S05: Nonlinear oscillations

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Numerical Simulation of droplet oscillations with arbitrarily large deformations

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In Plümacher et al. (2020), a potential flow inside an oscillating droplet was assumed and the unified transformed method of Fokas (1997) was applied to transform the free boundary value problem formulated on a time-dependent domain into a nonlinear system of integro-differential equations defined on a time-independent unit sphere. This geometrically nonlinear theory (GNLT) governs the general droplet oscillation with arbitrarily large deviations from the spherical shape. In this work, the governing equations of the GNLT are solved numerically for arbitrarily large droplet deformations. By means of the Galerkin method, the unknowns are decom- posed into spherical harmonics to obtain a series of ordinary differential equations for the time-dependent coefficients. These are solved for arbitrary amplitudes and various initial deformation modes (l=2,3,4,5,6) by Newton's method. Starting from the relative position of the north pole of the droplet and the modal decomposition of the droplet shape, defined by the radius R, fully nonlinear effects are investigated, including modal coupling and quasi-periodicity. Moreover, the dependence of the oscillation frequency on the deformation of the droplet and the asymmetric time expenditure for the elongated shape are analyzed. Furthermore, the relative deviation of the surface area leads to the conclusion that the minimum surface area (spherical shape) is not reached during the oscillation. This effect increases with larger amplitudes. The nonlinear effects agree well with the known literature and extend the results found in the literature. The GNTL provides a very good possibility to analyze extreme nonlinear inviscid droplet oscillation in a vacuum.