Physics Senior Research Oral Presentations

Michigan Technological University

Thursday, April 15, 2010

3:00 – 5:00pm

Room 139 of Fisher Hall

Time of Presentation 3:05

3D Brownian Motion Measurements Utilizing In-Line Holography

Dan Miller

Advisor: Raymond Shaw

Abstract: We developed a new experimental setup for determining the Avogadro's number through The measurement of Brownian motion in 3D. A digital in-line holography system takes a series of images of particles motion in 3D undergoing brownian motion in an external gravitational field. Diffraction patterns of 2 micrometer particles solution were magnified 12 times and recorded with a digital camera. The digital holograms were then numerically reconstructed to determine the x,y,z coordinates of the particles. The uncertainty in the x and y positions is merely limited by the camera's pixel size of 4.65 micrometers and diffraction. The z position, which is determined by the resolution of the hologram itself, has an added uncertainty due to the necessity of resolving smaller diffraction fringes. Our goal was to obtain sub-mm resolution in the z position. Once particle positions were obtained, a nearest-neighbor algorithm was used to track particles and calculate the mean square displacement between images. With this measurement and other physical constants Einstein's theoretical derivation of Brownian motion was confirmed in 3D by calculating Avogadro's number from his result to within an order of magnitude.

Time of Presentation 3:18

Clustering and Repulsion of Charged Inertial Particles in Turbulence

Hansen Nordsiek

Advisor: Dr. Raymond Shaw

Abstract: For electrically charged water droplets in turbulent air, it was experimentally observed in a turbulence chamber that the droplets form spatial clusters analogous to those in a nonideal gas: at close separation distances particles repel, and at long distances particles tend to gather in bunches (cluster) due to inertial drift. These observations are important in understanding the droplet dynamics in thunderstorms and electrosprays. The turbulence chamber is a speaker driven cube 0.5 m on a side producing turbulent energy dissipation rates (power put into turbulence per unit mass of fluid) from 20 mW/kg to 200 mW/kg. Water droplets with diameters of 30-40 microns and electric charges on the order of 100,000 elementary charges were used. A theoretical model is developed that describes the structure of the clustering by balancing Coulomb repulsion, inertial drift, and turbulent diffusion (mixing). The model's functional form closely matches the experimental structure of clustering with the exception that it underestimates the distance scale that marks the transition from the dominance of Coulomb repulsion over inertial drift to the dominance of inertial drift over Coulomb repulsion. The experimental observations and the theoretical model describing them will be presented.

Time of Presentation 3:31

Diameter-Controlled Growth of Boron-Nitride Nanotubes Via Chemical Vapor Deposition

Aaron DeWahl

Advisor: Yoke Khin Yap

Abstract: We explored the possibilities of controlling the diameter of Boron-Nitride Nanotubes (BNNTs) via a modified chemical vapor deposition (CVD) process. In the course of the experiment we altered the thickness of the catalyst film, grown over a so-called Aluminum “melt layer” on the growth substrate. Additionally, various other growth parameters were varied as well. Over the course of experimentation, the melt layer was shown to have no negative effects on tube growth. In addition, a correlation was seen between catalyst layer thickness and average tube diameter. Preliminary SEM images and Raman Spectrographic analysis suggest the presence of single-walled BNNTs.

Time of Presentation 3:44

Measurement of the Kirkwood-Rihaczek Distribution of a light beam

Viktor Bollen

Advisor: Dr. Kim Fook Lee

Abstract: We present direct measurement of Kirkwood-Rihaczek distribution for position and momentum coordinates of a light beam using two-local oscillator balanced heterodyne detection method. This schematic can be used to measure the Kirkwood-Rihaczek distribution for any complex wave field (including quantum mechanical wave function) without applying any tomography methods. Transformation of Kirkwood-Rihaczek distribution to Wigner, Glauber Sudarshan P- and Husimi or Q- distributions in spatial coordinates are illustrated through experimental data. The direct measurement of Kirkwood-Rihaczek distribution could provide local information of wave field, which is suitable for studying particle properties of a quantum system.

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