Generic problem for a vesicle deformation

Amal AARAB, LAMAI Laboratory, Cadi Ayyad University

Nour Eddine ALAA, LAMAI Laboratory, Cadi Ayyad University

Mohammed GUEDDA, LAMFA Laboratory, University of Picardie Jules Verne

Mots-clés : Dynamic system, exact solution, spherical harmonics, generic problem, phase plane, vesicle dynamics

Generally soft objects make the interest of the recent researches, especially vesicles, capsules and red blood cells, because of their wide applications for the food industry, cosmetic, pharmaceutical as well as in the medical research. Understanding the behaviour of this one will allow us for example to diagnose diseases related to blood.

Due to the complexity of the cell membranes, we chose the vesicle model analysed in the small deformation regime under simple shear $v_0 = (\dot{\gamma_a} y, 0, 0)$ where $\dot{\gamma_a} = constante$ is the shear rate, set and resolved numerically by Misbah [4] and theoretically by Guedda et al. [3]

$$\left\{\begin{array}{lcl} \frac{dR}{dt} & = & h[1-4\frac{R^2}{\Delta}]sin(2\psi) \\ \frac{d\psi}{dt} & = & -\frac{1}{2}+\frac{h}{2R}cos(2\psi) \end{array}\right. \tag{1}$$

System (1) above describes the evolutionin time of Ψ the inclinaition angle and R the shape deformation of the vesicle as a function of excess area $\Delta = \frac{A-4\pi r_0^2}{r_0^2}$ (where A is the vesicle area and r_0 is the radius of sphere) and the parameter $h = 60\sqrt{\frac{2\pi}{15}}\frac{1}{(32+23\lambda)}$ (or the viscosity ratio $\lambda = \frac{\eta_{int}}{\eta_{out}}$, where η_{int} and η_{out} are inner and outer viscosity). It is found that vesicles display three types of dynamics; Tank Treading (TT) where the vesicle incline at a stationary angle $0 < \Psi < \frac{\pi}{4}$ with the flow direction, while its membrane turn around the cytoplasm, Tumbling (TB) in which the membrane flips like a rigid body, provided its initial shape is not spherical and the new regime Vacillating-breading (VB) where the vesicle oscillates about the flow direction and its shape makes a breathing motion. In the same spirit, we set a generic system defined by

$$\left\{\begin{array}{l} \frac{dR}{dt} = (\alpha-\beta R^2)sin(2\psi) \\ \frac{d\psi}{dt} = -\frac{q}{2}+\frac{\alpha}{2R}cos(2\psi) \end{array}\right. \tag{2}$$

Then the objective is to give a complete description of the global structure of solutions to (2).

Références

[1] Cordasco, Daniel and Bagchi, Prosenjit, Dynamics of red blood cells in oscillating shear flow, Journal of Fluid Mechanics, 800 (2016).

[2] M. Guedda, Membrane compression in tumbling and vacillating-breathing regimes for quasispherical vesicles, Phys. Rev. E 89, 012703 (2014).

[3] M. Guedda, M. Abaidi, M. Benlahsen, and C. Misbah, *Dynamic modes of quasispherical vesicles: Exact analytical solutions*, Phys. Rev. E 86, 051915 (2012).

[4] C. Misbah, *Vacillating Breathing and Tumbling of Vesicles under Shear Flow*, Phys. Rev. Lett. 96, 028104 (2006).

[5] JM. Skotheim and Timothy W. Secomb, *Red blood cells and other nonspherical capsules in shear flow: oscillatory dynamics and the tank-treading-to-tumbling transition*, Physical review letters, 98, 078301 (2007).

[6] R. G. Cox, *The deformation of a drop in a general time-dependent fluid flow*, Journal of fluid mechanics, 37, 03 (1969).

Amal AARAB, FST, Boulevard Abdelkrim Al Khattabi, 40000 Marrakech, Morocco
amal.aarab@edu.uca.ac.ma