## sc00aa

The covariant components of the tangential magnetic field are related to the singular currents at the interfaces.

[called by: xspech.] [calls: coords.]

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## 1.1 covariant representation

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

$$A_{\theta}(s,\theta,\zeta) = \sum_{i,l} A_{\theta,e,i,l} \, \overline{T}_{l,i}(s) \cos \alpha_i + \sum_{i,l} A_{\theta,o,i,l} \, \overline{T}_{l,i}(s) \sin \alpha_i, \tag{1}$$

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

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

$$\sqrt{g} \mathbf{B} = \mathbf{e}_{s} \sum_{i,l} \left[ (-m_{i} A_{\zeta,e,i,l} - n_{i} A_{\theta,e,i,l}) \overline{T}_{l,i} \sin \alpha_{i} + (+m_{i} A_{\zeta,o,i,l} + n_{i} A_{\theta,o,i,l}) \overline{T}_{l,i} \cos \alpha_{i} \right] 
+ \mathbf{e}_{\theta} \sum_{i,l} \left[ (-m_{i} A_{\zeta,e,i,l}) \overline{T}'_{l,i} \cos \alpha_{i} + (-m_{i} A_{\zeta,o,i,l} + n_{i} A_{\theta,o,i,l}) \overline{T}'_{l,i} \sin \alpha_{i} \right] 
+ \mathbf{e}_{\zeta} \sum_{i,l} \left[ (-A_{\theta,e,i,l}) \overline{T}'_{l,i} \cos \alpha_{i} + (-A_{\theta,o,i,l}) \overline{T}'_{l,i} \sin \alpha_{i} \right]$$
(3)

3. The covariant representation for the field is  $\mathbf{B} = B_s \nabla s + B_\theta \nabla \theta + B_\zeta \nabla \zeta$ , where

$$B_{s} = B^{s}g_{ss} + B^{\theta}g_{s\theta} + B^{\zeta}g_{s\zeta}$$

$$B_{\theta} = B^{s}g_{s\theta} + B^{\theta}g_{\theta\theta} + B^{\zeta}g_{\theta\zeta}$$

$$B_{\zeta} = B^{s}g_{s\zeta} + B^{\theta}g_{\theta\zeta} + B^{\zeta}g_{\zeta\zeta}$$

where  $g_{\alpha\beta}$  are the metric elements (computed by coords).

4. On the interfaces,  $B^s = 0$  by construction.

## 1.2 output data

1. The Fourier harmonics of the even-and-odd, covariant components of the magnetic field,  $B_s$ ,  $B_\theta$  and  $B_\zeta$ , are saved in

Btemn(1:mn,0:1,1:Mvol),
Bzemn(1:mn,0:1,1:Mvol),
Btomn(1:mn,0:1,1:Mvol),
Bzomn(1:mn,0:1,1:Mvol);

and these are written to ext.sp.h5 by hdfint.

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SPEC subroutines;