The Role of Interaction Range and Buoyancy on the Adhesion of Vesicles

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The adsorption of vesicles on substrates plays a fundamental role in many biological processes, ranging from neurotransmitter release at the synapse on small scales to the nutrient intake of trees by large vesicles. The classical theory assumes a zero-ranged interaction between vesicle membrane and substrate and predicts a second-order adsorption transition at finite attraction.

We systematically study the adsorption of a vesicle to planar substrates with short- and long-range interaction, with and without buoyancy [1]. We demonstrate that (i) a attraction with nonzero spatial extension leads to a pinned state, where the vesicle benefits from the attractive membrane-substrate interaction without significant deformation and that this experimentally relevant feature results in a first-order adsorption transition when the interaction switches from repulsive to attractive. The classical theory is only recovered as a singular limit. (ii) Buoyancy is important for large vesicles and upwards buoyancy renders adsorbed vesicles at most metastable. We relate the adsorption behavior of vesicles to the wetting behavior of a planar liquid film (with short range repulsion and a longer-range interaction that changes from repulsive to attractive).

We determine the stability limit and the desorption mechanisms and compile the thermodynamic data into an adsorption diagram. Our findings reveal that buoyancy, as well as spatially extended interactions, are essential when quantitatively comparing experiments to theory [2].

References

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