Steady rigid body-Navier-Stokes fluid interaction: asymptotic behavior of the fluid and applications to drag minimization

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Consider a rigid body $\mathcal{S} \subset \mathbb{R}^3$ immersed in an infinitely extended Navier-Stokes liquid and the motion of the body-fluid interaction system described from a reference frame attached to $\mathcal{S}$. We are interested in steady motions of this system, where the region occupied by the fluid is the exterior domain $\Omega = \mathbb{R}^3 \setminus \mathcal{S}$.

In this context, we will address the following topics:

1. Assuming the velocity $V(x) := \xi + \omega \times x$ of $\mathcal{S}$ is known, understand the asymptotic behavior of solutions to the exterior Navier-Stokes equations in terms of the interplay between ξ and ω. This is done with the aid of the fundamental solution of the generalized 3D Oseen equations. The presentation is not limited to the case where translation and rotation of the solid are parallel, including a preparatory framework for the 2D case.

2. The use of boundary controls v_*, acting on the whole $\partial\Omega$ or just on a portion Γ of $\partial\Omega$, to generate a self-propelled motion of $\mathcal{S}$ with a target velocity $V(x)$ and minimize the drag about $\mathcal{S}$.

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