Neuronal Excitability and Canards

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The notion of excitability was first introduced in an attempt to understand firing properties of neurons. It was Alan Hodgkin who identified three basic types (classes) of excitable axons (integrator, resonator and differentiator) distinguished by their different responses to injected steps of currents of various amplitudes. Pioneered by Rinzel and Ermentrout, bifurcation theory explains repetitive (tonic) firing patterns for adequate steady inputs in integrator (type I) and resonator (type II) neuronal models. In contrast, the dynamic behavior of differentiator (type III) neurons cannot be explained by standard dynamical systems theory. This third type of excitable neuron encodes a dynamic change in the input and leads naturally to a transient response of the neuron.
In this talk, I will show that "canards" - peculiar mathematical creatures - are well suited to explain the nature of transient responses of neurons due to dynamic (smooth) inputs. I will apply this geometric theory to a driven FitzHugh-Nagumo/Morris-Lecar type neural model and to a more complicated model where anomalous delays in intracellular calcium dynamics are observed.