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Computing the Shape Gradient of Coil Complexity with Respect to the Plasma Boundary. ARTHUR CARLTON-JONES, ELIZABETH PAUL, WILLIAM DORLAND, University of Maryland, College Park — Coil complexity is a critical factor in stellarator design. Complex coils are difficult and expensive to engineer and tight coil-coil spacing makes maintenance difficult. The traditional two-step approach to stellarator design can produce plasma shapes which require excessively complex coils. Coil complexity metrics can be computed with REGCOIL (Landreman 2017), which optimizes coil shapes using a linear least squares method based on a current potential approximation. We extend REGCOIL to compute analytic derivatives of these metrics with respect to parameters describing the plasma boundary using an adjoint method. It is then only necessary to solve the linear system used in REGCOIL twice, rather that for every surface parameter. This provides a great computational advantage over finite-difference differentiation. Shape gradients of the REGCOIL metrics are computed from these derivatives; they tell us how normal perturbations of the plasma surface alter these metrics. We also compute these shape gradients while fixing coil complexity. This reveals how to alter the plasma surface to be better reproduced by coils with a desired complexity. We present a new representation of the plasma surface which uses a single Fourier series to describe the radial distance from an axis. This representation is advantageous over the VMEC (Hirshman & Whitson 1983) representation, as it only requires a series for a single variable rather than for two separate variables. It also uses a uniquely defined poloidal angle, which eliminates a null space in the optimization over the plasma surface.

Arthur Carlton-Jones
University of Maryland, College Park

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