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Chaotic rotation of a rigid ellipsoid immersed in a viscous flow

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Jeffery's solution for the motion of a rigid ellipsoid in a general viscous flow allows calculation of the trajectories of the angles describing the orientation of the ellipsoid over time. Using both mathematical analysis and numerical experiments the occurrence of chaos in this system is investigated. Poincaré sections and Lyapunov exponents were calculated for (i) uniform distributions of possible initial orientations, (ii) flow type ranging from simple to pure shear and (iii) different particle axis ratios. Chaotic behaviour is found to be extremely common for tri-axial ellipsoids in simple shear. Under pure shear ellipsoids align themselves with the stretching axes of the deformation. In the case of intermediate flows chaotic behaviour becomes increasingly evident with the transition from pure to simple shear. It is shown that chaos cannot occur in the case of a biaxial ellipsoid. These results have important implications for the deciphering of useful information from 3D distributions of rigid objects.