## bfield

Returns  $\dot{s} \equiv B^s/B^{\zeta}$  and  $\dot{\theta} \equiv B^{\theta}/B^{\zeta}$ .

[called by: pp00ab.]

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## 1.1 equations of field line flow

1. The equations for the fieldlines are normalized to the toroidal field, i.e.

$$\dot{s} \equiv \frac{B^s}{B^{\zeta}}, \qquad \dot{\theta} \equiv \frac{B^{\theta}}{B^{\zeta}}. \tag{1}$$

## 1.2 representation of magnetic field

1. The components of the vector potential,  $\mathbf{A} = A_{\theta} \nabla + A_{\zeta} \nabla \zeta$ , are

$$A_{\theta}(s,\theta,\zeta) = \sum_{i,l} A_{\theta,e,i,l} \, \overline{T}_{l,i}(s) \cos \alpha_i + \sum_{i,l} A_{\theta,o,i,l} \, \overline{T}_{l,i}(s) \sin \alpha_i, \tag{2}$$

$$A_{\zeta}(s,\theta,\zeta) = \sum_{i,l} A_{\zeta,e,i,l} \, \overline{T}_{l,i}(s) \cos \alpha_i + \sum_{i,l} A_{\zeta,o,i,l} \, \overline{T}_{l,i}(s) \sin \alpha_i, \tag{3}$$

where  $\overline{T}_{l,i}(s) \equiv \overline{s}^{m_i/2} T_l(s)$ ,  $T_l(s)$  is the Chebyshev polynomial, and  $\alpha_j \equiv m_j \theta - n_j \zeta$ . The regularity factor,  $\overline{s}^{m_i/2}$ , where  $\overline{s} \equiv (1+s)/2$ , is only included if there is a coordinate singularity in the domain (i.e. only in the innermost volume, and only in cylindrical and toroidal geometry.)

2. The magnetic field,  $\sqrt{g} \mathbf{B} = \sqrt{g} B^s \mathbf{e}_s + \sqrt{g} B^{\theta} \mathbf{e}_{\theta} + \sqrt{g} B^{\zeta} \mathbf{e}_{\zeta}$ , is

$$\sqrt{g} \mathbf{B} = \mathbf{e}_{s} \sum_{i,l} \left[ (-m_{i} A_{\zeta,e,i,l} - n_{i} A_{\theta,e,i,l}) \overline{T}_{l,i} \sin \alpha_{i} + (+m_{i} A_{\zeta,o,i,l} + n_{i} A_{\theta,o,i,l}) \overline{T}_{l,i} \cos \alpha_{i} \right] 
+ \mathbf{e}_{\theta} \sum_{i,l} \left[ (-m_{i} A_{\zeta,e,i,l}) \overline{T}'_{l,i} \cos \alpha_{i} + (-m_{i} A_{\zeta,o,i,l} + n_{i} A_{\theta,o,i,l}) \overline{T}'_{l,i} \sin \alpha_{i} \right] 
+ \mathbf{e}_{\zeta} \sum_{i,l} \left[ (-A_{\theta,e,i,l}) \overline{T}'_{l,i} \cos \alpha_{i} + (-A_{\theta,o,i,l}) \overline{T}'_{l,i} \sin \alpha_{i} \right]$$
(4)

3. In Eqn.(1), the coordinate Jacobian,  $\sqrt{g}$ , cancels. No coordinate metric information is required to construct the fieldline equations from the magnetic vector potential.

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 ${\bf SPEC\ subroutines;}$