`bfieldtools` — a software package for magnetic field modeling

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We present a novel Python software package, `bfieldtools`, for computing magnetic field and related physical quantities in complex geometries. The core functionality of the software relies on a stream-function representation of current density [1, 2, 3] and its discretization on a surface mesh. We aim to use purely Python code within the software package. Instead of using low-level language dependencies, we solve computational bottlenecks through just-in-time compilation and extensive use of the Numpy library [4]. Key features of the package include (at the time of writing):

- Matrix assembly for differential (gradient, Laplacian) and integral (inductance, resistance) operators on triangle meshes
- Computation of magnetic field due to line and surface current
- Target-field coil design using quadratic programming
- Magnetic Johnson–Nyquist noise computation, including inductive effects
- Representation of magnetic fields in source-free domains by spherical harmonic functions

Development of this software package is ongoing, and we intend to make it publicly available. A selection of examples showcasing `bfieldtools` functionality can be seen in Figure 1.

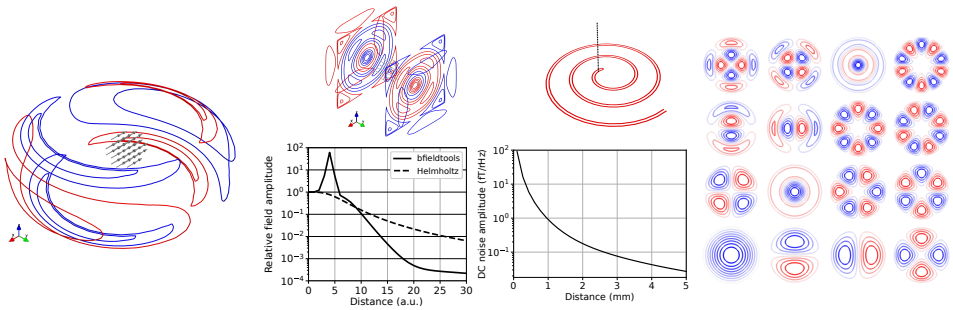

Figure 1. Far left: Toroidal coil producing homogeneous field on the X-axis. Top left: Biplanar coil generating a homogeneous field on the Y-axis while producing a minimal stray field. Bottom left: Comparison of the stray field due to these coils with Helmholtz coils of similar size. Right: Magnetic noise of a thin platinum double spiral heater at the points marked with black dots. Far right: The first 16 thermal current modes in a conducting disc.

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