

## dforce

Calculates  $\mathbf{F}(\mathbf{x})$ , where  $\mathbf{x} \equiv \{\text{geometry}\} \equiv \{R_{i,v}, Z_{i,v}\}$  and  $\mathbf{F} \equiv [[p + B^2/2]] + \{\text{spectral constraints}\}$ , and  $\nabla \mathbf{F}$ .

[called by: [hesian](#), [newton](#), [pc00aa](#), [pc00ab](#) and [xspech](#).]

[calls: [packxi](#), [ma00aa](#), [matrix](#), [ma02aa](#), [lforce](#), [volume](#), [packab](#), [tr00ab](#), [coords](#) and [brcast](#).]

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### 1.1 unpacking

1. The geometrical degrees of freedom are represented as a vector,  $\mathbf{x} \equiv \{R_{i,v}, Z_{i,v}\}$ , where  $i = 1, \text{mn}$  labels the Fourier harmonic and  $v = 1, \text{Mvol}-1$  is the interface label. This vector is “unpacked” using [packxi](#). (Note that [packxi](#) also sets the coordinate axis, i.e. the  $R_{i,0}$  and  $Z_{i,0}$ .)

### 1.2 parallelization over volumes

1. In each volume, `vvol = 1, Mvol`,
  - (a) the logical array `ImagneticOK(vvol)` is set to `.false.`
  - (b) the energy and helicity matrices, `dMA(0:NN,0:NN)`, `dMB(0:NN,0:2)`, etc. are allocated;
  - (c) the volume-integrated metric arrays, `DToocc`, etc. are allocated;
  - (d) calls [ma00aa](#) to compute the volume-integrated metric arrays;
  - (e) calls [matrix](#) to construct the energy and helicity matrices;
  - (f) calls [ma02aa](#) to solve for the magnetic fields consistent with the appropriate constraints, perhaps by iterating on [mp00ac](#);
  - (g) calls [volume](#) to compute the volume of the  $v$ -th region;
  - (h) calls [lforce](#) to compute  $p + B^2/2$  (and the spectral constraints if required) on the inner and outer interfaces;
  - (i) the derivatives of the force-balance will also be computed if `LComputeDerivatives = 1`;
2. After the parallelization loop over the volumes, [brcast](#) is called to broadcast the required information.

### 1.3 broadcasting

1. The required quantities are broadcast by [brcast](#).

### 1.4 construction of force

1. The force vector,  $\mathbf{F}(\mathbf{x})$ , is a combination of the pressure-imbalance Fourier harmonics,  $[[p + B^2/2]]_{i,v}$ , where  $i$  labels Fourier harmonic and  $v$  is the interface label:

$$F_{i,v} \equiv [(p_{v+1} + B_{i,v+1}^2/2) - (p_v + B_{i,v}^2/2)] \times \text{BBweight}_i, \quad (1)$$

where `BBweight(i)` is defined in [preset](#); and the spectral condensation constraints,

$$F_{i,v} \equiv I_{i,v} \times \text{epsilon} + S_{i,v,1} \times \text{sweight}_v - S_{i,v+1,0} \times \text{sweight}_{v+1}, \quad (2)$$

where the spectral condensation constraints,  $I_{i,v}$ , and the “star-like” poloidal angle constraints,  $S_{i,v,\pm 1}$ , are calculated and defined in [lforce](#); and the `sweightv` are defined in [preset](#).

### 1.5 construct derivatives of matrix equation

1. Matrix perturbation theory is used to compute the derivatives of the solution, i.e. the Beltrami fields, as the geometry of the interfaces changes:

## 1.6 extrapolation: planned redundant

1. The extrapolation constraint is  $R_{j,1} = R_{j,2} \psi_1^{m/2} / \psi_2^{m/2}$ . Combining this with the regularization factor for the geometry, i.e.  $R_{j,i} = \psi_i^{m/2} \xi_{j,i}$ , we obtain

$$\xi_{j,1} = R_{j,2} / \psi_2^{m/2}. \tag{3}$$