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1) Modelling a tangle of quantum vortices as gas of line elements.

Line segments of quantum vortices ('virions').

Length of the order of the average radius of curvature.

They are characterised by the average tangent and average binormal (curvature x binormal unit vector).

Interactions between elements are due to reconnections in which they loss their identity and new curvature is produced. We expect that due to reconnections the tangle is in local near equilibrium state in the small spatial scale.

The aim is

- Derive Boltzman like formulation for dynamic of virion gas. We want to put special attention to mechanically generated anisotropic turbulence in which vortex lines carry non-vanishing tangent and binormal.

# 2) Interaction of quantum turbulence with sedimenting particles
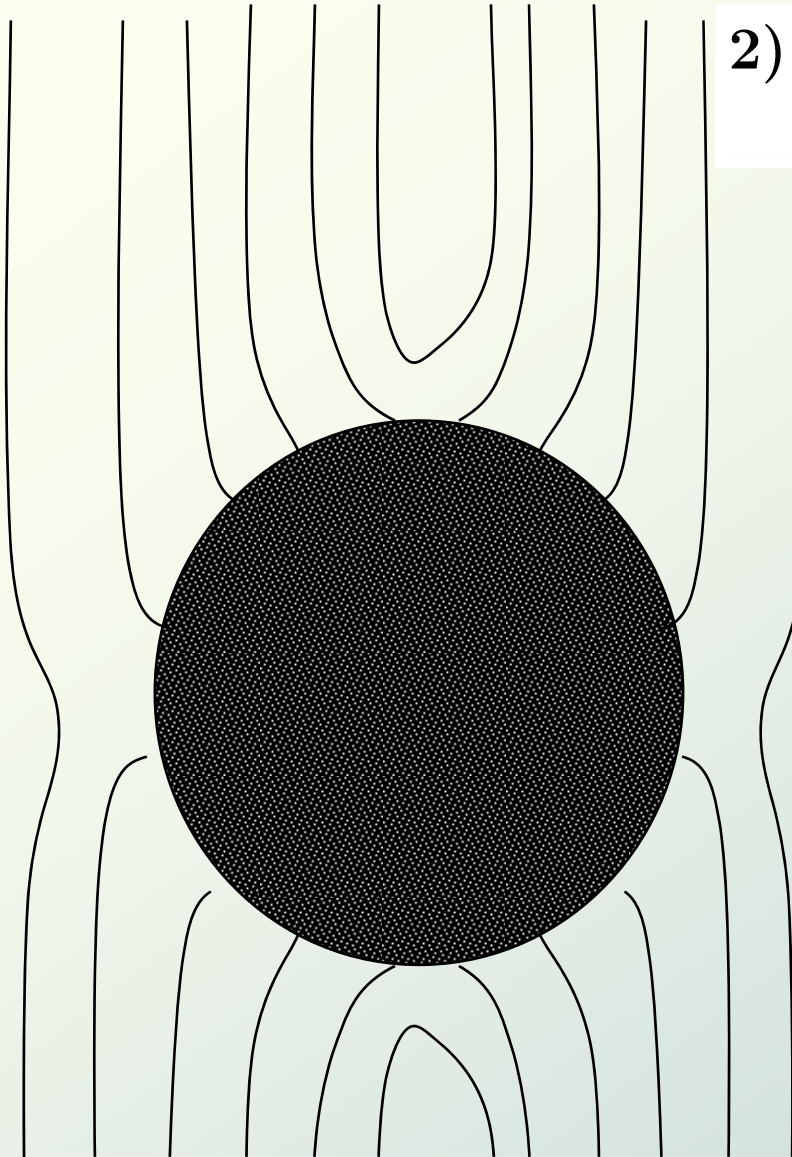
Analyze interaction of vortex gas with small tracer particles, sedimentation of particles in the presence of (anisotropic) quantum turbulence.

Measure the settling rate of a cloud of particles. This should be easier than PIV and feasible even at large concentrations

Particles interacting with quantum tangle <u>may</u> promote reconnections and therefore affect the tangle by reducing the vortex line density
If this is the case, then one could detect the response of the tangle to sedimenting particles.

3) Particle with nonuniform surface temperature

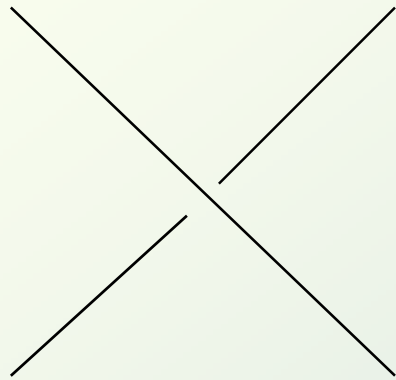Nonuniform heating is likely to generate force on a particle.
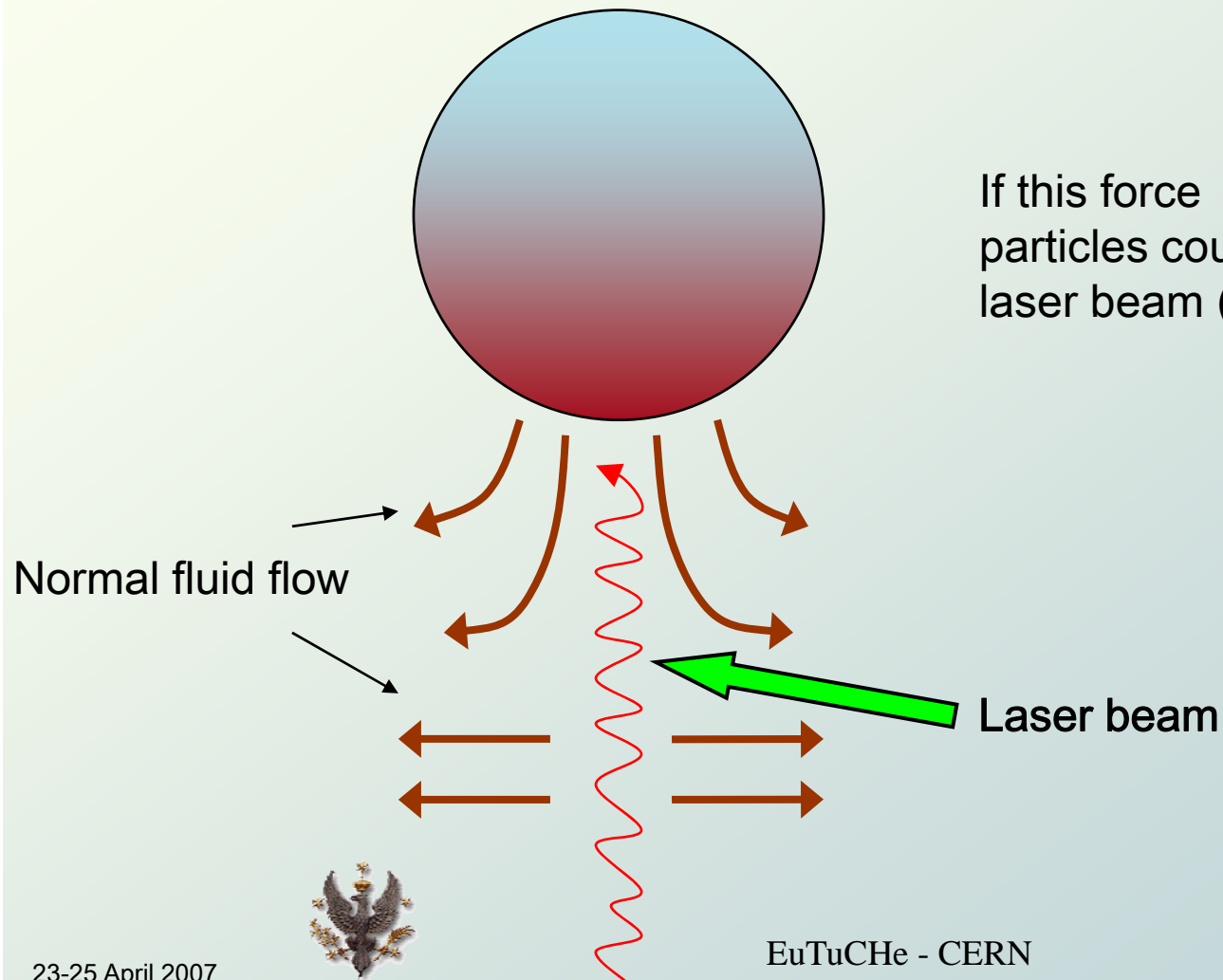
If this force proves signifficant, particles could be manipulated with laser beam (optical snooker).
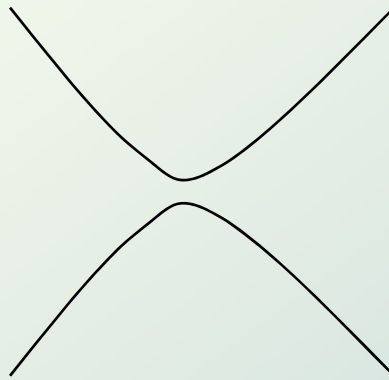
Normal fluid flow

Laser beam

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4) Effect of particles on the large-scale heat flux

Suspension of particles is likely to interact with vortex tangle
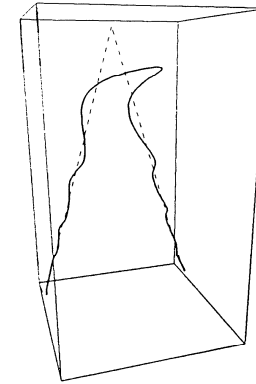
If suspension promotes reconnections,
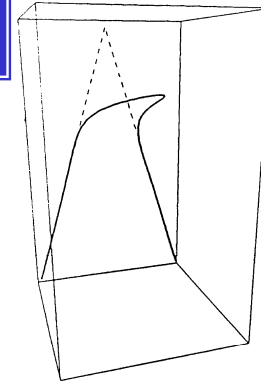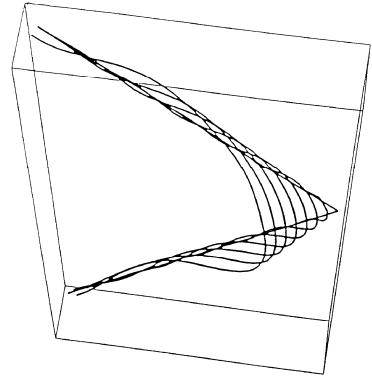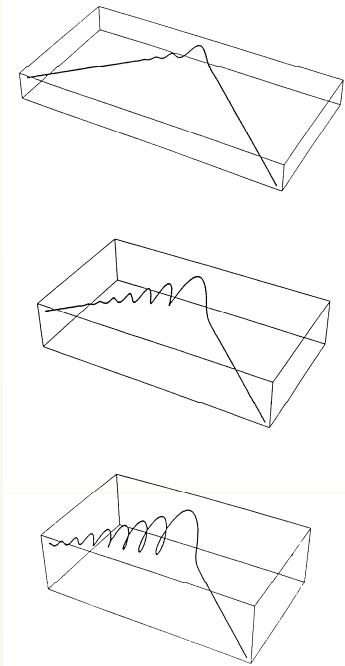
Two diagonals

two sides < two diagonals

then the length of the tangle decreases, the coupling between normal and superfluid component decreases and the heat flux increases.
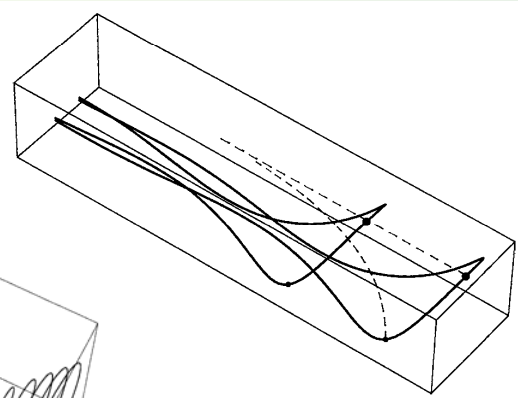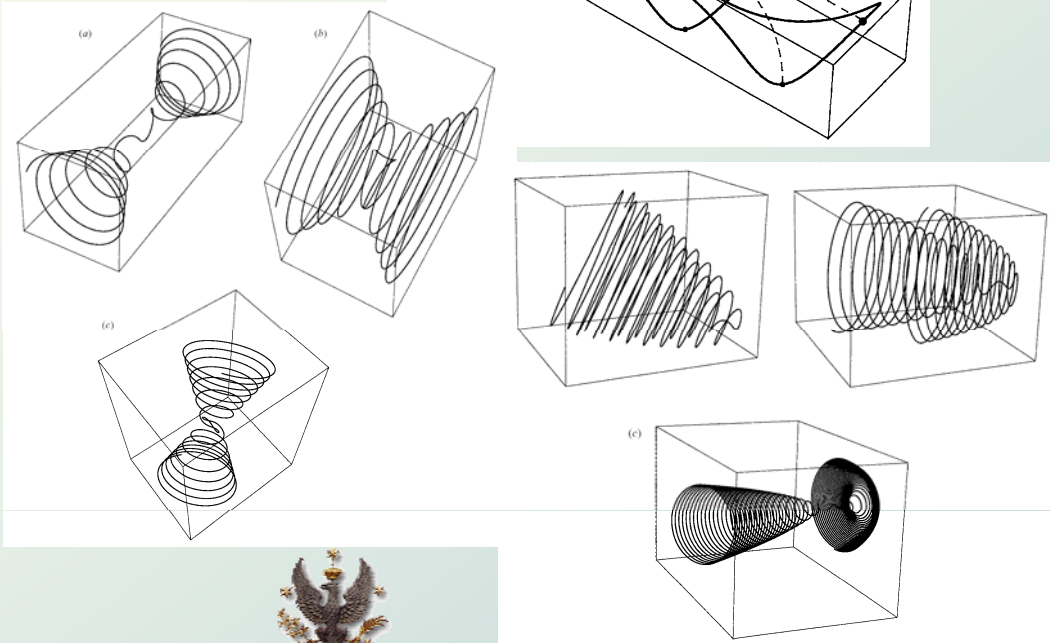Such effect would make superfluid helium even better coolant.

Variety of exact solutions

Such solutions help to model the relation between the statistics of reconnection and the global parameters of the tangle (distribution of binormal, etc.)

Solutions help in numerical simulations, as the moment of reconnection is computationally tricky

Lipniacki, T. (2000)
Eur. J. Mech. B Fluids **19**(3), 361-378.

Lipniacki, T. (2003)
Phys. Fluids **15**(6), 1381-1395.

Lipniacki, T. (2003)
J. Fluid Mech. **477**, 321-337.

Lipniacki, T. (2006)
Eur. J. Mech. B Fluids **25**(4), 435-458.

Computations on parallel-architecture machines:

1) Biot-Savart evolution of the tangle

2) Tangle as a 'gas' of line segments

   COMPARISON

Computer resources

Cray SV1ex
32 processors, 64 GB RAM, 0.5 TB local storage

Cray X1e
128 processors (SSP), 128 GB RAM, 1.3TB local storage

Cluster IBM e325 + SUN V40z + SUN X4600
196+96+64 processors, 196+192+128 GB RAM, 13.4 TB local storage

SUN BLADE X8400
520 processors to be installed in 2007 (Later to be expanded), 2080 GB RAM.