Navier-Stokes Flow past a Rigid Body that Moves by Time-Periodic Motion

Giovanni P. Galdi

Department of Mechanical Engineering and Materials Science
University of Pittsburgh, USA

Abstract

We study existence, uniqueness and asymptotic spatial behavior of time-periodic strong solutions to the Navier-Stokes equations in the exterior of a rigid body, $\mathscr{B}$, moving by time-periodic motion of given period T, when the data are sufficiently regular and small. Our contribution improves all previous ones in several directions. For example, we allow both translational, $\boldsymbol{\xi}$, and angular, $\boldsymbol{\omega}$, velocities of $\mathscr{B}$ to depend on time, and do not impose any restriction on the period T nor on the averaged velocity, $\overline{\boldsymbol{\xi}}$, of $\mathscr{B}$. If $\boldsymbol{\xi} \not\equiv \mathbf{0}$ we assume that $\boldsymbol{\xi}$ and $\boldsymbol{\omega}$ are both parallel to a constant direction, while no further assumption is needed if $\boldsymbol{\xi} \equiv \mathbf{0}$. We also furnish the spatial asymptotic behavior of the velocity field, $\boldsymbol{u}$, associated to such solutions. In particular, if $\mathscr{B}$ has a net motion characterized by $\overline{\boldsymbol{\xi}} \neq \mathbf{0}$, we then show that, at large distances from $\mathscr{B}$, $\boldsymbol{u}$ manifests a wake-like behavior in the direction $-\overline{\boldsymbol{\xi}}$, entirely similar to that of the velocity field of the steady-state flow occurring when $\mathscr{B}$ moves with velocity $\overline{\boldsymbol{\xi}}$.