CMP Seminar
Michigan State University

Vladimir Manucharyan
University of Maryland

Quantum electrodynamics of high-impedance superconducting circuits

An electromagnetic resonator is characterized by its resonance frequency and characteristic impedance. The latter controls the scale of quantum fluctuations of charge and flux circuit variables. In most superconducting circuits the impedance is close to 50 Ohm and is linked to the impedance of free space. This “low” impedance favors small fluctuations of flux (compared to flux quantum) and high fluctuations of charge (compared to charge quantum). If a Josephson junction is inserted in such a low-impedance circuit, it's rich and unusual non-linearity is reduced to a simple quartic in flux term. Novel strongly non-linear effects are expected in high-impedance Josephson circuits which remained largely unexplored today.

In this talk we present experiments with three types of high-impedance circuits. We start with a single-mode resonator made of a short chain of 30-50 Josephson junctions inductance shunted by an antenna-like capacitance. The resonator’s dimensions are an order of magnitude smaller than the free-space wavelength and the Josephson non-linearity is reduced as the square of the number of junctions. Such resonators can also be used to explore interplay of a very weak non-linearity and a very high quality factor. Next, we fabricated a high-impedance Josephson transmission line consisting of two parallel chains containing over 15,000 junctions each. The transmission line shows standing wave resonances corresponding to wave propagation hundred times slower than light. We will describe how this system makes an excellent platform to study quantum impurity physics, such as Kondo effect or Lutttinger liquid tunneling with microwaves. Finally, we present a measurement of energy relaxation of a superconducting fluxonium qubit, obtained by shunting a small junction with an array of about 100 junctions. By tuning the qubit parameters with a magnetic flux, we suppressed a transition matrix element for flux tunneling in the loop and observed relaxation rates well in excess of 0.5 millisecond. Such a decoupling from mundane dissipation opens up possibilities to explore unconventional relaxation processes in superconducting circuits.

Monday, November 14, 2016
4:10 p.m.
BPS 1400
Prof. Mark Dykman - Host