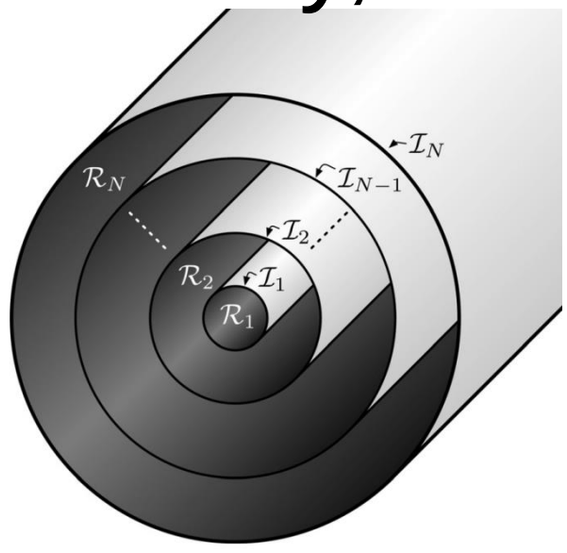
MHD equilibrium ≡ constrained, minimum-energy state with given pressure, boundary, . . .

1. SPEC minimizes the global plasma energy, $W \equiv \int_{\mathcal{R}} \left(\frac{p}{\gamma - 1} + \frac{B^2}{2} \right) dv$
   where the pressure $p(\psi)$ is a given function of toroidal flux, ψ.



2. The volume integral is partitioned (and parallelized), $\int_{\mathcal{R}} dv \equiv \sum_{i=1}^{N} \int_{\mathcal{R}_i} dv$

3. The simplest constraints are conserved helicity: $H_i \equiv \int_{\mathcal{V}_i} \mathbf{A} \cdot \mathbf{B}\, dv = H_{i,o} = const.$ in each $\mathcal{R}_i$
   and the "ideal-constraint": $\delta\mathbf{B} = \nabla \times (\boldsymbol{\xi} \times \mathbf{B})$ at each $\mathcal{I}_i$

4. The multi-region, relaxed MHD (MRxMHD) energy functional is
   $F \equiv \sum_{i=1}^{N} \left[W_i - \frac{\mu_i}{2} \left(H_i - H_{i,o} \right) \right]$ [Hole, et al. JPP, 72:1167, 2006]
   The equilibrium state satisfies $\nabla \times \mathbf{B} = \mu \mathbf{B}$ in each $\mathcal{R}_i$, and $[[p + B^2/2]] = 0$ across each $\mathcal{I}_i$.

5. If $N = 1$, recover globally-relaxed, Taylor state.
   If $N \to \infty$, recover globally-ideal, $\nabla p = \mathbf{j} \times \mathbf{B}$ [Dennis et al. PoP, 20:032509, 2013]
   If N is finite, flat pressure and islands at resonances; pressure jumps at arbitrarily many KAM surfaces.

6. SPEC [Hudson et al. PoP, 19:112502, 2012] is the only equilibrium code that, simultaneously,
   (1) is based on an energy functional, (2) computes magnetic field consistent with given pressure profile,
   (3) accurately computes singular currents in ideal-MHD equilibria [Loizu et al. PoP, 22:022501, 2015],
   (4) allows for partially relaxed fields, magnetic islands and chaos, (5) is parallelized.

Multi-region, relaxed MHD can include pressure anisotropy and flow

- two papers on MRxMHD with flow have already been published

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Multi-region relaxed magnetohydrodynamics with flow

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We present an extension of the multi-region relaxed magnetohydrodynamics (MRxMHD) equilibrium model that includes plasma flow. This new model is a generalization of Woltjer's

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Multi-region relaxed magnetohydrodynamics with anisotropy and flow

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We present an extension of the multi-region relaxed magnetohydrodynamics (MRxMHD) equilibrium model that includes pressure anisotropy and general plasma flows. This anisotropic

- required modifications to SPEC are minor