FAR3d Construction Routines

BLOCKJ (TX, ITX, IEQN, IVAR, ITH, IR, IZT, COEFF)

This adds a term into equation IEQN as follows:

$$\mathrm{COEFF} * \mathrm{TX} \left(\frac{1}{r}\frac{\partial}{\partial\theta}\right)^{ITH} \frac{\partial^{IR}}{\partial r^{IR}} \frac{\partial^{IZT}}{\partial \zeta^{IZT}} f^{IVAR}$$

Here the FAR3d coordinates are (r, θ, ζ) corresponding to the radial, poloidal, toroidal directions in Boozer coordinates

COEFF = a scalar number

TX = a 2D (tokamak) or 3D (stellarator) set of Fourier amplitudes

ITX = +1 or −1 depending on the type of TX → i.e., is it represented by a $\cos(m\theta - n\zeta)$ series or a $\sin(m\theta - n\zeta)$ series

IVAR = variable # of f (see below)

ITH, IR, IZT = order of θ, r, and ζ derivatives acting on f (typically these all are ≤ 2)

Other versions:

BLOCKϕ is for the case where TX only depends on radius (ITX not needed)

B2LX, B2LXϕ are the versions of BLOCK and BLOCKϕ that are used in subroutine LINCHECK

Variable and Equation numbering

The number of equations is determined by noeqn. Below the variable and equation numbers are given for the simplest case noeqn = 7. If EP FLR terms are included or a second fast ion species is added, the noeqn is increased.

Variable	IVAR#	ITYPE (cos or sin)
1	ψ	+1
2	ϕ	−1
3	p	+1
4	U_3	−1
5	n_{fast}	+1
6	$V_{\parallel,fast}$	−1
7	$V_{\parallel,thermal}$	−1

Equation	IEQN#
ψ (Ohm's law)	1
U_3 (vorticity)	2
p (thermal press.)	3
U_3 in terms of ϕ	4
n_{fast}	5
$V_{\parallel,fast}$	6
$V_{\parallel,thermal}$	7

OM(TX, ITX, IEQN, ITH, IR, IZT, COEFF)

This adds a term into equation IEQN:

$$\text{COEFF} * \text{TX} \left(\frac{\partial}{\partial \zeta} - \frac{1}{q}\frac{\partial}{\partial \theta}\right) \frac{\partial^{IR}}{\partial r^{IR}} \frac{1}{r}\frac{\partial^{ITH}}{\partial \theta^{ITH}} \frac{\partial^{IZT}}{\partial \zeta^{IZT}} f$$

Such terms result from gradients parallel to the magnetic field: $\vec{B} \cdot \vec{\nabla}$ acting on a variable. The arguments are defined in a similar way as for the BLOCK routines.

As with BLOCKS there are variations on OM:

OMØ for TX that only depend on r

OMC, OMCØ for use in subroutine lincheck

Derivative Routines

a = known quantity that you want derivatives of

DBYDZT (d, a, ltype, c1, c2)

$$d = c2 * d + c1 \frac{\partial a}{\partial \zeta}$$

ltype is the type of a

DBYDTH (d, a, ltype, c1, c2, k)

$$d = c2 * d + c1 \frac{1}{r} \frac{\partial a}{\partial \theta}$$

normally k=0, check subroutine for actions if k≠0

GRDPAR (d, a, ltype, c1, c2)

$$d = c1 * d + c2\left(\frac{\partial}{\partial \zeta} - \frac{1}{q} \frac{\partial}{\partial \theta}\right) a$$

DBYDR (d, a, c1, c2, k)

$$d = c1 * d + c2 \frac{\partial a}{\partial r}$$

normal case k=0, other options for k≠0

DBYDRφ (d, a, c1, c2, k)

similar to DBYDR, but a = a(r)

↳ a = a(r, θ)

DBYDR2φ → 2nd derivative

DBYDZTEQ, DBYDREQ, DBYDTHEQ and GRPAREQ are similar to the routines on page 4, but apply to equilibrium variables.

Convolution Routines

MULT (F, G, GTYPE, H, HTYPE, C1, C2)

$$F = \sum_\ell \{ F_{c_\ell}(r)\cos(m_\ell\theta + n_\ell\zeta) + F_{s_\ell}(r)\sin(m_\ell\theta + n_\ell\zeta)\}$$
$$= G \times H$$

where
$$G = \sum_\ell \{ G_{c_\ell}(r)\cos(m_\ell\theta + n_\ell\zeta) + G_{s_\ell}(r)\sin(m_\ell\theta + n_\ell\zeta)\}$$
$$H = \sum_\ell \{ H_{c_\ell}(r)\cos(m_\ell\theta + n_\ell\zeta) + H_{s_\ell}(r)\sin(m_\ell\theta + n_\ell\zeta)\}$$

GTYPE, HTYPE = ±1 are the types of variables G and H.
→ These basically control whether the cos terms are stored first (+1) or the sin terms (-1)

e.g. in an up-down symmetric tokamak
- B is +1
- $\partial B/\partial\theta$ is -1
- R is +1
- Z is -1

MULT has different forms: MULTEQ, MULTB, etc. for equilibrium and banded variables