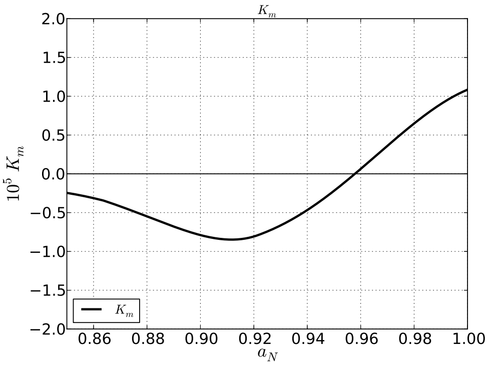

Figure 8: $K_m(a_N)$ (NF2008)

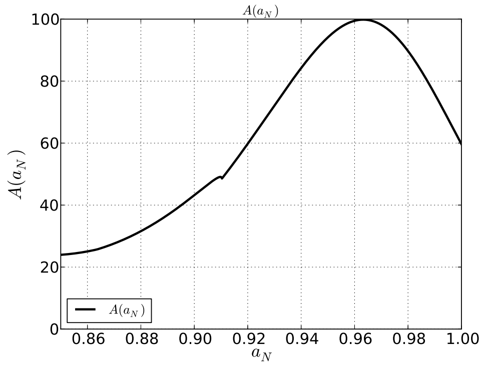

Figure 9: $A(a_N)$ (NF2008)

8 $Q_m(a_N)$

Real (11) and imaginary (12) part of $Q_m(a_N)$ (Fig.10):

$$Q_m(a_N) = \frac{K_m(a_N)A_m(a_N)\left(mK_m(a_N)F_m^2(a_N) + iA_m(a_N)\frac{c}{4\pi\sigma(a_N)a_Na}\right)}{\left(mK_m(a_N)F_m^2(a_N)\right)^2 + \left(A_m(a_N)\frac{c}{4\pi\sigma(a_N)a_Na}\right)^2} \tag{10}$$

$$\mathrm{Re}Q_m = \frac{mK_m^2(a_N)F_m^2(a_N)A(a_N)}{\left(mK_m(a_N)F_m^2(a_N)\right)^2 + \left(A_m(a_N)\frac{c}{4\pi\sigma(a_N)a_Na}\right)^2} \tag{11}$$

$$\mathrm{Im}Q_m = \frac{K_m(a_N)A^2(a_N)\dfrac{c}{4\pi\sigma(a_N)a_N a}}{\left(mK_m(a_N)F_m^2(a_N)\right)^2 + \left(A_m(a_N)\dfrac{c}{4\pi\sigma(a_N)a_N a}\right)^2} \tag{12}$$

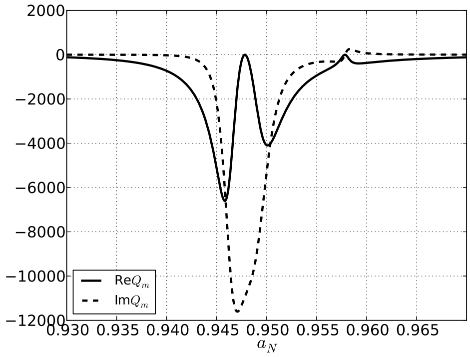

Figure 10: $Q(a_N)$: $m = -11, V_0 = 0km/sec$ (NF2008)

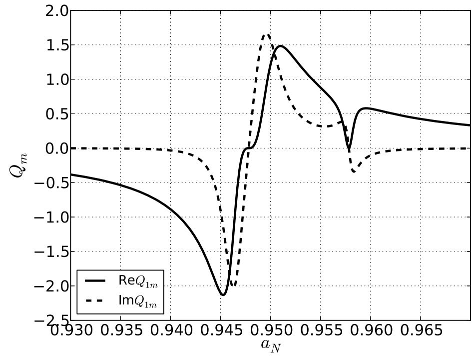

Figure 11: Q_{1m} : $m = -11, V_0 = 0km/sec$ (NF2008)

9 $Q_{1m}(a_N)$

Real (14) and imaginary (15) part of Q_{1m} (Fig.11):

$$Q_{1m}(a_N) = \frac{K_m(a_N)F_m(a_N)\left(mK_m(a_N)F_m^2(a_N) + iA_m(a_N)\dfrac{c}{4\pi\sigma(a_N)a_N a}\right)}{\left(mK_m(a_N)F_m^2(a_N)\right)^2 + \left(A_m(a_N)\dfrac{c}{4\pi\sigma(a_N)a_N a}\right)^2} \tag{13}$$

$$\mathrm{Re}Q_{1m} = \frac{mK_m^2(a_N)F_m^3(a_N)}{\left(mK_m(a_N)F_m^2(a_N)\right)^2 + \left(A_m(a_N)\dfrac{c}{4\pi\sigma(a_N)a_N a}\right)^2} \tag{14}$$

$$\mathrm{Im}Q_{1m} = \frac{K_m(a_N)F_m(a_N)A(a_N)\dfrac{c}{4\pi\sigma(a_N)a_N a}}{\left(mK_m(a_N)F_m^2(a_N)\right)^2 + \left(A_m(a_N)\dfrac{c}{4\pi\sigma(a_N)a_N a}\right)^2} \tag{15}$$

10 Pressure perturbation P_m

Real and imaginary part of pressure perturbations (16,17):

$$\mathrm{Re}P_m = -a_N \frac{dp_0}{da_N} \frac{R}{a} \frac{mK_m(a_N)F_m(a_N)A(a_N)\dfrac{c}{4\pi\sigma(a_N)a}}{\left(mK_m(a_N)F_m^2(a_N)\right)^2 + \left(A(a_N)\dfrac{c}{4\pi\sigma(a_N)a}\right)^2} \frac{B_m^a}{B_0} \tag{16}$$

$$\mathrm{Im}P_m = a_N \frac{dp_0}{da_N} \frac{R}{a} \frac{m^2K_m^2(a_N)F_m^3(a_N)\dfrac{B_{0\varsigma}}{B_0}}{\left(mK_m(a_N)F_m^2(a_N)\right)^2 + \left(A(a_N)\dfrac{c}{4\pi\sigma(a_N)a}\right)^2} \frac{B_m^a}{B_0} \tag{17}$$

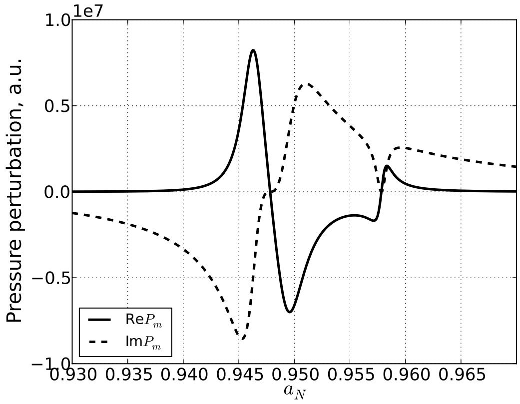

Figure 12: Plasma pressure perturbation (NF2008)

Part II

Profiles NF2013

11 Density n_e and temperature $T_{e,i}$

All subsequent profiles correspond 60^o phase.

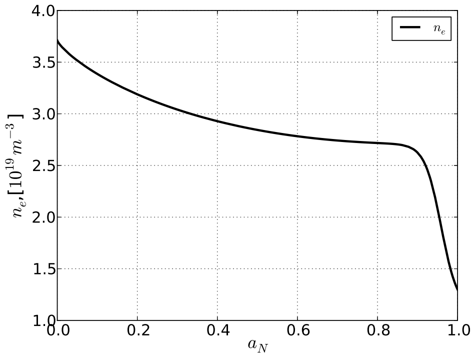

Figure 13: Electron density, $10^{19}m^{-3}$ (NF2013)

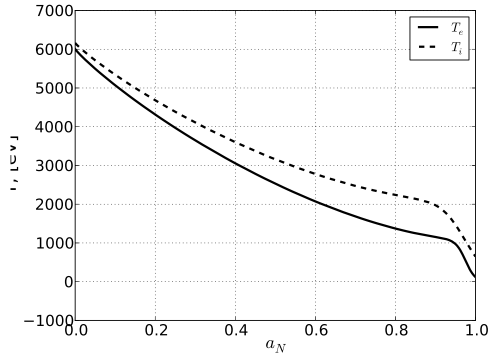

Figure 14: Electron and ion temperature, eV (NF2013)

12 Plasma pressure and pressure gradients

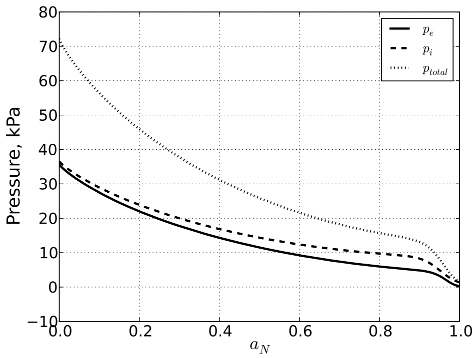

Figure 15: Electron, ion and total pressure, kPa (NF2013)

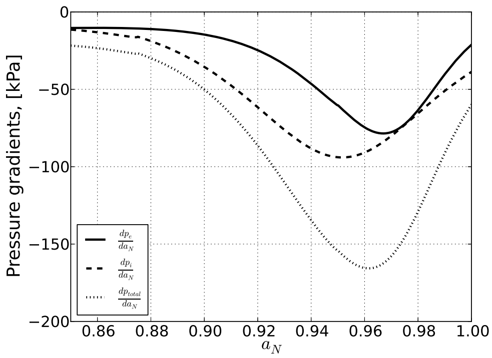

Figure 16: Pressure gradients, kPa (NF2013)

13 Radial electric field $E_{0r}(a_N)$

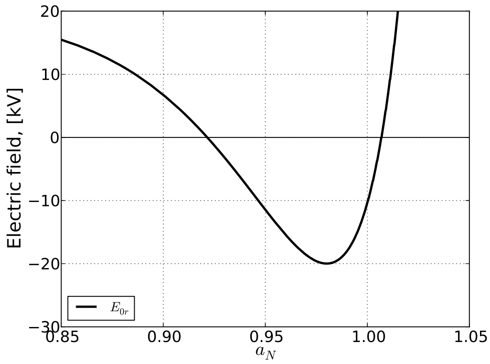

Figure 17: Radial electric field, kV (NF2013)

14 $K_m(a_N)$, $A(a_N)$

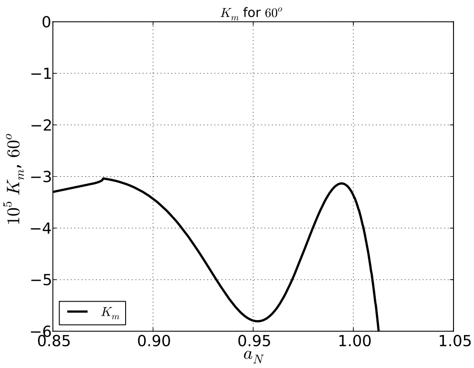

Figure 18: $K_m(a_N)$ (NF2013)

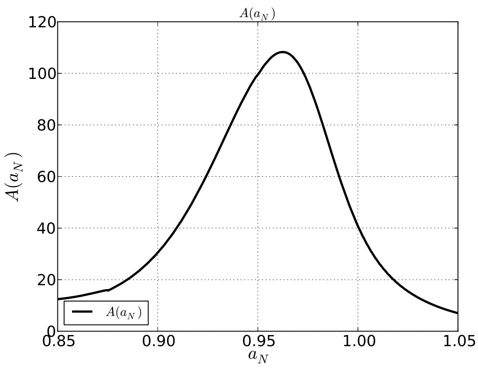

Figure 19: $A(a_N)$ (NF2013)

15 $Q_m(a_N)$, $Q_{1m}(a_N)$

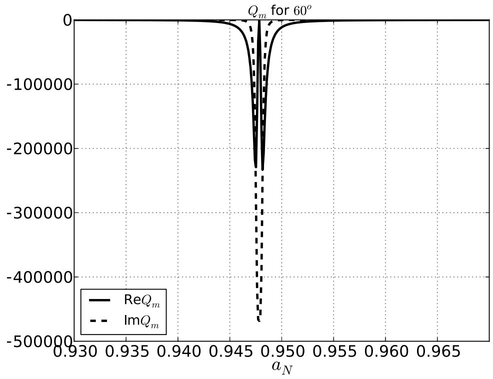

Figure 20: $Q(a_N)$: $m = -11, V_0 = 0km/sec$ (NF2013)

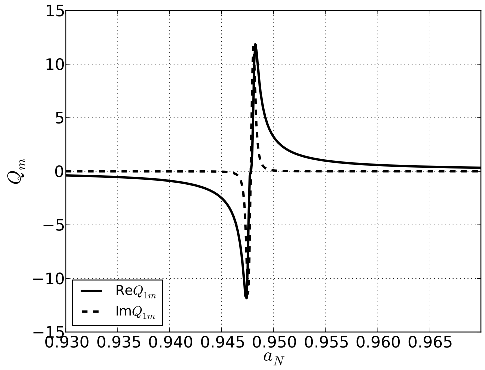

Figure 21: Q_{1m} : $m = -11, V_0 = 0km/sec$ (NF2013)

16 Plasma pressure perturbation P_m

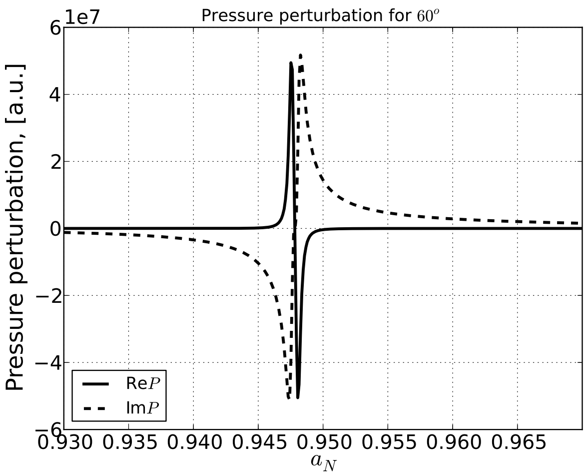

Figure 22: Plasma pressure perturbation (NF2013)

Part III
Bootstrap current

17 Comparing

Bootstrap current [Wesson (4.9.2)]:

$$j_b(a_N) = \left(\frac{a}{R}\right)^{-0.5} \frac{cn_0(a_N)q(a_N)}{B_{0\zeta}} \left[2.44\Big(T_{0e}(a_N)+T_{0i}(a_N)\Big)\frac{1}{n_0(a_N)}\frac{dn_0}{da_N}+0.69\frac{dT_{0e}}{da_N}-0.42\frac{dT_{0i}}{da_N}\right] \tag{18}$$

We need to compare two quantities: $Q_m(a_N)$ (10) and $Q_m^*(a_N)$ (19):

$$Q_m^*(a_N) = \left(\frac{R}{a}\right)^{1.5} \frac{4\pi m a_N^2}{B_{0\zeta}^2} Q_{1m}(a_N) \frac{d}{da_N}\Bigg\{ n_0(a_N)q(a_N)\times$$
$$\times\left[2.44\Big(T_{0e}(a_N)+T_{0i}(a_N)\Big)\frac{1}{n_0(a_N)}\frac{dn_0}{da_N}+0.69\frac{dT_{0e}}{da_N}-0.42\frac{dT_{0i}}{da_N}\right]\Bigg\} \tag{19}$$

$$\frac{Q_m(a_N)}{Q_{1m}(a_N)} = \frac{A_m(a_N)}{F_m(a_N)} \tag{20}$$

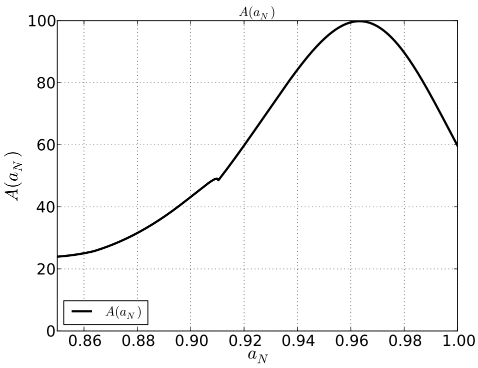

Figure 23: $A_m(a_N)$ (NF2008)

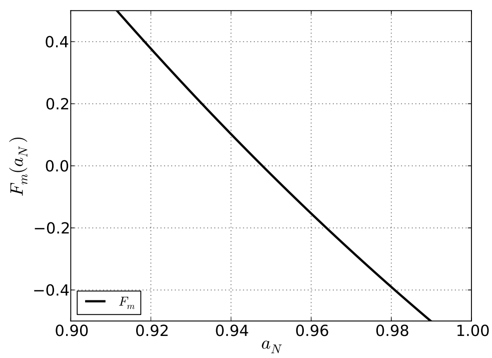

Figure 24: $F_m(a_N)$(NF2008)

Compare two quantities $qu1$ and $qu2$ (Fig. 25):

$$qu1 = 2m\frac{dp_0}{da_N}(\mu^2-9) \longleftrightarrow qu2 = \left(\frac{R}{a}\right)^{1.5} a_N F_m(a_N)\frac{d}{da_N}\Bigg\{ n_0(a_N)q(a_N)\times$$
$$\times\left[2.44\Big(T_{0e}(a_N)+T_{0i}(a_N)\Big)\frac{1}{n_0(a_N)}\frac{dn_0}{da_N}+0.69\frac{dT_{0e}}{da_N}-0.42\frac{dT_{0i}}{da_N}\right]\Bigg\} \tag{21}$$

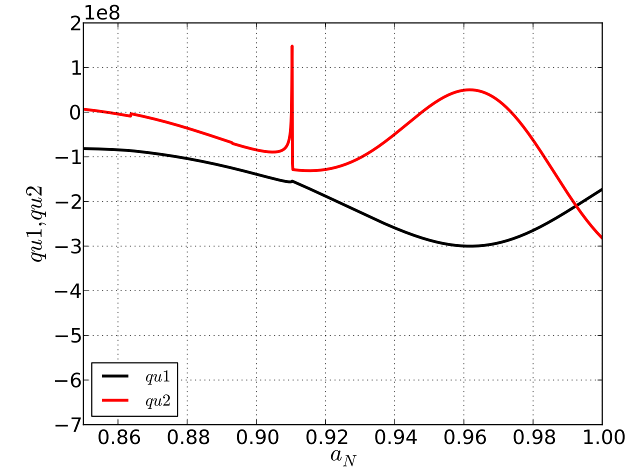

Figure 25: Compare(NF2008)

Real and imiginary part of $Q^*(a_N)$:

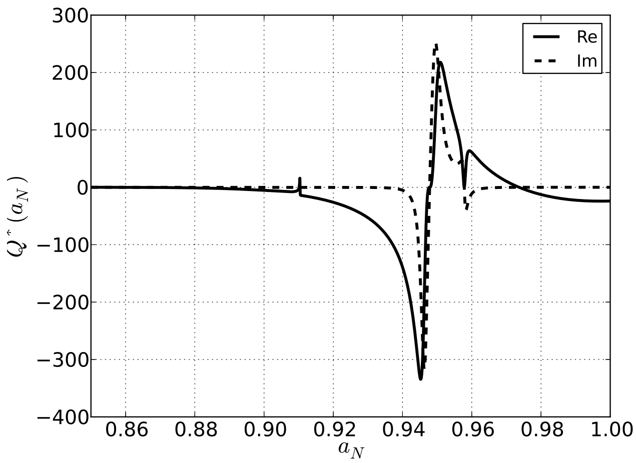

Figure 26: Q^* (NF2008)