PHYSICS AND ASTRONOMY

COLLOQUIUM

Dr. Ka Yee Lee

University of Chicago

"Beyond Wrinkling: Stress Relaxation in Lung Surfactant Monolayers and Other Thin Films"

Abstract

Lung surfactant is a mixture of lipids and proteins that coats the alveoli, and its main mechanical function is to reduce the work of breathing by reducing the surface tension. Insufficient amount of lung surfactant in premature infants leads to neonatal respiratory distress syndrome, while lung trauma can result in acute respiratory distress syndrome. In order to develop effective treatment for these conditions, a better understanding of the interactions between lung surfactant lipids and proteins is needed. Utilizing optical and atomic force microscopy techniques, we have examined the collapse process in lung surfactant, and have examined how the presence of lung surfactant peptide, $SP\text{-}B_{1\text{-}25}$, induces a reversible collapse in lung surfactant monolayers. Our observation indicates that $SP\text{-}B_{1\text{-}25}$ in simple phospholipid and model lung surfactant monolayers promote the protrusion of folds into the subphase at low surface tensions. The folds remain attached to the monolayer and reversibly reincorporated upon expansion. Without SP-B, an unsaturated lipid-rich phase is irreversibly "squeezed-out" of the monolayer at higher surface tensions. These folded reservoirs reconcile how lung surfactant can achieve both low surface tensions upon compression and rapid respreading upon expansion, and have important implications concerning the design of replacement lung surfactants. The onset of this folding instability can be understood in terms of the mechanical properties of the film. Statistics of the folding events will be presented and the link between folding on monolayers of nm thickness and that on polyester films that are 3 orders of magnitude thicker will be discussed. By studying different types of monolayers, we have shown that this folding transition in monolayers is not limited to lung surfactant films, but rather represents a much more general type of stress relaxation mechanism. Our study indicates that collapse modes are found most closely linked to in-plane rigidity. We characterize the rigidity of the monolayer by analyzing in-plane morphology on numerous length scales. More rigid monolayers collapse out-of-plane via a hard elastic mode similar to an elastic membrane, with the folded state being the final collapse state, while softer monolayers relax in-plane by shearing. For the hard elastic mode of collapse, we have further demonstrated experimentally and theoretically that the folded state is preceded by a wrinkled state.

Wednesday, October 05, 2011

3:30 p.m.

Bob Wright Centre

Room A104