Construction of EFIT File

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The EFIT equilibrium magnetic field is written

$$\mathbf{B} = T(\Psi)\,\nabla\phi + \nabla\phi\times\nabla\Psi, \tag{1}$$

whereas the TJ equilibrium field is written

$$\mathbf{B} = B_0\,R_0\left[g(r)\,\nabla\phi + R_0\,f(r)\,\nabla\phi\times\nabla r\right]. \tag{2}$$

So,

$$T = B_0\,R_0\,g, \tag{3}$$

$$\frac{d\Psi}{dr} = B_0\,R_0^{\,2}\,f. \tag{4}$$

Here, B_0 and R_0 are the toroidal magnetic field strength at the magnetic axis, and the major radius of the magnetic axis, respectively. Let $\Psi = 0$ at the plasma boundary, $r = \epsilon$. It follows that

$$\Psi(r) = B_0\,R_0^{\,2}\int_r^{\epsilon} f(r')\,dr'. \tag{5}$$

Also,

$$q = \frac{r\,g}{f}. \tag{6}$$

Let $\hat{r} = r/\epsilon$. It follows that

$$\frac{d\Psi}{d\hat{r}} = \epsilon\,B_0\,R_0^{\,2}\,f, \tag{7}$$

and

$$\Psi(\hat{r}) = \epsilon\,B_0\,R_0^{\,2}\int_{\hat{r}}^{1} f(\hat{r}')\,d\hat{r}'. \tag{8}$$

Furthermore,

$$T\,\frac{dT}{d\Psi} = B_0\,\frac{g}{\epsilon\,f}\,\frac{dg}{d\hat{r}}, \tag{9}$$

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and

$$\frac{dP}{d\Psi} = \frac{B_0}{\mu_0\,R_0^2}\,\frac{1}{\epsilon\,f}\,\frac{dP}{d\hat{r}}. \tag{10}$$

Let $\hat{r}\,f = \epsilon\,f_1 + \epsilon^3\,f_3$. It follows that

$$\Psi(\hat{r}) = \epsilon^2\,B_0\,R_0^2\int_{\hat{r}}^1 \frac{f_1(\hat{r}') + \epsilon^2\,f_3(\hat{r}')}{\hat{r}'}\,d\hat{r}', \tag{11}$$

$$q(\Psi) = \frac{\hat{r}^2\,(1+\epsilon^2\,g_2)}{f_1 + \epsilon^2\,f_3}, \tag{12}$$

$$T(\Psi) = B_0\,R_0\left(1+\epsilon^2\,g_2\right), \tag{13}$$

$$p(\Psi) = \frac{B_0^2}{\mu_0}\,\epsilon^2\,p_2(\hat{r}), \tag{14}$$

$$T\,\frac{dT}{d\Psi} = B_0\,\frac{1}{f_1+\epsilon^2\,f_3}\,\hat{r}\,\frac{dg_2}{d\hat{r}}\left(1+\epsilon^2\,g_2\right), \tag{15}$$

$$\frac{dP}{d\Psi} = \frac{B_0}{\mu_0\,R_0^2}\,\frac{1}{f_1+\epsilon^2\,f_3}\,\hat{r}\,\frac{dp_2}{d\hat{r}}. \tag{16}$$

At small $\hat{r}$, $g_2 = 0$, $f_1 = f_{1\,c}\,\hat{r}^{\,2}$, $f_3 = f_{3\,c}\,\hat{r}^{\,2}$, $\hat{r}\,p_2' = p_{2\,c}''\,\hat{r}^{\,2}$, $\hat{r}\,g_2' = g_{2\,c}'\,\hat{r}^{\,2}$, $\Psi = \Psi(0) + \epsilon^2\,B_0\,R_0^2\,(1/2)\,(f_{1\,c} + \epsilon^2\,f_{3\,c})\,\hat{r}^{\,2}$, where $g_{2\,c}' = -2\,(f_{1\,c}^{\,2} + p_{2\,c}''/2)$, and $f_{3\,c} = -f_{1\,c}\,(\hat{H}_{2\,c}^2 + \hat{V}_{2\,c}^2)$. For $\hat{r} > 1$,

$$\Psi(\hat{r}) = \epsilon^2\,B_0\,R_0^2\,\ln\hat{r}\,[f_1(1) + \epsilon^2\,f_3(1)]. \tag{17}$$

TJ flux surfaces are parameterized via

$$R(\hat{r},\omega) = 1 - \epsilon\,\hat{r}\,\cos\omega + f_R(\hat{r},\omega), \tag{18}$$

$$Z(\hat{r},\omega) = \epsilon\,\hat{r}\,\sin\omega + f_Z(\hat{r},\omega), \tag{19}$$

where

$$\begin{aligned} f_R(\hat{r},\omega) &= \epsilon^{\,2}\sum_{j>0} H_j(\hat{r})\,\cos[(j-1)\,\omega] + \epsilon^{\,2}\sum_{j>1} V_j(\hat{r})\,\sin[(j-1)\,\omega] \\ &\quad + \epsilon^{\,3}\,[L_3(\hat{r}) + \epsilon\,L_4(\hat{r})]\,\cos\omega, \end{aligned} \tag{20}$$

$$\begin{aligned} f_Z(\hat{r},\omega) &= \epsilon^{\,2}\sum_{j>1} H_j(\hat{r})\,\sin[(j-1)\,\omega] - \epsilon^{\,2}\sum_{j>1} V_j(\hat{r})\,\cos[(j-1)\,\omega] \\ &\quad - \epsilon^{\,3}\,[L_3(\hat{r}) + \epsilon\,L_4(\hat{r})]\,\sin\omega. \end{aligned} \tag{21}$$

For $\hat{r} > 1$, let $L_3(\hat{r}) = L_3(1)$, $L_4(\hat{r}) = L_4(1)$, $H_j(\hat{r}) = H_j(1)$, and $V_j(\hat{r}) = V_j(1)$. To obtain the $\hat{r}$, ω coordinates that correspond to the point R, Z, our initial guess is

$$\hat{r} = \frac{[(R-1)^2 + Z^2]^{1/2}}{\epsilon}, \tag{22}$$

$$\frac{\sin\omega}{\cos\omega} = \frac{Z}{1-R}. \tag{23}$$

We can then iterate the following equations

$$\hat{r} = \frac{[(\hat{R}-1)^2 + \hat{Z}^2]^{1/2}}{\epsilon}, \tag{24}$$

$$\frac{\sin\omega}{\cos\omega} = \frac{\hat{Z}}{1-\hat{R}}, \tag{25}$$

where

$$\hat{R} = R - f_R(\hat{r},\omega), \tag{26}$$

$$\hat{Z} = Z - f_Z(\hat{r},\omega). \tag{27}$$

EFIT integer parameters are NRBOX, NZBOX, NPBOUND, NLIMITER. EFIT float parameters are RBOXLEN, ZBOXLEN, RBOXLFT, ZOFF. Also, R0EXP $= R_0$, B0EXP $= B_0$, RAXIS $= R_0$, ZAXIS $= 0$, PSIAXIS $= \Psi(0)$, PSIBOUND $= 0$, CURRENT$=$ $\epsilon^2\,(B_0\,R_0/\mu_0)\,\hat{I}_t(1)$. The R, Z grid-points are

$$R\,R_0 = \text{RBOXLFT} + \text{RBOXLEN} * i/(\text{NRBOX}-1), \tag{28}$$

$$Z\,Z_0 = \text{ZOFF} - \text{ZBOXLEN}/2 + \text{ZBOXLEN} * j/(\text{NZBOX}-1), \tag{29}$$

for $i = 0, \text{NBBOX}-1$, $j = 0, \text{NZBOX}-1$. The profiles are evaluated on the grid PSI $=$ PSIAXIS $* (\text{NRBOX}-1-i)/(\text{NRBOX}-1)$ for $i = 0, \text{NRBOX}-1$.