The breakup of liquid jets is ubiquitous with rich underpinning physics and widespread applications. The natural breakup of liquid jets originates from small ambient perturbations, which can grow exponentially until the amplitude as large as the jet radius is reached. For unelectrified inviscid jets, surface energy analysis shows that only the axisymmetric perturbation is possibly unstable, and this mode is referred as varicose instability. For electrified jets, the presence of surface charge enables additional unstable modes, among which the most common one is the whipping (or kink) instability that bends and stretches the charged jet that is responsible for the phenomena of electrospinning. A closer examination of the two instabilities suggests that due to mass conservation, the uneven jet stretching from whipping may translate into radial perturbations and trigger varicose instabilities. Although the varicose and whipping instabilities of electrified microjets have both been extensively studied separately, there is little attention paid to the combined effect of these two, which may lead to new jet breakup phenomena. This dissertation investigates the dynamic response of electrified jets under transverse electrohydrodynamic (EHD) perturbations which were introduced by exciters driven by alternating voltage of sweeping frequency. Three different jetting mechanisms are used to generate jets with various ranges of jet diameters: ~150 micrometer inertial jets from liquid pressurized through a small orifice, ~50 micrometer flow focused jets, and ~20 micrometer electrified Taylor-cone jets. The transverse perturbations enable systematic triggering of varicose and whipping instabilities, and consequently a wide range of remarkable phenomena emerge. For inertia jets with zero or low charge levels, only varicose instability is observable due to suppressed whipping instability. At modest charge levels, inertia jets can respond to the fundamental perturbation frequency as well as the second harmonic of the perturbation frequency. Highly charged jets such as fine jets generated from Taylor cones exhibit distinct behavior for different perturbation wavenumber $x$. Typical behavior include: whipping jets with superimposed varicose instability at small $x$, jet bifurcation from crossover of whipping and instability instabilities at $x \approx 0.5$, Coulombic fission owing to the surge of surface charge density as the slender liquid segments recover spherical shapes at $x \approx 0.7$, and simple varicose mode near wave numbers of unity. The phenomena observed in this work may be explained by a linear model and rationalized by the phase diagram in the space of wave number and dimensionless charge levels. The experimental apparatus used in this dissertation is simple, non-intrusive, and scalable to a linear array of jets. The rich phenomena combined with the versatile apparatus may spawn new research directions such as regulated electrospinning, generating strictly monodisperse micro/nano droplets, and manufacturing of non-spherical particles from drying droplets that undergo controlled Coulombic fissions.

Major: Mechanical Engineering

Educational Career:
Bachelor's of Physics, BS, 2009, University of Science and Technology of China
Master's of Mechanical Engineering, MS, 2012, University of Central Florida

Committee in Charge:
Weiwei Deng, Chair, Mechanical & Aerospace Engineering
Louis Chow, Mechanical & Aerospace Engineering
Ranganathan Kumar, Mechanical & Aerospace Engineering
Jiyu Fang, Materials Science & Engineering

Approved for distribution by Weiwei Deng, Committee Chair, on April 18, 2014.

The public is welcome to attend.