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Slow Rotation of a Double Sphere in a Viscous Fluid

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The problem of slow steady rotation of a double sphere in a viscous fluid in the limit of low-Reynolds number is addressed. The geometry of the double sphere is assumed to be formed by two overlapping spheres of radii a and b cutting at an angle $\frac{\pi}{n}$, n an integer. The classical method of electrical inversion, also known as Kelvin's inversion, is utilised to obtain an exact solution for the axisymmetric rotation of the double sphere in the Stokes/creeping flow approximation. The exceedingly simple nature of the method leads to the representation of the solution in terms of elementary Green's functions for rotational flow, namely, the rotlets (or couplets). The image system for this case contains a finite number of rotlets all aligned parallel to the axis of rotation and located at the respective inverse points on the axis of symmetry. The strengths of those image rotlets depend on the two radii, distance between the centers of the two spheres and the angular speed. The couple/torque exerted on the double is extracted directly from the singularity solution without explicitly integrating the stresses on the surface. It is shown graphically that the vertex angle influences the couple significantly. It is observed that the torque is greater than the volume of a single sphere but less than the sum of the volumes of two spheres. This brings out an interesting inequality that provides an upper and lower bounds for the couple. The present solution may be conveniently utilised to study pair interactions of a double sphere with other axisymmetric bodies in the rotational motions. Furthermore, the exact results provided here could also be useful in validating numerical codes on merging objects in electrostatic and microfluidic environments.

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