Prolate microswimmer in surface gravity waves

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Planktonic microorganisms immersed in a fluid interact with the ambient flow, altering their trajectories. In surface gravity waves, a common goal for microswimmers is vertical migration. By modeling phytoplankton as spheroidal bodies with a certain swimming velocity, we investigate how the combination of swimmer's dynamical characteristics and fluid velocity gradients affect the motion. We investigate the case of prolate, negative buoyant and bottom heavy microswimmers. We find that it is possible for microswimmers to be trapped at a finite depth below the sea level. This phenomenon is due to the coupling between swimming, gravitaxis and flow-induced reorientations. The trajectories obtained by numerical simulations, indicate that the dynamics consists of fast oscillations at the surface wavelength superposed with a slower trend at a longer timescale. This suggests using a multiple time-scale expansion to remove the fast oscillations[1]. The presence of stable fixed points for the slow dynamics allows the trapping behaviour (Fig. 1). The work was developed considering each dynamical aspect of phytoplankton and their combinations. The last part is focused on a particular alteration of the flow field in which a shear term is added in order to reproduce the wind transport above the surface[2].

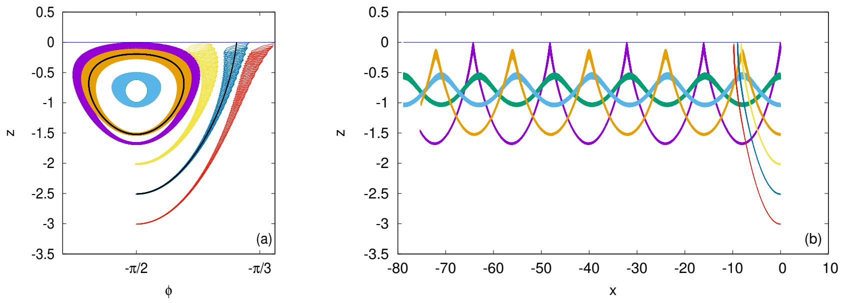

Figure 1: Numerical simulations in the case of gyrotactic swimmers. Lines with different colors represent trajectories starting from different heights and a fixed initial orientation. The blue horizontal line is the surface. (a) Representation of the neutral fixed point in the phase space. Black lines represents two examples of slow dynamics as average of fast oscillations. (b) Real space representation of same trajectories. Waves propagate from left to right. Swimming is against the current and bounded below sea level.

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