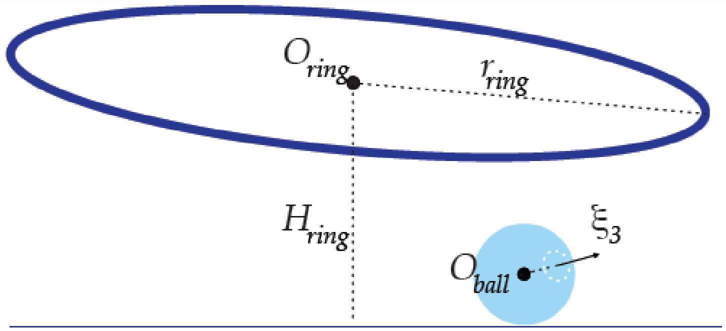
Hamel's magnetic top

owhaditopa.mov

Consider a magnetized top and ring.

Mathematical model

Hamel's device is modeled as two rigid bodies in magnetostatic interaction



- a ball with a magnetic dipole aligned to one of its axes
- a fixed magnetized ring of radially aligned magnetic dipoles

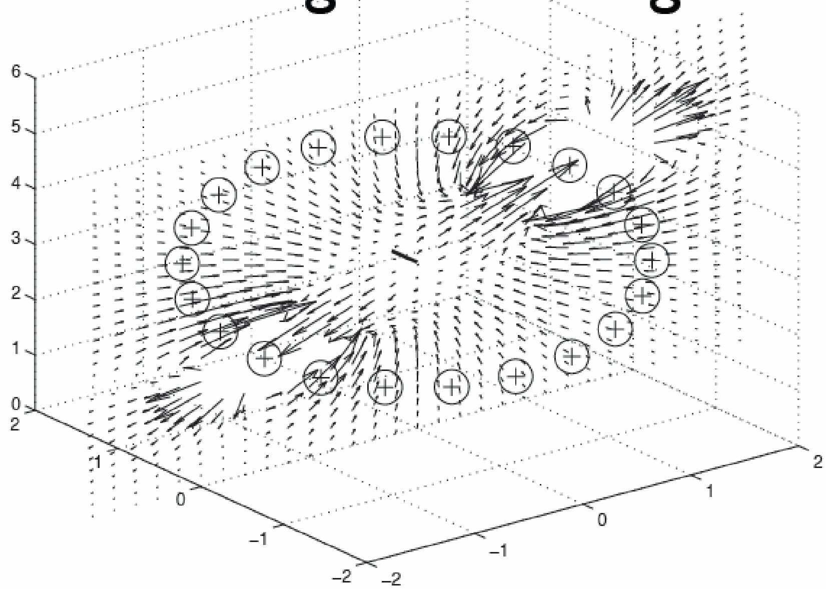
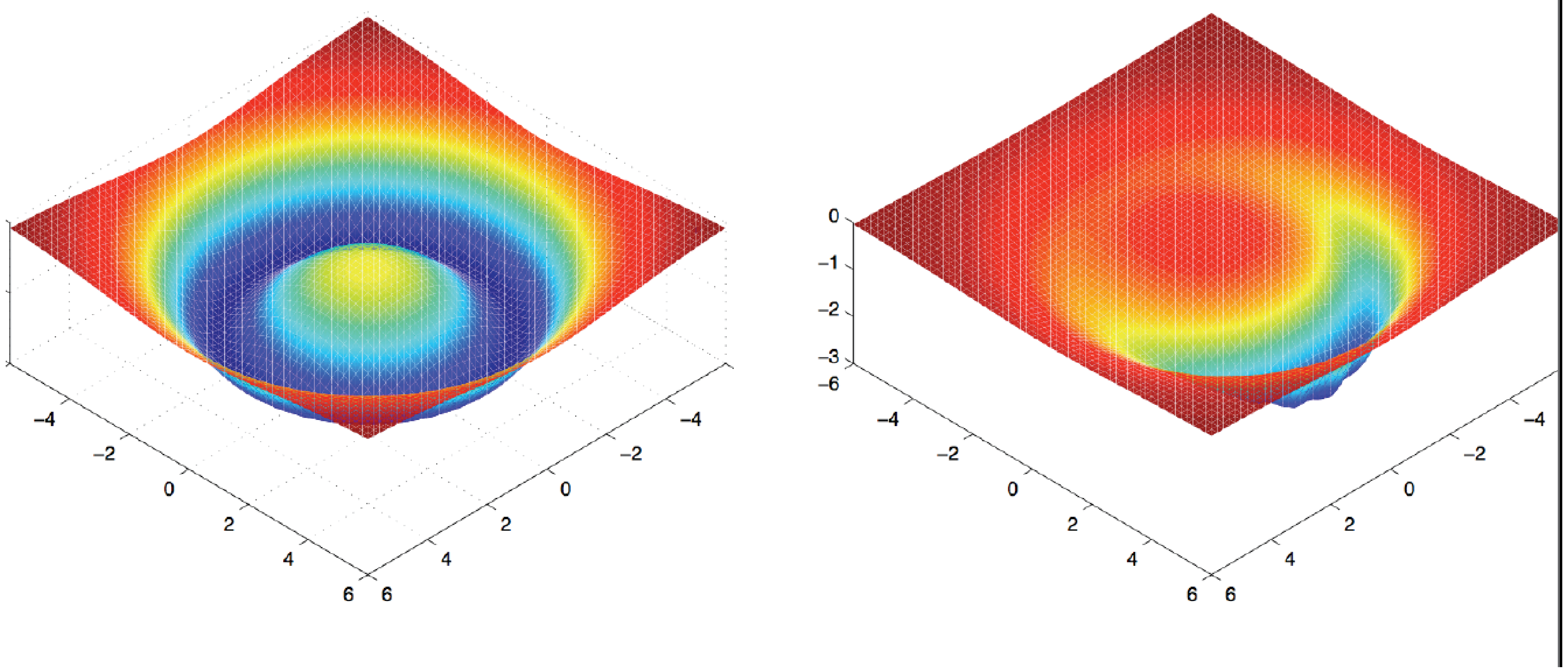


Illustration of Magnetized Ring and its Magnetic Field

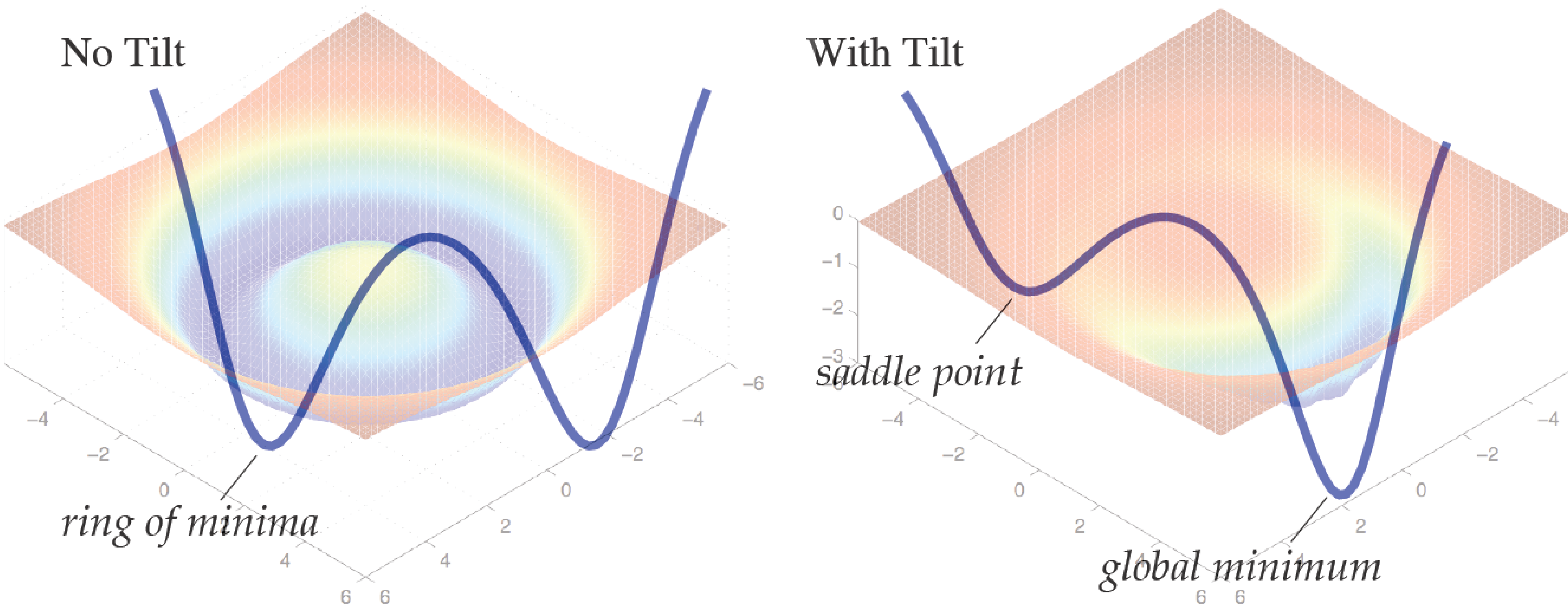
Fixed point of the system

- Fixed points of system's governing equations correspond to the magnetic top being at rest with its axis of symmetry aligned with the local magnetic field and its translational position at a critical point of the magnetic potential energy.
- Stability of fixed points is determined by analyzing geometry of the magnetic potential energy surface.

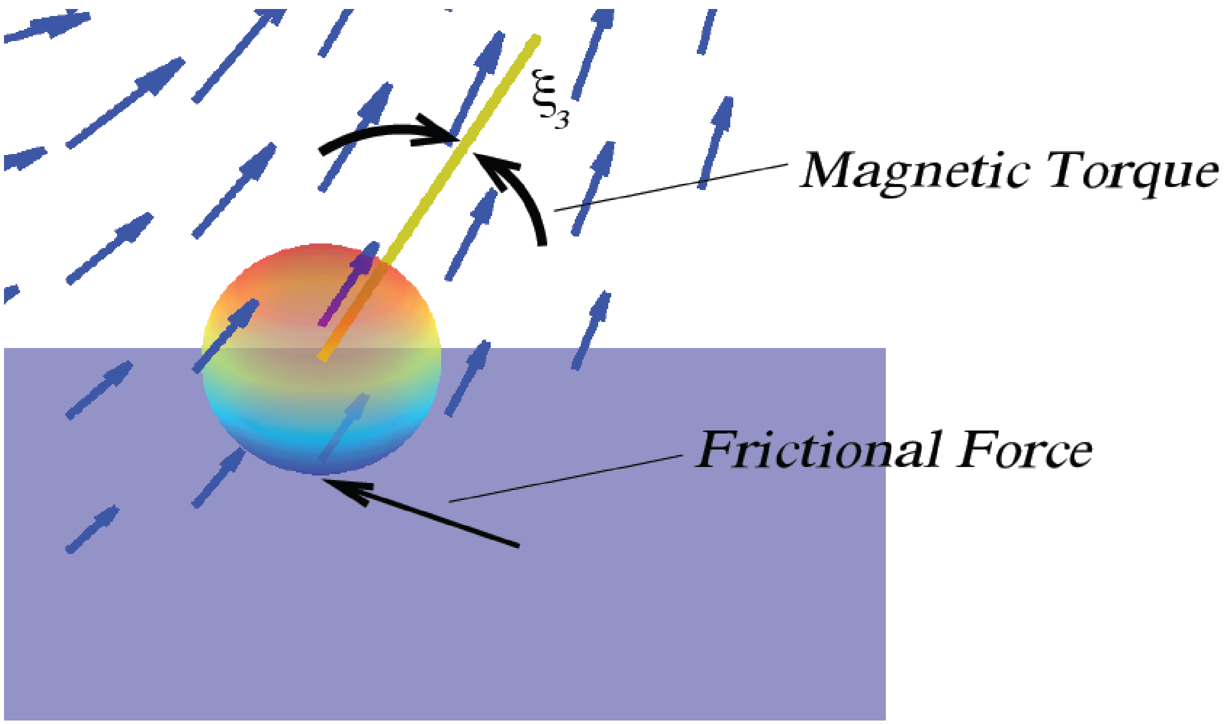
Geometry of the potential



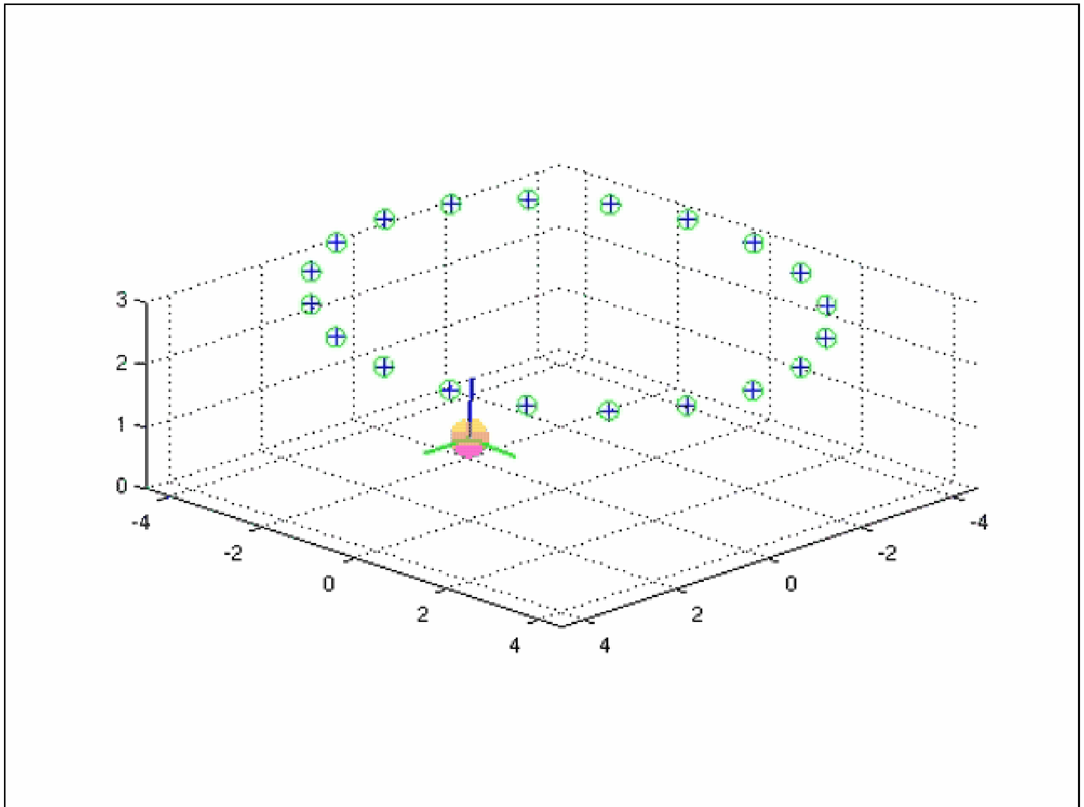
Geometry of the potential



Mechanism behind the curious rotation



Simulation using Variational Integrators



owhaditoptilt.mov

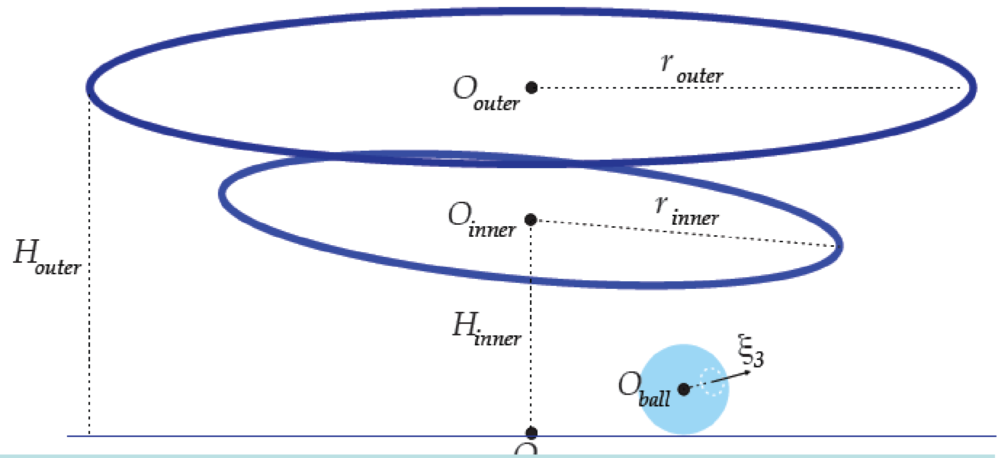
For more simulations see :

http://www.acm.caltech.edu/~owhadi/BallisticTransport/

Fluctuation driven motor

•The magnetic ring is allowed to be dynamic, and a fixed outer ring of a finite number of magnetic dipoles is introduced to stabilize it.

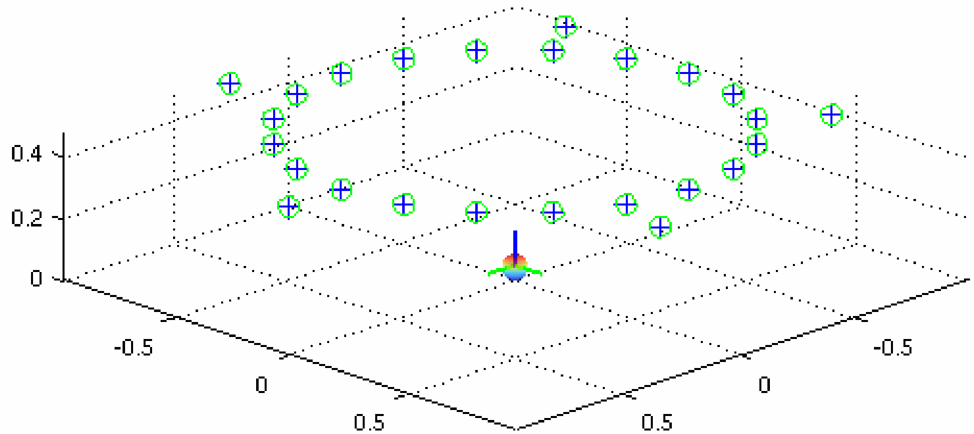
•The inner magnetic ring is randomly perturbed by white noise applied as a torque.



To put the motor at uniform temperature, one needs to generalize Langevin processes to Lie-Poisson systems.

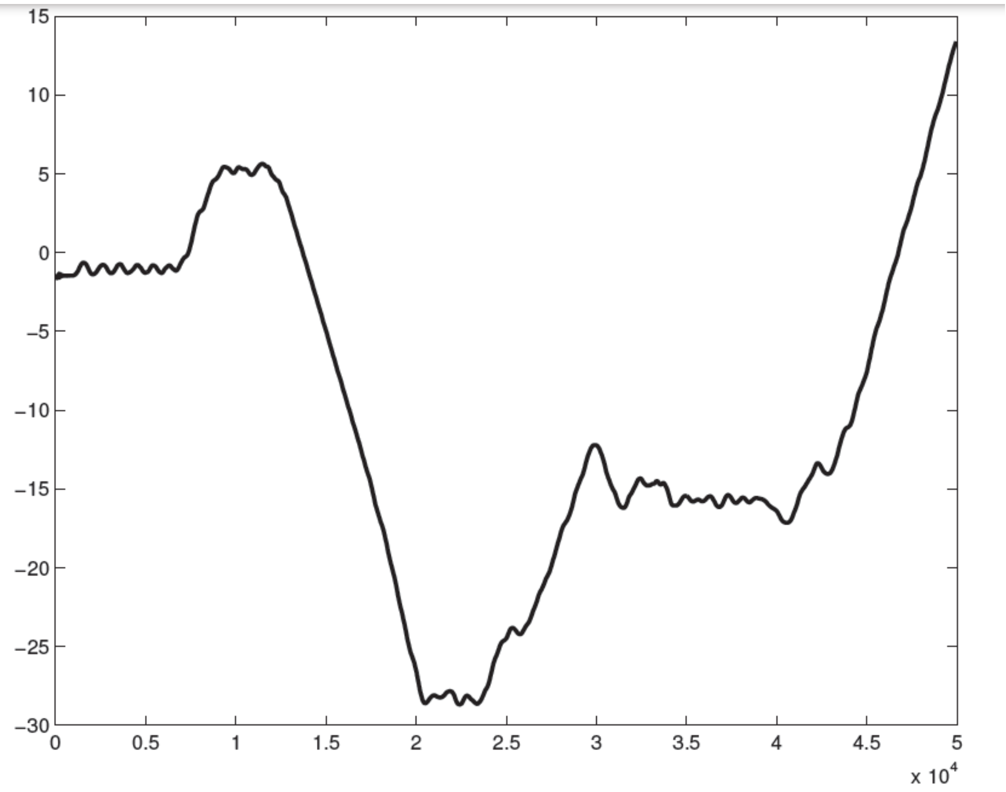
Moreover we wish to apply degenerate noise and friction on momentums ... proving ergodicity in this context requires novel techniques

Fluctuation driven motor



The simulation shows two kinds of metastable states: stochastic resonance and flights.

Angular displacement of the ball



This phenomenon persists at **uniform temperature**.