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Minimum Drag Shape of a Hemi-ellipsoid Exposed to Shear Flow and Its Possible Relation to Deformation of Arterial Endothelial Cell
DONG WOOK LEE, IN SEOK KANG, POSTECH — As a model problem for an endothelial cell subject to blood flow, we consider a hemi-ellipsoid attached to a wall in the imposed shear flow. The minimum drag shape is obtained under the condition that the volume is kept constant. The aspect ratio of major axis to minor axis of the minimum drag shape turns out to be close to those of the equilibrium shapes of endothelial cells under steady blood flow. This fact suggests that there might be a possible connection between the objective function of drag minimization and the feedback mechanism for shape adjustment of an endothelial cell. From the fluid mechanics point of view, this mechanism can be considered as that the endothelial cell adjusts its shape in a way to minimize the drag force exerted by the shear flow. The analytical solution to the model problem is not available. So, the problem is solved numerically to compute the drag force exerted on the hemi-ellipsoid. However, an analytical solution is available for a closely related problem, which is the problem of a fixed ellipsoid in a shear flow. When the upper half domain is considered, the analytical solution satisfies everything of the original problem except for the velocity y-component at the flat surface. The analytical solution is Jeffery's classic result on the motion of an ellipsoidal particle in a viscous fluid [Proc. Roy. Soc. A (1922)].

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