Leonid Prigozhin (Institutes for Desert Research)

- **Variational and free boundary problems**
- **Numerical analysis**
- **Sand surface evolution and Aeolian sand transport**
- **Applied superconductivity**
- **Hysteresis in ferromagnets**

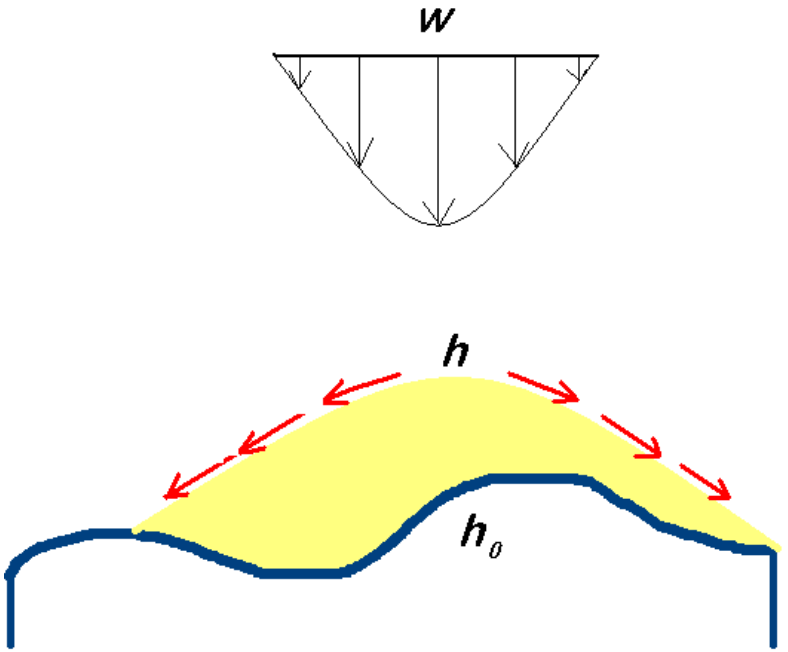
Main collaborators:

V. Sokolovsky (Physics Dept, BGU)

J. W. Barrett (Math Dept, Imperial College)

Sand surface evolution

The shape of a growing sandpile



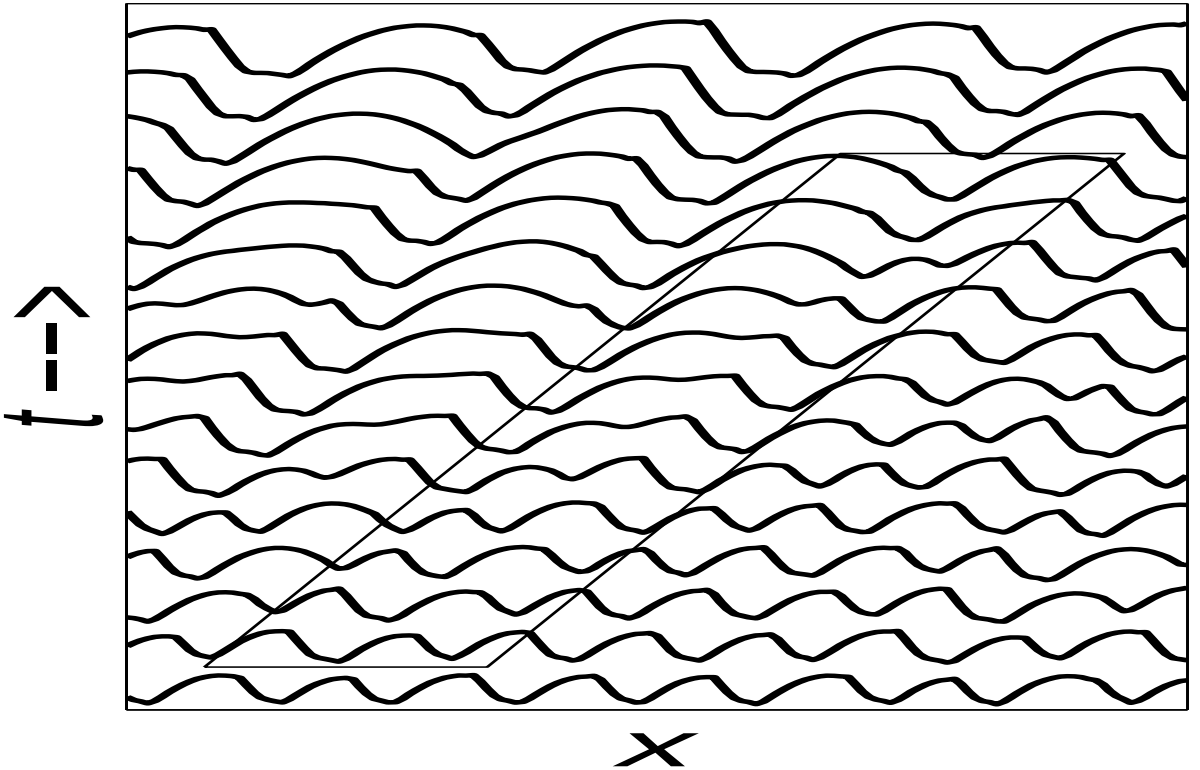
A variational model has been developed.
Mathematics: existence, convergence of numerical methods, the dual and mixed formulations.

Aeolian dunes and ripples

The variational model is the large scale limit of a mesoscopic model (work with B. Zaltzman). Two spatio-temporal scales of Aeolian sand patterns: dunes (large) and ripples (small);

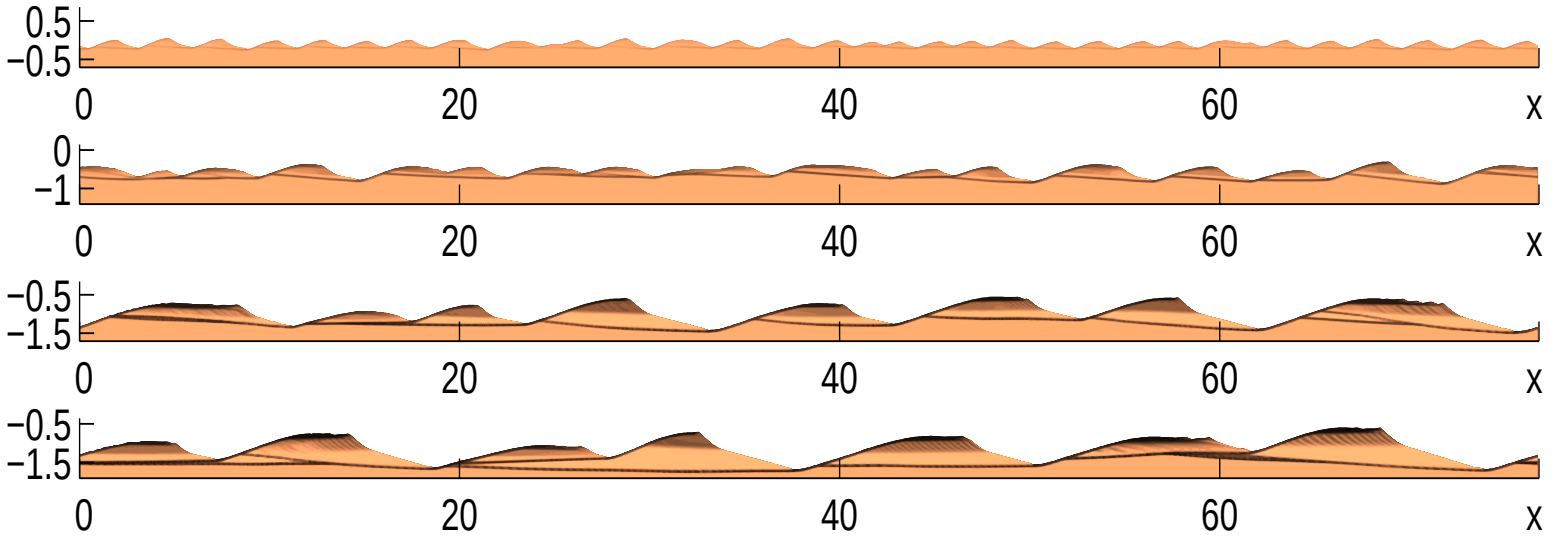
Sand ripples

Aeolian sand transport makes flat sand surfaces unstable; this can be simulated using the mesoscopic model for sand surface dynamics. After the initial linear growth, the ripples undergo coarsening and their wavelength grows.



Megaripples

Ripples of homogeneous sand are small: their growth saturates soon. For inhomogeneous sand the ripples can turn into megaripples.



Size segregation and armoring layer formation. Numerical simulation.

Type-II superconductors

Sand piles

Mass balance + equilibrium condition:

- Pile slope cannot exceed a critical angle;
- No surface flow of sand if the slope is subcritical.

Superconductors

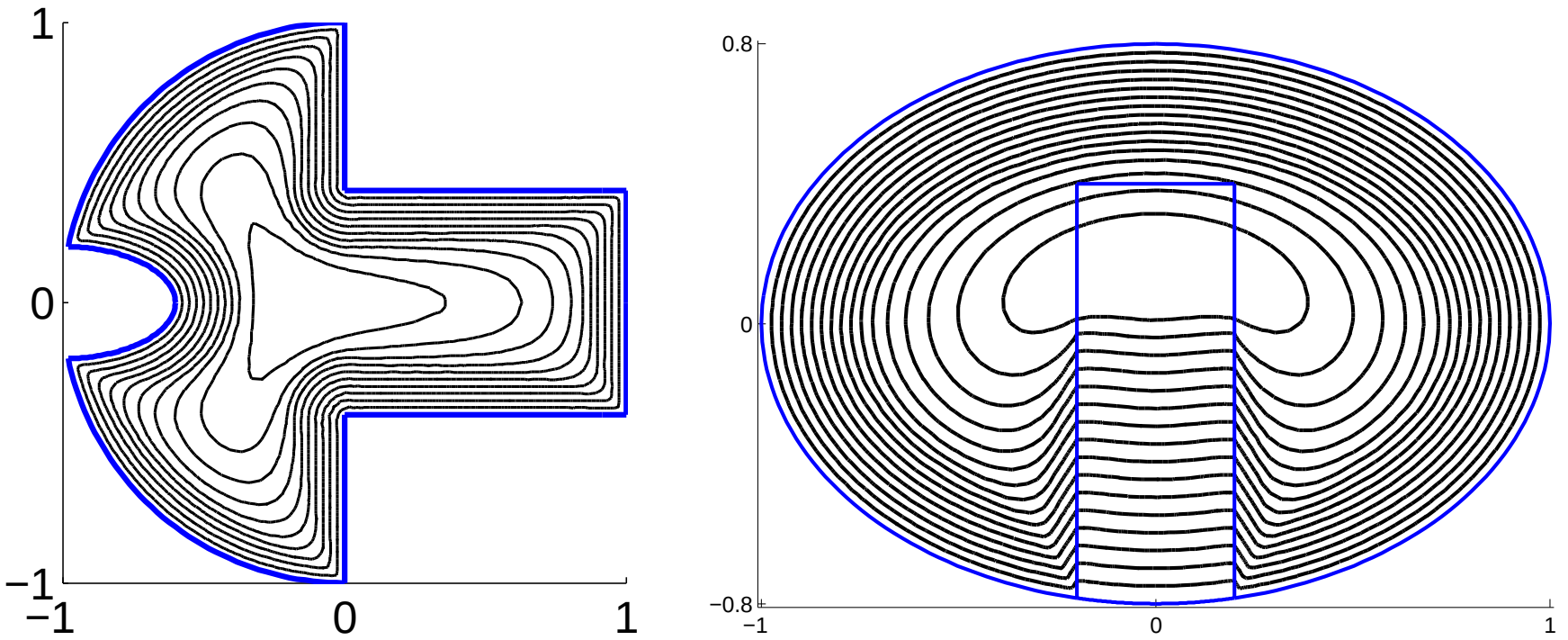
Maxwell equations + nonlinear Ohm law:

- Current density cannot exceed a critical value;
- No electric field if the density is subcritical.

Similar const. relations $\Rightarrow$ similar math. problems.

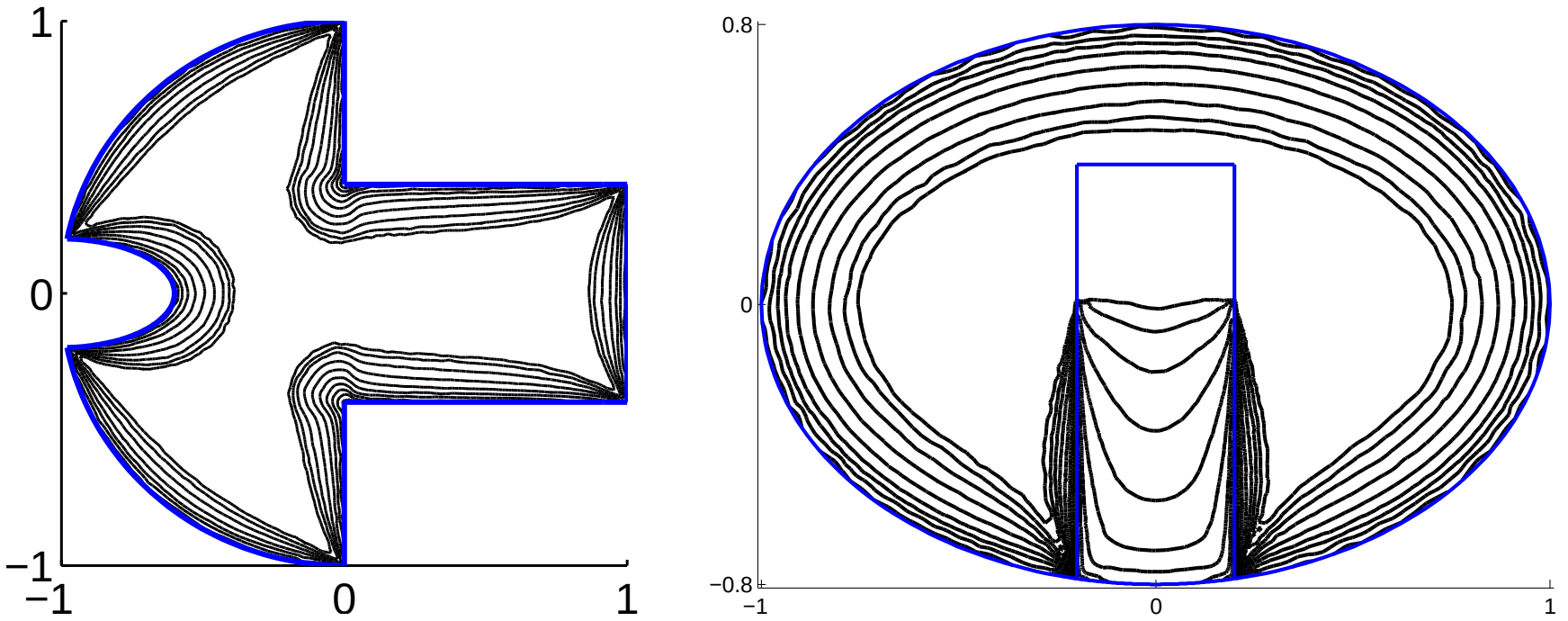
Problems: sc coils, thin films, magnetic traps for cold atoms on sc chips.

Sc films: current streamlines



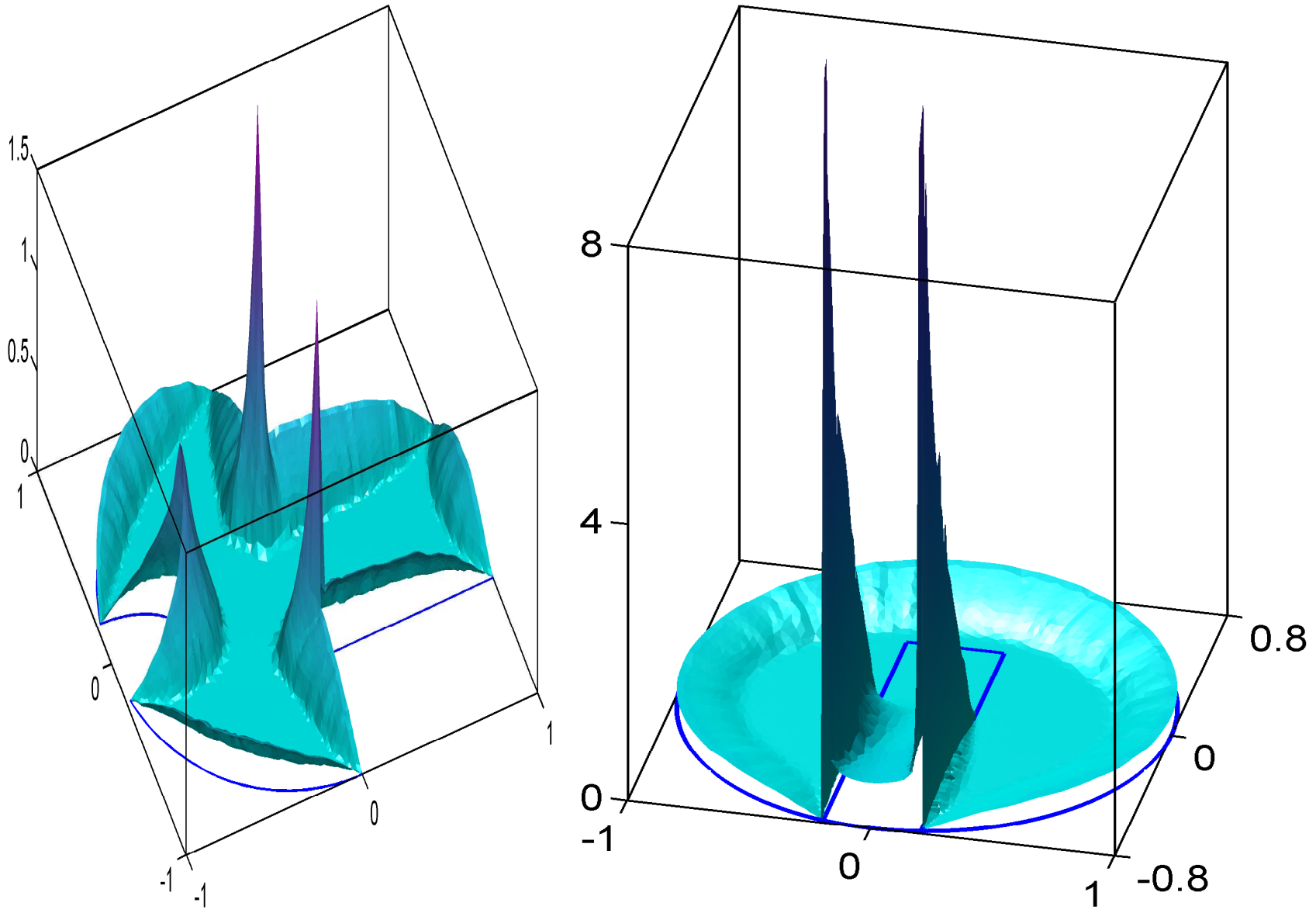
Thin film magnetization problem.
Left: a film with an indentation and corners.
Right: an inhomogeneous film ($J_c/2$ in the rect. part).

Sc films: $H_\perp$



Magnetic field penetration.

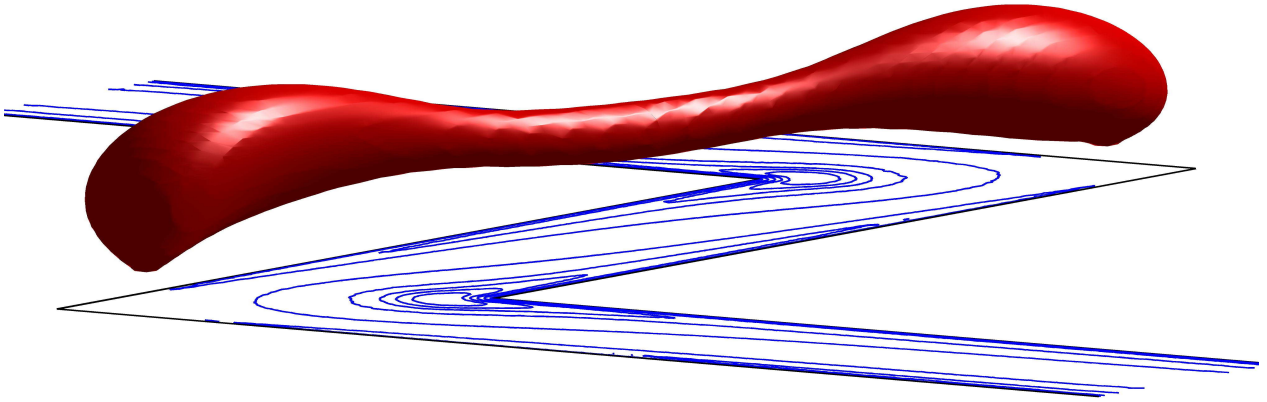
Sc films: electric field



Dual or mixed variational formulation is needed.

Magnetic traps on SC chips

Ultra-cold atoms can be trapped near the minima of the magnetic field magnitude. Traps on sc chips provide an extremely low noise environment for trapped atoms. We derived an efficient numerical method for modeling such devices.



Magnetic trap (|b| iso-surface) induced by a persistent current (current streamlines) remaining after a transport current pulse. A bias field is added.

Magnetic hysteresis

The popular engineering models for ferromagnetic hysteresis are less successful and do not have a physical interpretation as good as the models for hysteresis in type-II superconductors.

We derived an efficient numerical scheme for a refined version of the model for quasi-static ferromagnetic hysteresis proposed by Bergqvist in 97.

The model is based upon consistent energy arguments and a dry-friction like representation of the irreversible domain wall movement, is intrinsically vectorial, has a convenient variational formulation, and was incorporated as a local constitutive relation with memory into a finite element approximation of the Maxwell equations.

Thank you!