# A TWO FIELD PERIOD CANDIDATE FOR ARIES-CS

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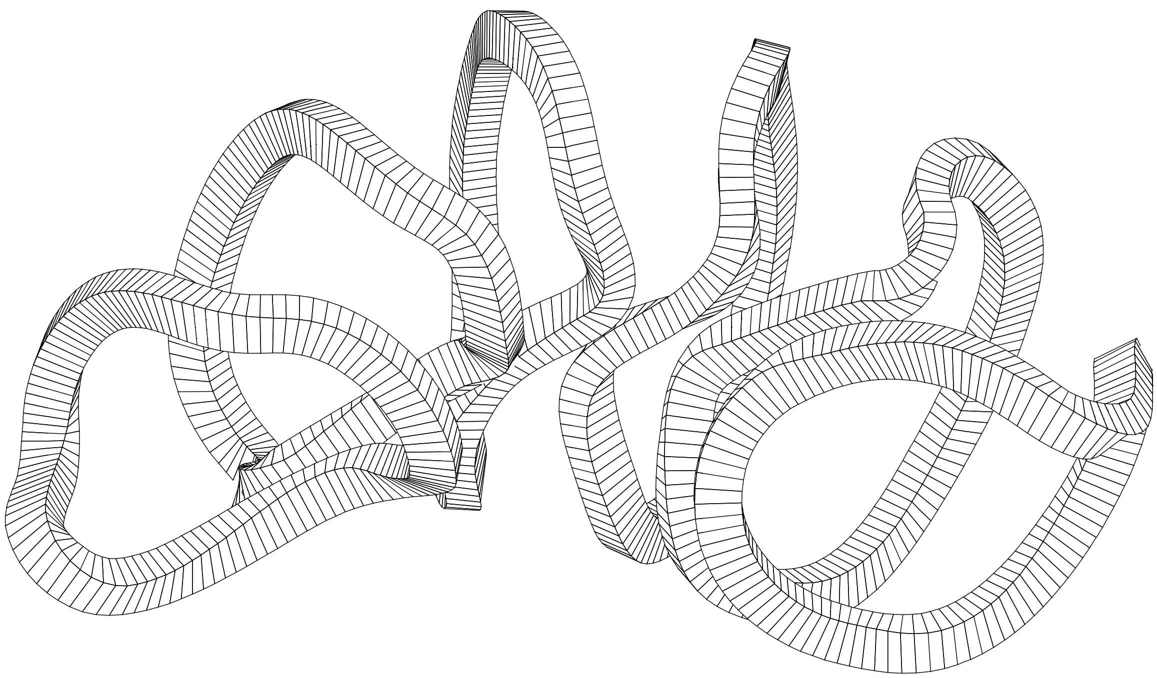
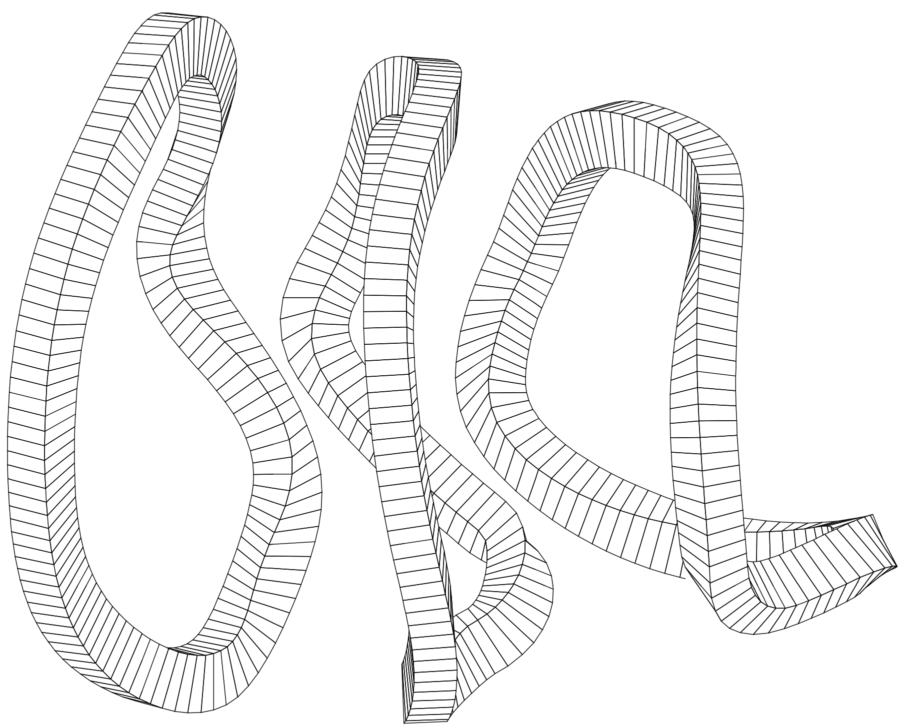
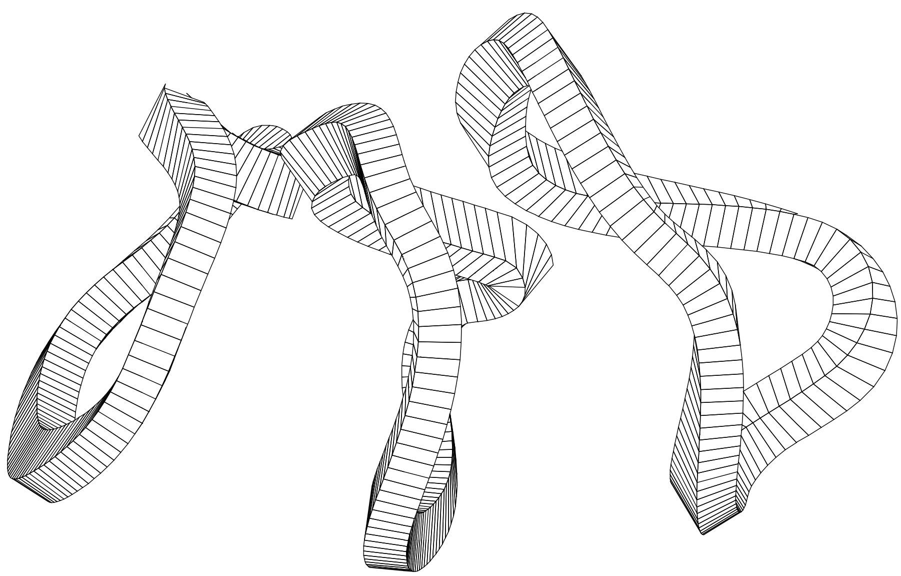
Good correlation of computations with observations in the LHD has been applied to assess equilibrium, stability, and transport for a two field period compact stellarator. A reactor has been designed that has major radius 9 m and plasma radius 2.6 m. The $\beta$ limit is 4%, and 12 only moderately twisted coils provide robust magnetic surfaces. There is easy access for maintenance between the coils, and the gap between the separatrix and single filaments defining the coils is everywhere bigger than 140 cm.



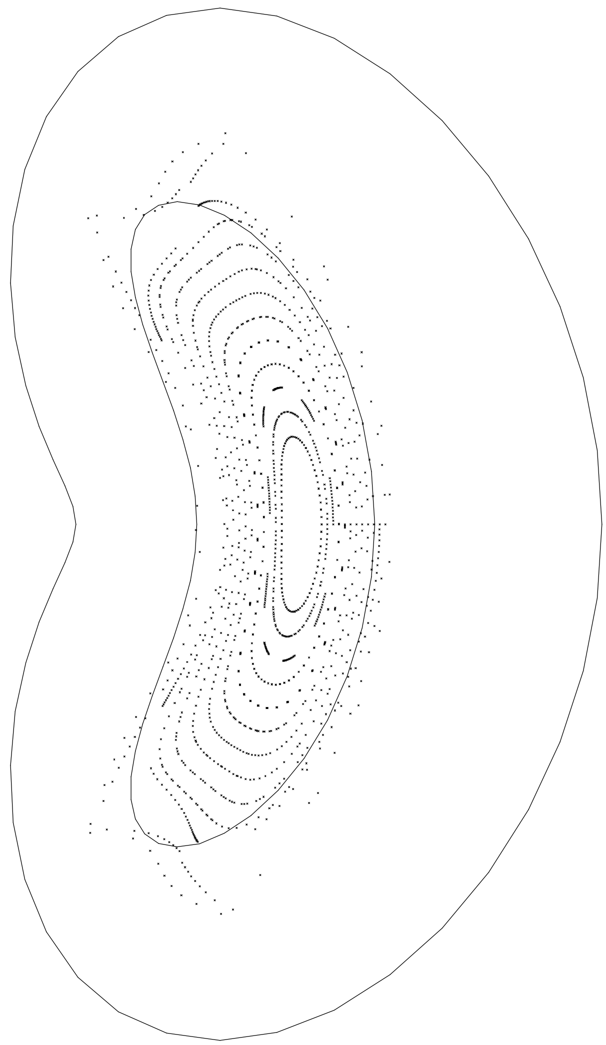
Asymmetric view of six out of twelve modular coils of the MHH2 stellarator in a vacuum magnetic field given by the Biot-Savart law. Judicious filtering of the Fourier series used to calculate filaments specifying the geometry of the configuration defines shapes that are not excessively twisted. Parameters have been adjusted to provide ample space around each coil, and the aspect ratio of the plasma is 3.5.



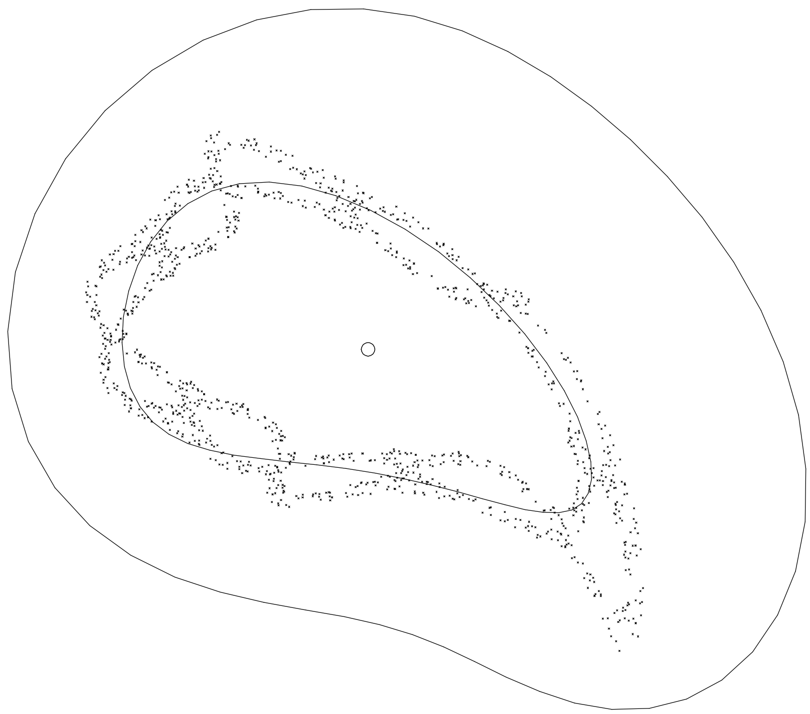
Exterior view of a triad of distinct coils for the MHH2 reactor showing that they are only moderately twisted and are well separated. Good quality of the coils is found by line tracing calculations to produces robust magnetic surfaces.



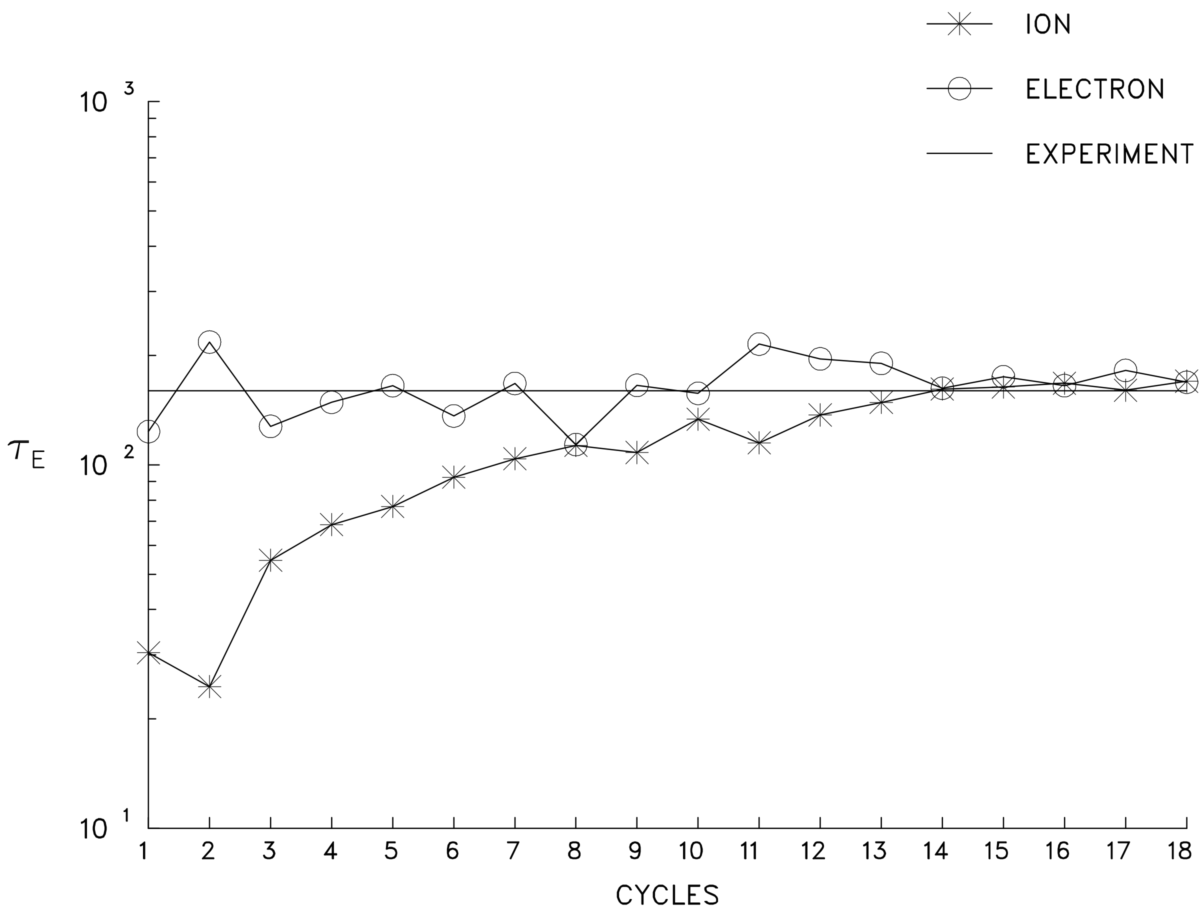
Top view of a triad of distinct coils for the MHH2 reactor showing that there is easy access from outside.



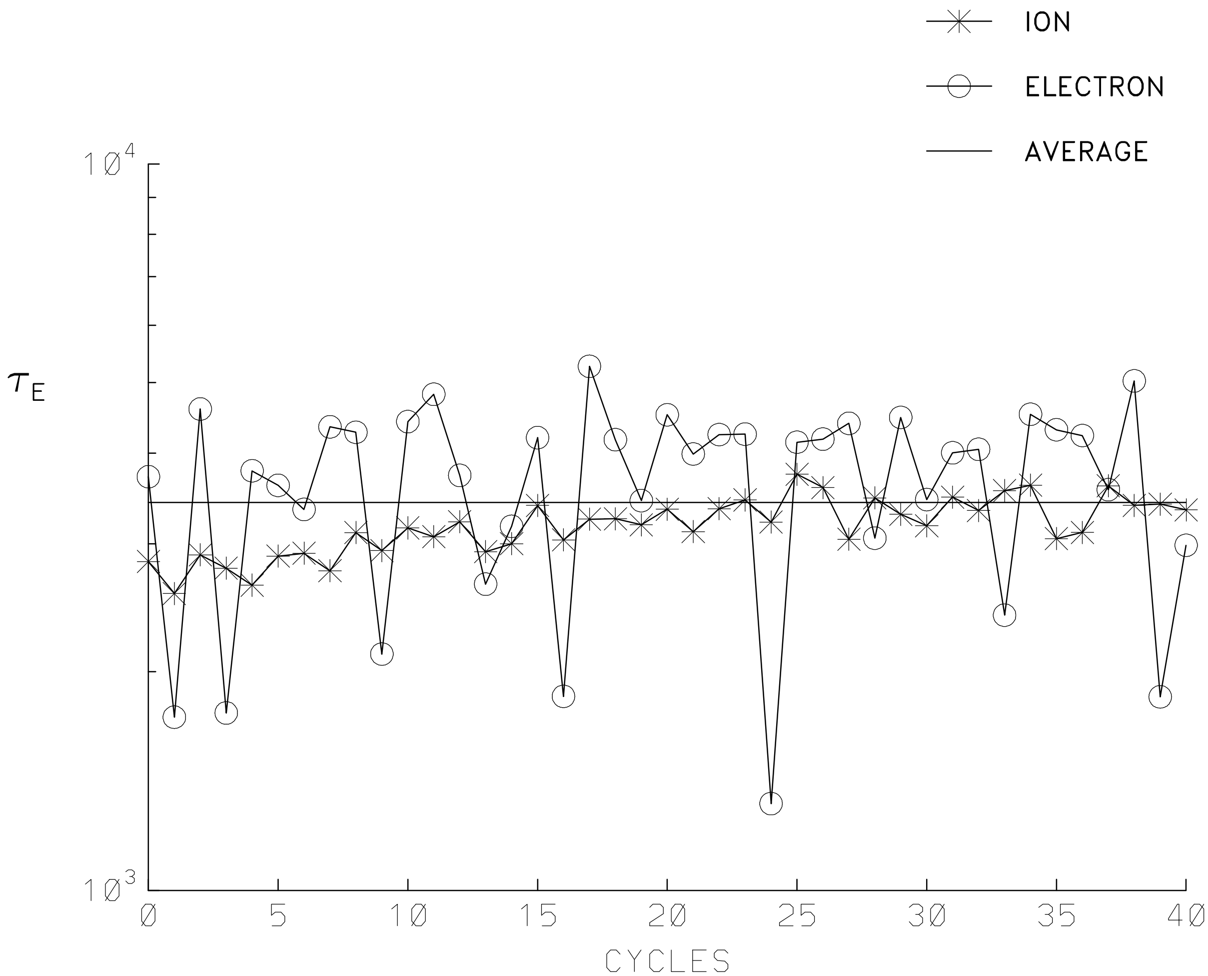
Poincaré section of a line tracing calculation for the MHH2 stellarator displaying the control surface for the coils and the magnetic surfaces at $\beta = 0$. There are islands in the scrape-off layer of the solution, where the rotational transform reaches the resonant value $\iota = 2/5$. Vertical and toroidal fields have been included to perturb the optimal equilibrium.



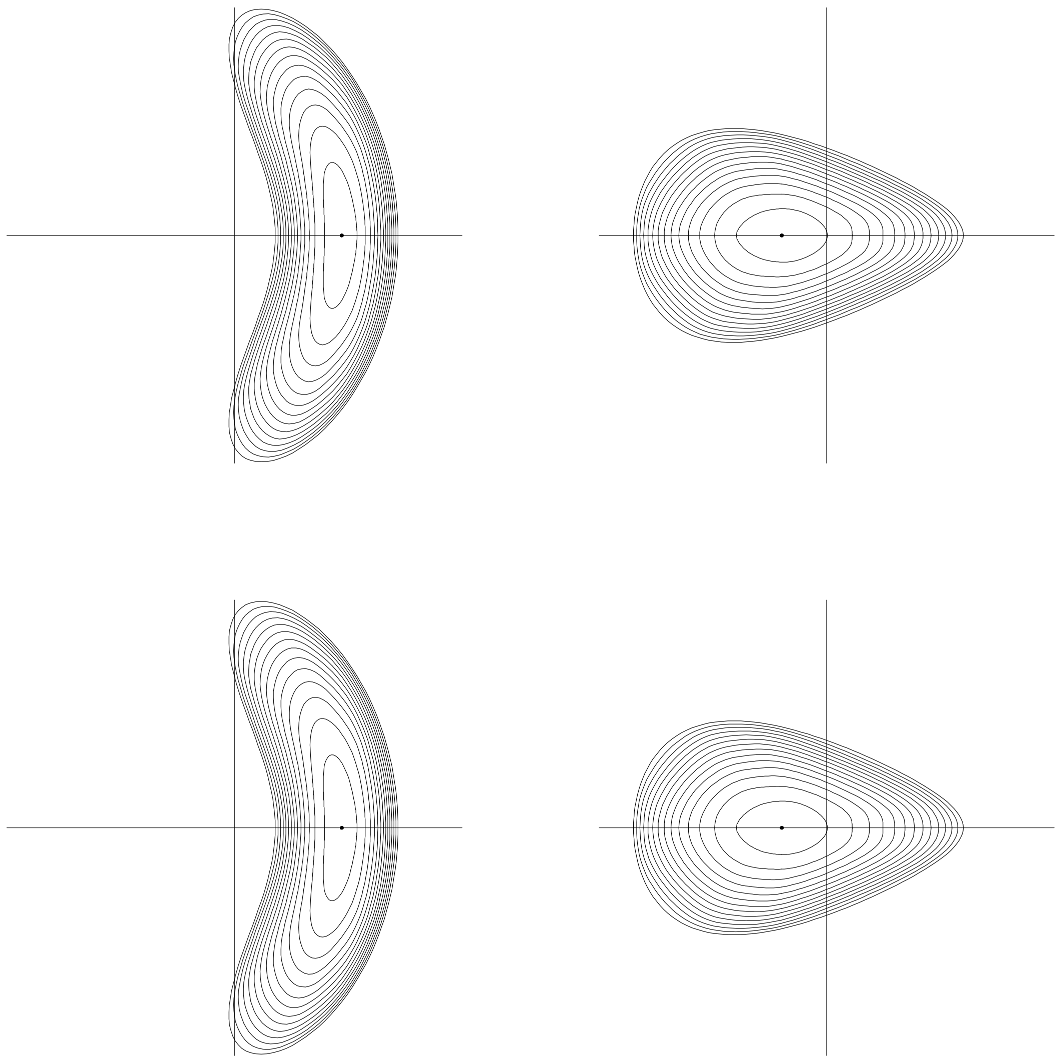
Poincaré section of a free boundary calculation for the MHH2 stellarator displaying the control surface for the coils, the known shape of the plasma at $\beta = 0$, a filament that simulates current in the plasma, and magnetic lines computed at finite $\beta$ in the scrape-off layer of the solution, where the rotational transform is crossing the resonant value $\iota = 2/5$.



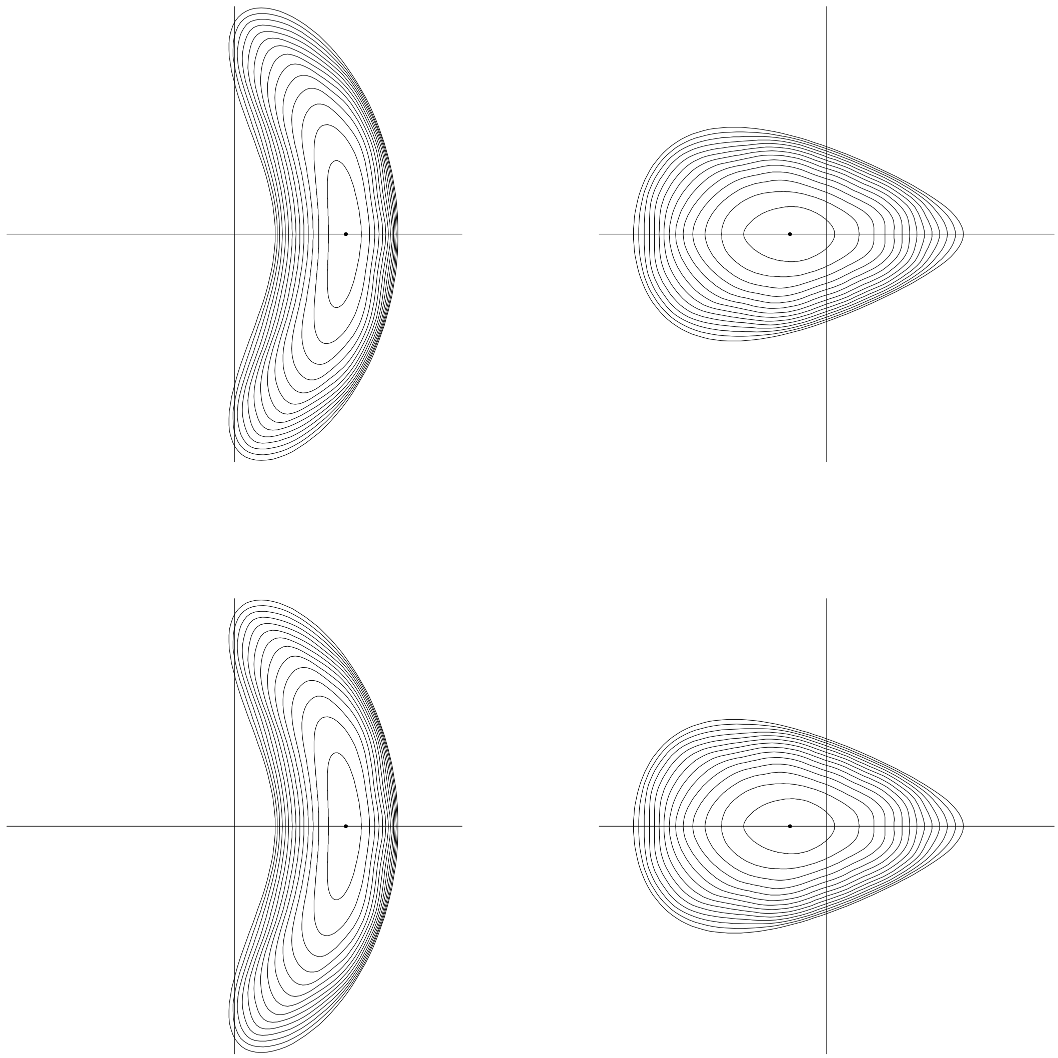

Cycles of a calculation of the energy confinement time $\tau_E$ in milliseconds for an NBI shot of the LHD experiment using a quasineutrality algorithm to adjust the electric potential $\Phi$. Oscillations of $\Phi$ along the magnetic lines model turbulence and anomalous transport, so there is good agreement with the measured value.



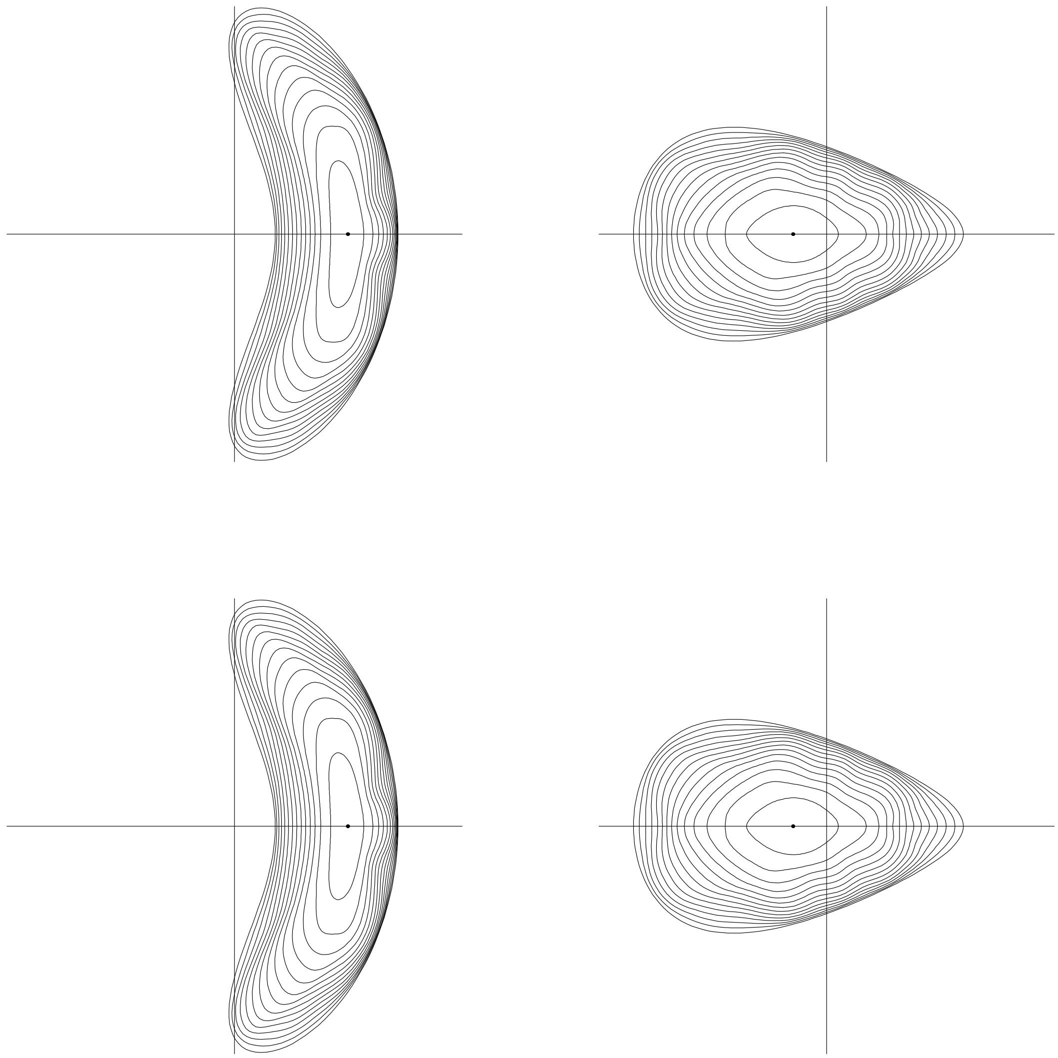

Iterations to quasineutrality in a Monte Carlo computation of the energy confinement time $\tau_E$, measured in milliseconds, for an MHH2 stellarator with major radius 9 m and plasma radius 2.6 m at reactor conditions with average $T = 24\,\text{keV}$, $n = 7\times 10^{13}\,\text{cm}^{-3}$, and $B = 5\,\text{tesla}$. The magnetic spectrum has good quasiaxial symmetry, and the radial electric field rises to a potential level two and a half times as big as the temperature.



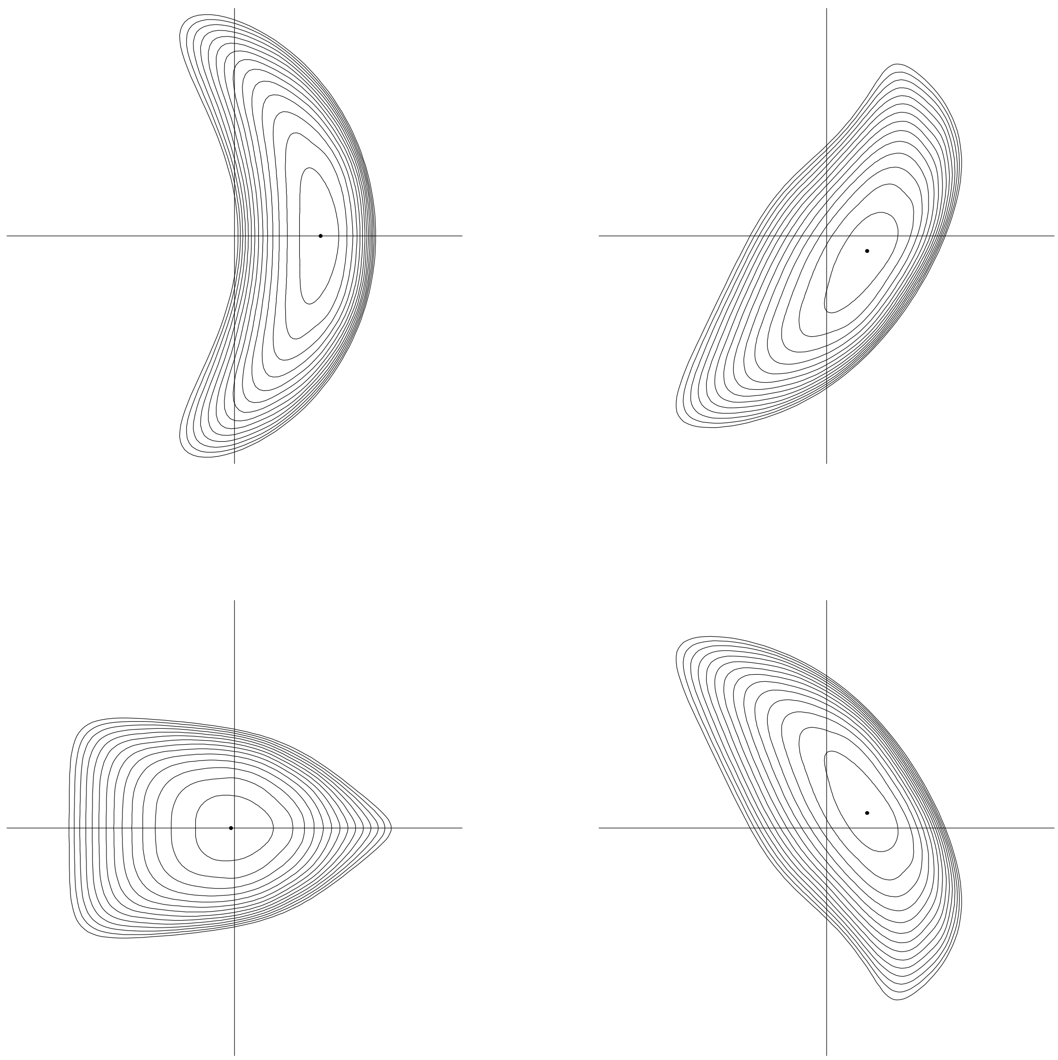
Four cross sections of the flux surfaces over the full torus of a stable MHH2 equilibrium at $\beta = 0.02$ with a pressure profile $p = p_0(1 - s^{1.5})^{1.5}$ and net current bringing the rotational transform into the interval $0.55 > \iota > 0.51$. NSTAB calculations demonstrate that in this case there can be no possibility of ideal MHD instability.



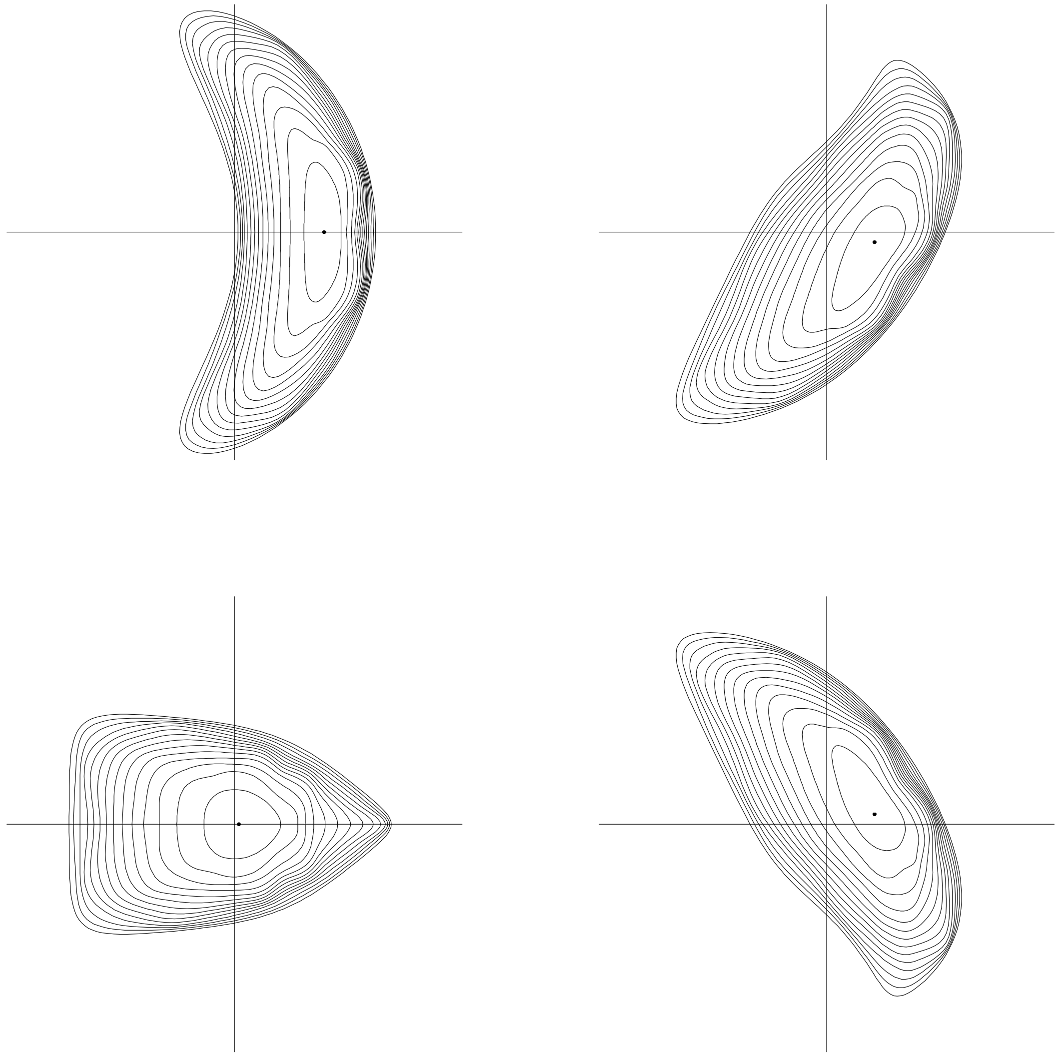
Four cross sections of the flux surfaces over the full torus of a stable MHH2 equilibrium at $\beta = 0.04$ with pressure profile $p = p_0(1 - s^{1.5})^{1.5}$ and hybrid current bringing the rotational transform into the interval $0.55 > \iota > 0.51$. In this example the NSTAB code was run 200,000 cycles using spectral terms of degree 24 in each of the poloidal and toroidal angles and using 27 radial mesh points.



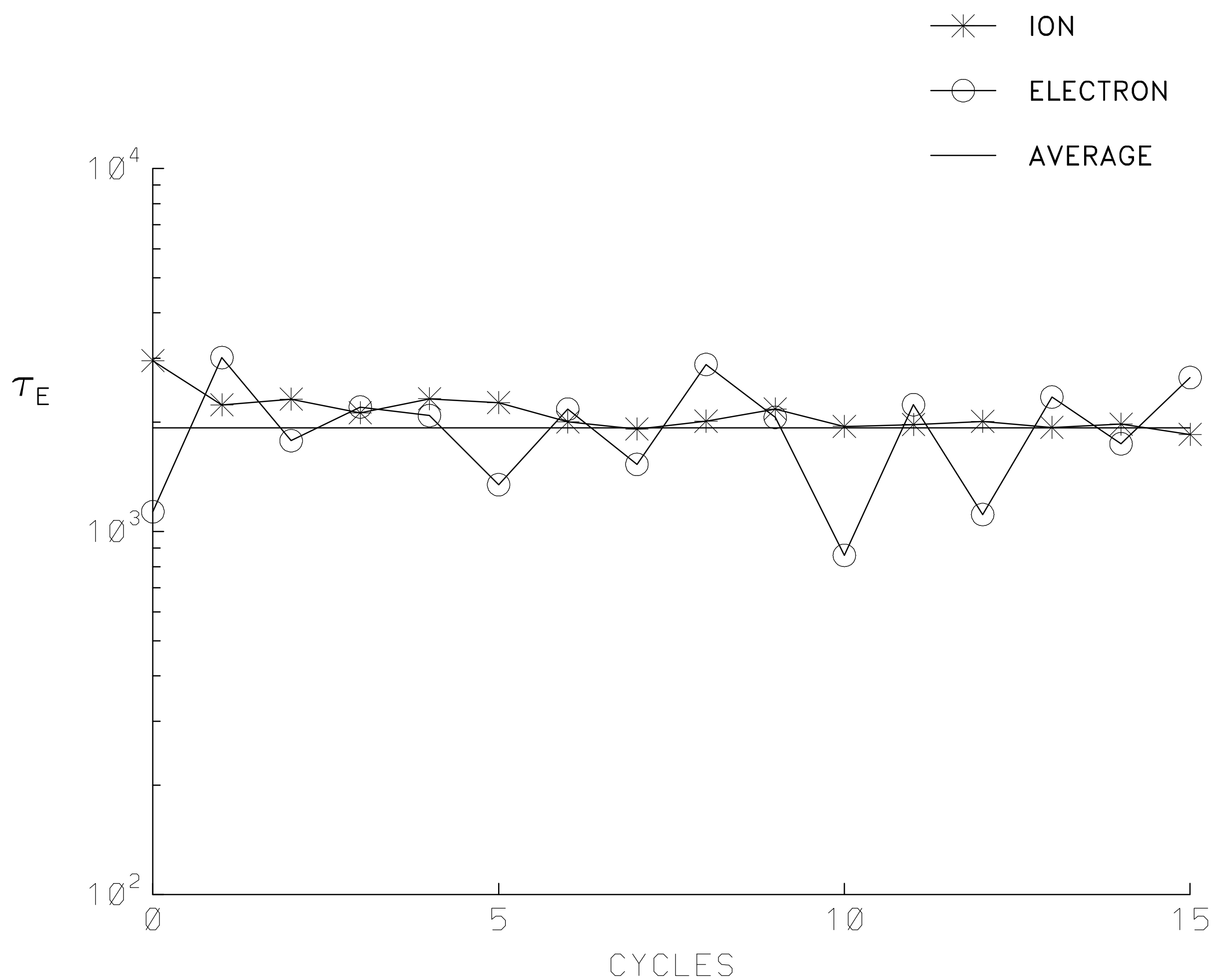
Four cross sections of the flux surfaces over the full torus of a wall stabilized MHH2 equilibrium at $\beta = 0.05$ with a pressure profile $p = p_0(1 - s^{1.5})^{1.5}$ and with bootstrap current bringing the rotational transform into the interval $0.55 > \iota > 0.51$. The visible $m = 4,\ n = 2$ island and symmetric balloning mode in the solution show that a free boundary $\beta$ limit has been exceeded.



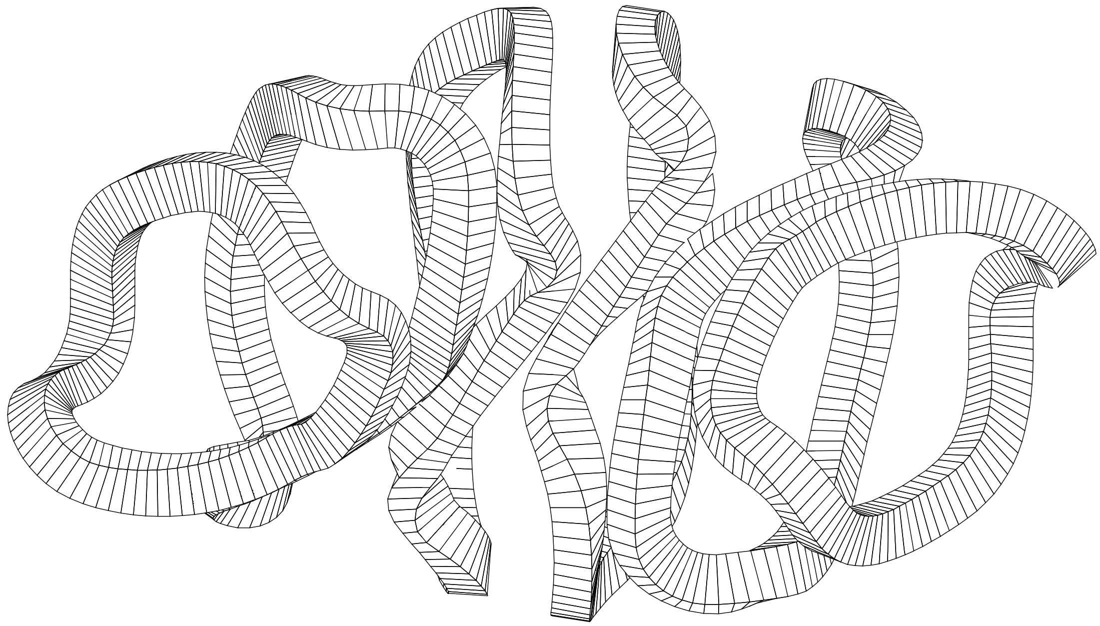
Four cross sections of the flux surfaces over the full torus of a stable PG3 (simulated LI383) equilibrium at $\beta = 0.06$ with a pressure profile $p = p_0(1 - s^{1.5})^{1.5}$ and with bootstrap current bringing the rotational transform into the interval $0.40 < \iota < 0.65$, where the shear is reversed.



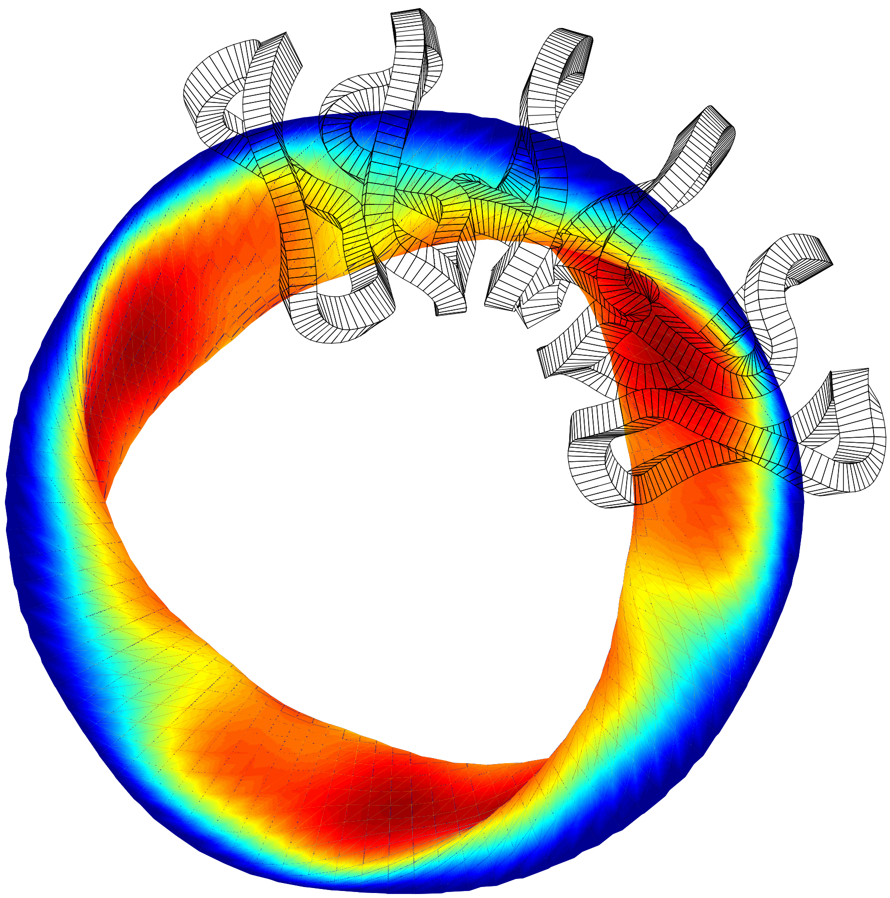
Four cross sections of the flux surfaces over the full torus of a wall stabilized PG3 (simulated LI383) equilibrium at $\beta = 0.055$ with a moderately peaky pressure profile $p = p_0(1 - s^{1.2})^{1.8}$ and with bootstrap current bringing the rotational transform into the interval $0.40 < \iota < 0.65$. The shear $\iota'$ changes sign at $s = 0.6$, so a visible $m = 5,\ n = 3$ island and a ballooning mode occur in the solution, showing that a $\beta$ limit may have been reached.




Iterations to quasineutrality in a Monte Carlo computation of the energy confinement time $\tau_E$, measured in milliseconds, for the PG3 (simulated LI383) stellarator with major radius 13 m and plasma radius 3 m at reactor conditions with average $T = 12\,\text{keV}$, $n = 1.4 \times 10^{14}\,\text{cm}^{-3}$, and $B = 5\,\text{tesla}$. The magnetic spectrum has features of quasiaxial symmetry, and the radial electric field rises to a potential level three times as big as the temperature. Small harmonics of high order degrade the transport.



Symmetric view of six out of eighteen modular coils of the PG3 (simulated LI383) stellarator in a vacuum magnetic field given by the Biot-Savart law. Judicious filtering of the Fourier series used to calculate filaments specifying the geometry of the configuration defines shapes that are not excessively twisted and do not introduce superfluous harmonics. The minimum gap between the separatrix and the filaments for the coils is 55% of the plasma radius.



Computational model of fusion plasma in a thermonuclear reactor based on the PG3 simulation of the NCSX experiment. Eighteen moderately twisted modular coils, six of which are plotted, produce a magnetic field whose strength has a symmetry feature displayed by the color map of the plasma surface.