Motion of rigid bodies in incompressible flows

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Lecture 1:
The Cauchy problem for the motion of rigid bodies immersed in a viscous incompressible fluid.

In this lecture I will recall some results regarding the Cauchy problem for the motion of rigid bodies immersed in a viscous incompressible fluid with finite energy data, encompassing the issues of existence, uniqueness and partial regularity.

Lecture 2:
The Cauchy problem for the motion of rigid bodies immersed in an inviscid incompressible fluid.

In this second lecture I will turn to the case of an inviscid incompressible fluid, starting with the Cauchy problem for smooth data before to move to the case of irregular data in two dimensions. Roughly speaking we will see that many of the results known in the case of a fluid alone can be extended to the case where some rigid bodies are immersed.

Lecture 3:
Regularity of the trajectories; Lagrangian and Hamiltonian interpretations.

My third lecture will provide some additional features of the motion of rigid bodies immersed in an inviscid incompressible fluid. On the one hand we will establish some smoothness results regarding the trajectories of the fluid particles and of the immersed rigid bodies as well. On the other hand we will give some Lagrangian and Hamiltonian interpretations of the coupled system.

Lecture 4:
Dynamics of vortex points as limits of shrinking rigid bodies.

In this lecture we will restrict ourselves to the two dimensional case. We will see that when a rigid body shrinks to a pointwise particle its dynamics in the limit is given by some vortex point equations. Depending on whether or not the body's mass is hold fixed or vanishes in the shrinking process, we will obtain the classical vortex point equation or a massive counterpart involving a Kutta-Joukowski-type lift force.

Lecture 5:
Mean-field limits.

In the last lecture we will consider the case of many small immersed bodies. Mean-field limits suggest that kinetic formulations may provide some accurate description of the systems ``fluid+rigid bodies". Depending on the parameter one may capture distinct effects as the added-mass phenomenon, drag or lift forces, Einstein's enhanced viscosity. We will discuss in particular an Euler-Vlasov system recently introduced as a model of two dimensional gyrokinetic spray.