3D SPECTRAL SIMULATIONS FOR THE FLOW AROUND A RIGID SPHERE SUBJECT TO SIMPLE SHEAR FLOW

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We perform pseudospectral numerical simulations for the steady, three-dimensional creeping flow around a freely rotating rigid sphere subject to simple shear flow imposed at infinity. The fluid viscoelasticity is modelled using the second-order-fluid model, the Upper Convected Maxwell, the exponential affine Phan-Thien-Tanner and the Giesekus constitutive equations. A spherical coordinate system with origin at the center of the sphere is used to describe the flow field. The solution of the governing equations is expanded as a series with small values of the Deborah number. The resulting sequence of differential equations is solved numerically up to the fourth order in Deborah number by employing fully spectral representations for all the primary variables describing the flow. In particular, Chebyshev polynomials are used in the radial coordinate and Double Fourier Series along the longitudinal and latitudinal coordinates. In the latitudinal direction the singularity of the governing equations is circumvented by developing a shifted Discrete Fourier Transform with grid points that do not include the poles of the sphere. The numerical results for a Newtonian matrix fluid and a weakly viscoelastic matrix fluid are identical with the available analytical solutions clearly indicating the correctness and accuracy of the numerical method developed here. Expressions for the angular velocity of the rigid sphere, which results at the four order of the perturbation scheme, are also given.