Title: Soap Films in Electric Fields

Abstract: In 1968, in the context of investigating fundamental questions in electrohydrodynamics, G.I. Taylor studied the electrostatic deflection of elastic membranes[1]. Utilizing soap film as the membrane material and applying a fixed high voltage potential difference between two supported circular membranes, Taylor showed experimentally that at a critical voltage the two membranes snap together and touch. That is, the equilibrium state where the membranes remained separate that existed at smaller voltages either became unstable or failed to exist. This instability is familiar to researchers in the MEMS (microelectromechanical systems) and NEMS (nanoelectromechanical systems) fields where it is known as the "pull-in" instability. In fact, in an interesting historical coincidence H.C. Nathanson[2] and his coworkers studied this instability in the context of a primitive MEMS device at roughly the same time as Taylor was conducting his studies. Nathanson is responsible for the "pull-in" nomenclature and the analysis of a mass-spring model of this effect. Taylor, in conjunction with R.C. Ackerberg[3] developed and numerically analyzed a more accurate membrane based model of electrostatic deflection. Recently, a rigorous analysis of this model was completed[4]. Surprisingly, even this simple model of electrostatic deflection contains a rich solution set exhibiting a bifurcation diagram with infinitely many folds. In this talk, we provide an overview of recent results on the interaction of soap films with electrostatic fields. We discuss a re-creation of the Taylor experiment, some new experimental results and discuss the relevance of this research to MEMS and NEMS systems.

[1] G.I. Taylor, Proc. Roy. Soc. A., 306, pp. 423-434, 1968
[2] H.C. Nathanson et. al., IEEE Trans. on Elec. Dev., 14, pp. 117-133, 1967
[3] R.C. Ackerberg, Proc. Roy. Soc. A., 312, pp. 129-140, 1969
[4] J.A. Pelesko and X.Y. Chen, Jrnl. of Elec., 57, pp. 1-12, 2003