Title: Graphene plasmons for extreme light-matter interactions

Rapid technological progress continues to provide new ways of manipulating and confining light on the nanoscale. The talk will discuss how 2D materials (such as graphene) create novel states of light that facilitate new effects of light-matter interaction and give new insight into old and fundamental problems in physics. We develop a new electron-plasmon scattering theory to propose a highly directional, tunable and monochromatic radiation source based on free electrons interacting with graphene plasmons. Graphene plasmons show strong confinement of light, 200-300 times more than light of the same frequency in vacuum. This enables the generation of high frequency radiation from relatively low energy electrons, bypassing the need for lengthy acceleration of the electrons. For instance, highly-directional 20 keV photons could be generated in a table-top design using electrons from conventional radiofrequency (RF) electron guns.

A related property of plasmons is their potentially very slow phase velocity, which for plasmons in 2D conductors can be several hundred times slower than the speed of light. We show how this property creates the scenario where the velocity of light can become comparable for the first time to that of charge carriers flowing through graphene. Then, the interaction between the charge carriers and the plasmons presents a highly efficient, tunable, and ultrafast conversion mechanism from electrical signal to plasmonic excitation. This happens since the velocity of the charge carriers breaks the "light barrier", leading to Čerenkov radiation of plasmons in 2D. Quantum mechanical considerations in the graphene Čerenkov effect reveal new features that the usual classical treatment does not predict.

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