8th. World Congress on Computational Mechanics (WCCM8)
5th. European Congress on Computational Methods in Applied Sciences and Engineering (ECCOMAS 2008)
June 30 – July 5, 2008
Venice, Italy

Dynamics of fluid membranes and budding of vesicles

*** Marino Arroyo[1] and Antonio DeSimone[2]**

[1] Universitat Politècnica de Catalunya
08034 Barcelona, Spain
Email: marino.arroyo@upc.edu

[2] SISSA-International School for Advanced Studies
Via Beirut 2-4, 34014 Trieste, Italy

Key Words: *lipid bilayer, interfacial Stokes flow, vesicles.*

ABSTRACT

We study the mechanics of multi-phase fluid membranes surrounded by a viscous fluid as a model system for lipid bilayer membranes found in biological and synthetic systems [1]. The partial order of the lipid membrane (the system is ordered in the direction perpendicular to the membrane and disordered in the tangential directions) endows the system with some features of a fluid (in-plane fluidity) and some of a solid (curvature elasticity). A seminal work in the mechanics of Newtonian fluids in the interfacial state is [2]. Here, we consider a fluid surface, surrounded by a viscous fluid, whose area preserving evolution is driven by curvature elasticity and line tension.

We focus on the inner flow–the motion of the lipids within the membrane surface. For this purpose, we obtain the equations of motion of a two-dimensional viscous fluid flowing on a curved surface that evolves in time. These equations are derived from the balance laws of continuum mechanics, and a geometric form of these equations is obtained. We use these equations to perform numerical simulations of selected examples, including the formation of a protruding bud in a fluid membrane, as a model problem for physiological processes on the cell wall. We study the dynamics of the budding process driven by line tension or interfacial energy, assuming that the neck of the bud corresponds to an interface between phases. We discuss the time and length scales that set different regimes in which the outer or inner flow are the predominant dissipative mechanism, and curvature elasticity or line tension dominate as driving forces. We view the governing equations as a flow of the Willmore energy, and compare with other flows studied in the literature.

REFERENCES

[1] K. Bacia, P. Schwille, and T. Kurzchalia, Proceedings of the National Academy of Sciences 102(9), 3272–3277 (2005).

[2] L. Scriven, Chem. Eng. Sci. 12, 98–108 (1960).