

**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

$$A_\theta(s, \theta, \zeta) = \sum_{i,l} \textcolor{red}{A}_{\theta,e,i,l} \bar{T}_{l,i}(s) \cos \alpha_i + \sum_{i,l} \textcolor{brown}{A}_{\theta,o,i,l} \bar{T}_{l,i}(s) \sin \alpha_i, \quad (1)$$

$$A_\zeta(s, \theta, \zeta) = \sum_{i,l} \textcolor{blue}{A}_{\zeta,e,i,l} \bar{T}_{l,i}(s) \cos \alpha_i + \sum_{i,l} \textcolor{blue}{A}_{\zeta,o,i,l} \bar{T}_{l,i}(s) \sin \alpha_i, \quad (2)$$

where  $\bar{T}_{l,i}(s) \equiv \bar{s}^{m_i/2} T_l(s)$ ,  $T_l(s)$  is the Chebyshev polynomial, and  $\alpha_j \equiv m_j \theta - n_j \zeta$ . The regularity factor,  $\bar{s}^{m_i/2}$ , where  $\bar{s} \equiv (1+s)/2$ , 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

$$\begin{aligned} \sqrt{g} \mathbf{B} &= \mathbf{e}_s \sum_{i,l} [(-m_i \textcolor{blue}{A}_{\zeta,e,i,l} - n_i \textcolor{red}{A}_{\theta,e,i,l}) \bar{T}_{l,i} \sin \alpha_i + (+m_i \textcolor{blue}{A}_{\zeta,o,i,l} + n_i \textcolor{brown}{A}_{\theta,o,i,l}) \bar{T}_{l,i} \cos \alpha_i] \\ &+ \mathbf{e}_\theta \sum_{i,l} [(-\textcolor{blue}{A}_{\zeta,e,i,l}) \bar{T}'_{l,i} \cos \alpha_i + (-\textcolor{blue}{A}_{\zeta,o,i,l}) \bar{T}'_{l,i} \sin \alpha_i] \\ &+ \mathbf{e}_\zeta \sum_{i,l} [(\textcolor{red}{A}_{\theta,e,i,l}) \bar{T}_{l,i} \cos \alpha_i + (\textcolor{brown}{A}_{\theta,o,i,l}) \bar{T}'_{l,i} \sin \alpha_i] \end{aligned} \quad (3)$$

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

$$\begin{aligned} B_s &= B^s g_{ss} + B^\theta g_{s\theta} + B^\zeta g_{s\zeta} \\ B_\theta &= B^s g_{s\theta} + B^\theta g_{\theta\theta} + B^\zeta g_{\theta\zeta} \\ B_\zeta &= B^s g_{s\zeta} + B^\theta g_{\theta\zeta} + B^\zeta g_{\zeta\zeta} \end{aligned}$$

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](#).