Mathematical Aeroelasticity: Well-posedness and Long-time Behavior of Flow-Structure Interactions

This talk focuses on the underlying mathematics of the aeroelastic phenomenon flutter—i.e., the way that an elastic structure may become unstable in the presence of an adjacent flow of air. Under certain circumstances, a feedback occurs between elastic deformations and pressure dynamics in the airflow, resulting in sustained oscillations. A canonical example was seen in the Tacoma Narrows bridge (Washington, USA), which collapsed in 1940 while fluttering in 65 kph winds. Flutter is typically discussed in the context of aero-mechanical systems: buildings and bridges in wind, and flight systems. However, applications also arise in biology (snoring and sleep apnea), and in alternative energy technologies (piezoelectric energy harvesters). We will look at a variety of flow-structure interaction models which are partial differential equation systems coupled via an interface. After a brief discussion of relevant modeling, we will examine well-posedness and long-time behavior properties of PDE solutions for three different physical configurations that can exhibit aeroelastic flutter: (1) projectile paneling, (2) a bridge deck, (3) an elastic energy harvester. From a rigorous point of view, we attempt to capture the mechanism that gives rise to the flutter instability. Additionally, when flutter occurs, we attempt to describe its qualitative features through a dynamical systems approach, as well as how to prevent it or bring it about (stability).