Session A

Kilonova Emissions - Particle-In-Cell Simulations of Mildly Relativistic Outflows

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Collisionless shocks are ubiquitous in astrophysical plasmas, and are observed to be the sites of very high energy particles (which then radiate photons over a wide range of energies). A long-standing, unsolved problems in high energy astrophysics how magnetic fields are generated in these shocks, and how these fields relate to the process of particle acceleration. Particle-in-cell codes are ideally suited to address this question and previous work has looked at cases of magnetic field generation and particle acceleration in both highly relativistic and non-relativistic shocks. The aim of this project is to examine shock development, magnetic field generation and particle acceleration in the case of mildly relativistic shocks, which are expected when the tidal ejecta of neutron star mergers shocks with the external medium. Using LANL's VPIC (vector particle-in-cell), we have run simulations of such mildly-relativistic, collisionless, (initially unmagnetized) plasmas and compute the resultant magnetic fields and particle energy spectra. We show the effects of varying plasma conditions, as well as explore the validity of using different and often unrealistic proton to electron mass ratios in VPIC. Our results have implications for observing late-time electromagnetic counterparts to gravitational wave detections of neutron star mergers.

Keywords: Astrophysics, Plasma Processes, Outflows

Transmission Line Pulser Topology: The Pros & Cons

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The generation of fast, high voltage pulses is essential for studying phenomena involving ionized fluids and their applications. Two line-pulsers are being developed. The first is a coaxial transmission line pulse and the other is a modification known as a self-matching pulser. The coaxial transmission line pulser, is simple yet robust, but is subject to the form of its output waveform being dependent on the relative mismatch between the transmission line and load impedances. While a well-known device, our implementation is devised to be self-contained and portable for maximum utility. The self-matching pulser arranges the component transmission lines so that the generator is always impedance matched and is load independent. The self-matching circuit has only rarely been implemented and is sparsely known. Moreover, the dependence of critical parameters has not been fully explored and researchers need to know more about them before investing their resources. This presentation will describe and explain the basic physics of both circuits. In addition, the data will show the outputs with different resistive loads, power outputs, reflections, and different applications.

Keywords:

Testing of Multiple 3D Printed Cylinders Against Surface Flash Over

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Insulators in a high voltage environment are a consistently challenging problem because of the threat of electrical breakdown and permanent damage resulting equipment failure. While engineered polymers such as acrylic and polycarbonate have substantial voltage holdoff capability, shaping is achieved by machining, requiring substantial effort. In many engineering areas, 3D printing has shown to be a novel and cost-effective manufacturing technique. The use of 3D printed insulators are used primarily because they can be designed to the exact specifications as required, with a variety of materials.
However, many 3D printing fabrication methods result in embedded air pockets which is detrimental to high voltage performance. In experimenting with one method, stereolithography (SLA), we have shown that it has excellent high voltage properties. This provides a unique and interesting way to investigate a variety of parameters in relation to electrical breakdown phenomena.
The manipulation of the length and material is the primary focus of this project. When dealing with insulators and high discharge, surface flashover is the result of electrons accelerating across the surface of an insulator where it eventually creates an arc between conductors of difference potentials, resulting in the limitation of voltage it can support. For this project, several 3d printed materials as well as Lexan will be tested in 1 in. diameter cylinders, with varying heights using a 25 stage Marx pulse generator in order to determine how each behaves and responds to surface flashover

Keywords: Electrical Engineering, Surface Flashover, Insulators

Biosensing with Spatial Resolution Using Arrays of Graphene Nanodisks

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The ability to detect the presence of molecules in low concentrations poses a unique but pressing technological challenge due to the weak interactions of these structures with light. In this context, metallic nanostructures capable of supporting surface plasmons, the collective oscillations of conduction electrons, have emerged as a promising platform to achieve this goal. This is because plasmons couple strongly to light, producing large confinement and enhancement of incident electromagnetic fields, which serve amplify the interaction with the vibrational modes of molecules placed in their vicinity. One material that is especially promising to this end is graphene, a two-dimensional honeycomb lattice of carbon atoms. This is because it can be doped to support surface plasmons in the mid-infrared part of the spectrum, which is where most molecules have their vibrational modes. In addition, the plasmons supported by graphene can be actively tuned by changing the doping level, which enables the detection of a wide range of chemical species using the same device. Here, we exploit these extraordinary properties to design and model an ultrasensitive optical sensor made of arrays of graphene nanodisks. Our proposed device, which consists of a set of subarrays, or pixels, each of which can be individually doped, can enable the detection of low concentrations of molecules with the added advantage of having subwavelength spatial resolution. This is achieved by sequentially bringing each pixel into resonance with a desired chemical species. The results of our work serve to inspire the development of new lab-on-a-chip technologies that can be used to study, in real time, complex biological structures and processes.

Keywords: Plasmons, Graphene, Biosensing, Periodic Arrays