Speaker: George Haller
Math Colloquium
November 16, 2009

Title: Aerodynamic Separation and Invariant Manifolds:
Recent Progress on a Century-old Problem

Abstract:
Flow separation -- the detachment of fluid from a boundary -- is a major cause of performance loss in engineering devices such as diffusers, airfoils and jet engines. In a landmark 1904 paper on boundary layers, L. Prandtl derived a criterion for flow separation from no-slip boundaries in steady two-dimensional incompressible flows. Despite widespread effort, however, no unsteady or three-dimensional extension of Prandtl's criterion has emerged in the fluid dynamics literature. In this talk, I discuss recent success in extending Prandtl's criterion to unsteady three-dimensional compressible flows as well as to slip boundaries. This new separation theory relies on advanced dynamical systems concepts such as nonhyperbolic invariant manifold theory and aperiodic averaging. Remarkably, these techniques render exact separation criteria that cannot be obtained from first principles. I show numerical and experimental results confirming the generalized separation criteria and discuss applications to flow control and pollution tracking.