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Analysis of the Oseen evolution operator and applications

Consider the motion of a viscous incompressible fluid filling the whole space outside a single rigid body in 3D. We prefer to take a frame attached to the body in order that the problem is reduced to the one in a time-independent exterior domain.

In the first half (Lecture 1,2), assuming that the rigid motion is prescribed but can be still time-dependent in the body-fixed frame, I will describe how one can deduce the regularity properties and large time behavior of a generalized Oseen evolution operator on the solenoidal Lebesgue space, that provides a solution to the initial value problem for a non-autonomous linearized system. This evolution operator is no longer of parabolic type due to rotation of the body unless the rigid motion is purely translatory, so that analysis must be involved. The linear theory leads to several results on the Navier-Stokes problem; in fact, the regularity theory with the aid of weighted estimates enables us to find a strong solution locally in time, while temporal decay estimates play a crucial role to show the stability/attainability of physically relevant basic flows, such as steady and time-periodic ones.

In the second half (Lecture 3,4), the methodology for deduction of the large time behavior mentioned above is adapted to the fluid-rigid ball interaction as well, in which the motion of the body is to be determined. Although the shape of the body is not allowed to be arbitrary, we adopt a monolithic approach to develop temporal decay estimates of the Oseen-structure evolution operator arising from linearization around a time-dependent basic motion, being assumed to possess better summability at spatial infinity than the scale-critical rate, and then discuss the nonlinear stability of such a motion. The theorem can be applied to nontrivial steady states under the self-propelling condition or with wake structure.