

**mp00ac**

Solves for magnetic vector potential given  $\boldsymbol{\mu} \equiv (\Delta\psi_t, \Delta\psi_p, \mu)^T$ .

[called by: [ma02aa](#).]

[calls: [packab](#), [curent](#) and [tr00ab](#).]

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**1.1 unpacking fluxes, helicity multiplier**

1. The vector of “parameters”,  $\boldsymbol{\mu}$ , is unpacked. (Recall that  $\boldsymbol{\mu}$  was “packed” in [ma02aa](#).) In the following,  $\boldsymbol{\psi} \equiv (\Delta\psi_t, \Delta\psi_p)^T$ .

**1.2 construction of linear system**

1. The equation  $\nabla \times \mathbf{B} = \mu \mathbf{B}$  is cast as a matrix equation,

$$\mathcal{M} \cdot \mathbf{a} = \mathcal{R}, \quad (1)$$

where  $\mathbf{a}$  represents the degrees-of-freedom in the magnetic vector potential,  $\mathbf{a} \equiv \{A_{\theta,e,i,l}, A_{\zeta,e,i,l}, \dots\}$ .

2. The matrix  $\mathcal{M}$  is constructed from  $\mathcal{A} \equiv \text{dMA}$  and  $\mathcal{D} \equiv \text{dMD}$ , which were constructed in [matrix](#), according to

$$\mathcal{M} \equiv \mathcal{A} - \mu \mathcal{D}. \quad (2)$$

Note that in the vacuum region,  $\mu = 0$ , so  $\mathcal{M}$  reduces to  $\mathcal{M} \equiv \mathcal{A}$ .

3. The construction of the vector  $\mathcal{R}$  is as follows:

- i. if `Lcoordinatesingularity=T`, then

$$\mathcal{R} \equiv -(\mathcal{B} - \mu \mathcal{E}) \cdot \boldsymbol{\psi} \quad (3)$$

- ii. if `Lcoordinatesingularity=F` and `Lplasmaregion=T`, then

$$\mathcal{R} \equiv -\mathcal{B} \cdot \boldsymbol{\psi} \quad (4)$$

- iii. if `Lcoordinatesingularity=F` and `Lvacuumregion=T`, then

$$\mathcal{R} \equiv -\mathcal{G} - \mathcal{B} \cdot \boldsymbol{\psi} \quad (5)$$

The quantities  $\mathcal{B} \equiv \text{dMB}$ ,  $\mathcal{E} \equiv \text{dME}$  and  $\mathcal{G} \equiv \text{dMG}$  are constructed in [matrix](#).

**1.3 solving linear system**

It is not assumed that the linear system is positive definite. The LAPACK routine `DSYSVX` is used to solve the linear system.

**1.4 unpacking, . . .**

1. The magnetic degrees-of-freedom are unpacked by [packab](#).
2. The error flag, `ImagneticOK`, is set that indicates if the Beltrami fields were successfully constructed.

**1.5 construction of “constraint” function**

1. The construction of the function  $\mathbf{f}(\boldsymbol{\mu})$  is required so that iterative methods can be used to construct the Beltrami field consistent with the required constraints (e.g. on the enclosed fluxes, helicity, rotational-transform, . . .). See [ma02aa](#) for additional details.

### 1.5.1 plasma region

(a) For `Lcoordinatesingularity = T`, the returned function is:

$$\mathbf{f}(\mu, \Delta\psi_p) \equiv \begin{cases} \begin{pmatrix} 0 \\ 0 \end{pmatrix}, & 0 \end{pmatrix}^T, & \text{if } \text{Lconstraint} = -1 \\ \begin{pmatrix} 0 \\ 0 \end{pmatrix}, & 0 \end{pmatrix}^T, & \text{if } \text{Lconstraint} = 0 \\ \begin{pmatrix} \epsilon(+1) - \text{iota}(\text{lvol}) \\ ? \end{pmatrix}, & 0 \end{pmatrix}^T, & \text{if } \text{Lconstraint} = 1 \\ \begin{pmatrix} ? \\ ? \end{pmatrix}, & ? \end{pmatrix}^T, & \text{if } \text{Lconstraint} = 2 \end{cases} \quad (6)$$

(b) For `Lcoordinatesingularity = F`, the returned function is:

$$\mathbf{f}(\mu, \Delta\psi_p) \equiv \begin{cases} \begin{pmatrix} 0 \\ 0 \end{pmatrix}, & 0 \end{pmatrix}^T, & \text{if } \text{Lconstraint} = -1 \\ \begin{pmatrix} 0 \\ 0 \end{pmatrix}, & 0 \end{pmatrix}^T, & \text{if } \text{Lconstraint} = 0 \\ \begin{pmatrix} \epsilon(-1) - \text{oita}(\text{lvol}-1) \\ ? \end{pmatrix}, & \epsilon(+1) - \text{iota}(\text{lvol}) \end{pmatrix}^T, & \text{if } \text{Lconstraint} = 1 \\ \begin{pmatrix} ? \\ ? \end{pmatrix}, & ? \end{pmatrix}^T, & \text{if } \text{Lconstraint} = 2 \end{cases} \quad (7)$$

### 1.5.2 vacuum region

(a) For the vacuum region, the returned function is:

$$\mathbf{f}(\Delta\psi_t, \Delta\psi_p) \equiv \begin{cases} \begin{pmatrix} 0 \\ I - \text{curtor} \end{pmatrix}, & 0 \end{pmatrix}^T, & \text{if } \text{Lconstraint} = -1 \\ \begin{pmatrix} I - \text{curtor} \\ G - \text{curpol} \end{pmatrix}, & G - \text{curpol} \end{pmatrix}^T, & \text{if } \text{Lconstraint} = 0 \\ \begin{pmatrix} \epsilon(-1) - \text{oita}(\text{lvol}-1) \\ ? \end{pmatrix}, & G - \text{curpol} \end{pmatrix}^T, & \text{if } \text{Lconstraint} = 1 \\ \begin{pmatrix} ? \\ ? \end{pmatrix}, & ? \end{pmatrix}^T, & \text{if } \text{Lconstraint} = 2 \end{cases} \quad (8)$$

2. The rotational-transform,  $\epsilon$ , is computed by `tr00ab`; and the enclosed currents,  $I$  and  $G$ , are computed by `curent`.

## 1.6 early termination

1. If  $|\mathbf{f}| < \text{mupftol}$ , then early termination is enforced (i.e., `iflag` is set to negative integer). (See `ma02aa` for details of how `mp00ac` is called iteratively.)