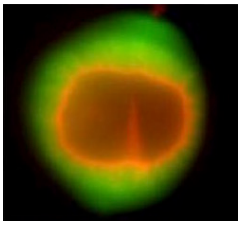
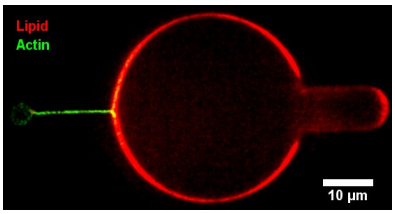
Project leaders: J. Plastino, C. Sykes, C. Campillo

Actin polymerization is triggered in a controlled fashion on surfaces by grafting them with actin polymerization activators. Surfaces include hard beads, soft beads and inner or outer leaflets of spherical lipid bilayers. We are currently mimicking complex physiological functions such as division, shape changes, and endocytosis by modifying actin dynamics and network-membrane attachment in our systems.

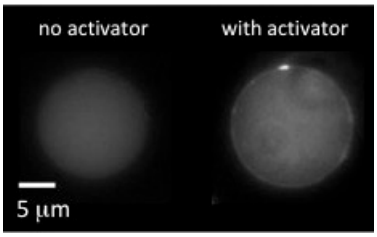
Current Projects



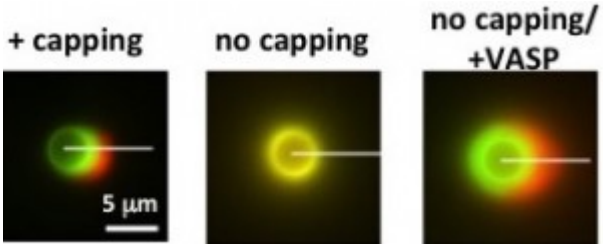
Deformation of the membrane by actin only in to endocytic- or filopodia-like structures.
(Camille Simon, PhD student).
Actin dynamics (actin in green) is reproduced at the membrane (red) of a liposome, and generate inward deformation as well as outward deformations. We explain this phenomenon through a localized perturbation and a continuum model of membrane deformation by growing branched actin networks.



Role of actin in membrane tube dynamics.
(Antoine Allard, PhD student).
We study how actin dynamics stabilizes or disrupts membrane tubes, in the context of membrane trafficking in cells. A thick (10-100 nm) membrane tube is pulled from a floppy liposome with the use of a bead trapped in optical tweezers (F. Valentino et al., Soft Matter). Tube force, thickness and shape fluctuations are recorded during the growth of the actin network.



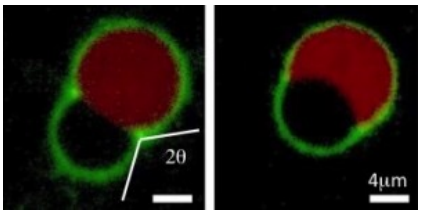
Liposomes encapsulating actin and myosin.
(Camille Simon, PhD student).
Actin and myosin are encapsulated in a liposome using the inverted emulsion technique. Actin polymerization is triggered at the inner surface of the membrane by encapsulating activators designed to attach to the membrane. Here, we look at the role of molecular motors on cortex dynamics.



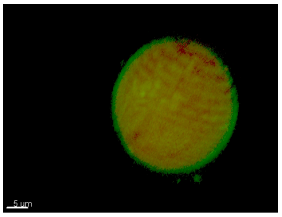
Ena/VASP proteins participate in the maintenance of actin network polarity.
(Majdouline Abou-Ghali, PhD student).
We follow the polarity of the actin network on a bead surface using a two-color actin approach. We find that Ena/VASP proteins preserve surface-directed polarity in the absence of capping protein. We are currently working to understand how elongation

enhancement by Ena/VASP could sustain actin network polarity even when capping protein concentrations are inadequate.

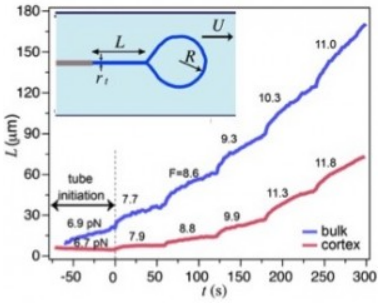
Past Projects



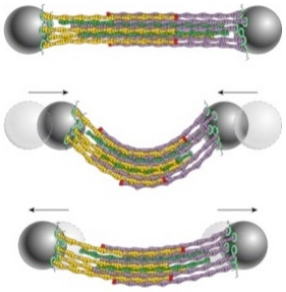
Active contraction of an actin network at a membrane.
A liposome doublet is covered with actin filaments and myosin motors and reproduces tension build up of cells. Its change in shape (flattening of the angle between the two liposomes) allows for an estimation of the produced tension (Caorsi et al., Soft Matter 2016.



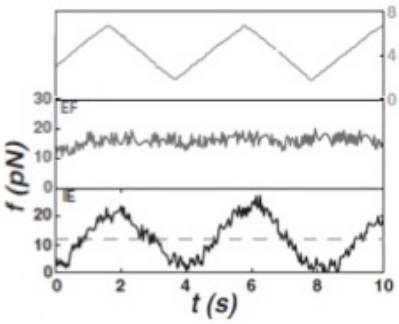
Designing different ways for reconstituting cortical tension.
An actin cortex is reproduced at the outside surface of a liposome membrane. It is put under tension by the addition of Myosin II to the chamber. At high tension, we observe the breakage of the cortex. (J. Lemière et al., Meth. Cell Biol. 2015; K. Carvalho et al., Phil Trans 2013; K. Carvalho et al., PNAS 2013; A. Kawska et al., PNAS 2012).



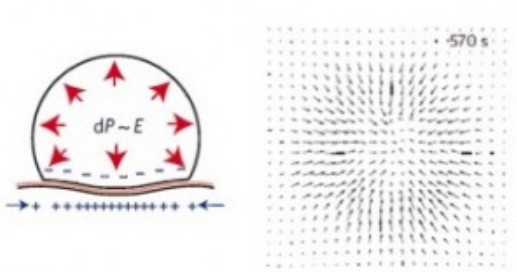
Mechanical characterizations of an actin cortex.
We reconstitute an actin cortex (or actin shell) at the inner surface of a liposome and investigate its role on membrane mechanics. In collaboration with Françoise Brochard, we study the dynamics of membrane tubes pulled by a hydrodynamic flow in the presence and absence of an actin shell. We show that the presence of the actin cortex limits the availability of membrane when a tube is pulled, affecting drastically the tube dynamics (K. Guevorkian et al., Biophys. J. 2015).



Mechanics of actin bundles generated by formins.
Actin bundles are micromanipulated with duplexed optical tweezers. We find an irreversibility of bundle deformation: once the bundle is squeezed by its extremities, it buckles and bends, but does not come back to its initial shape. We explain this phenomenon by friction of actin filaments sliding alongside each other (F. Ruckerl, et al., Biophys. J 2017).



Anomalous mechanics of membrane tubes in the presence of proteins.
For pure membranes, when the tube length is varied (top), the tube force remains constant (middle). This is not the case when proteins are incorporated in the membrane as can be seen by the variation of measured force as the tube length changes (bottom). This change in force is due to friction between the two membrane leaflets. An additional friction is caused by the presence of the actin network (C. Campillo, et al., Biophys. J. 2013).



Liposome adhesion generates traction stress
A pure membrane liposome that adheres on a deformable substate is able to contract the substrate and indent it because of Laplace pressure. Note that there is no acto-myosin contraction here (M. Murell et al., Nat. Phys. 2014).