PHYSICS & ASTRONOMY WEEKLY CALENDAR

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WEEKLY CALENDAR

December 3 - 7, 2012

DEPARTMENTAL COLLOQUIUM

"Macroscopic Quantum Objects"

3:30 PM, December 6, 2012
109 Nicholson Hall

Yanbei Chen
California Institute of Technology

Host: Thomas Corbitt/Gabriela Gonzalez

• Refreshments served at 3:10 PM in 232 (Library) Nicholson Hall •

A wide range of experiments have recently been performed to study motions of macroscopic objects in the quantum regime. In particular, research in the gravitational-wave community, has been carried out at the upper end of the mass spectrum, for objects from ~1 gram to ~10 kg --- and at the lowest end of frequency spectrum, at ~ 100 Hz -- 10 kHz. The original aim of this research had been to define the fundamental limit for force measurements, when the Heisenberg Uncertainty Principle was applied to macroscopic test objects. It soon became clear that no such fundamental limit existed, yet a so-called Standard Quantum Limit (SQL) still characterizes the sensitivity level at which one must consider measurement-induced back action carefully --- naively constructed experiments will be limited by the SQL. Initial detectors of the Laser Interferometer Gravitational-wave Observatory (LIGO) have already achieved a noise level within a factor 10 from the SQL, for measuring an effective mass of 2.7 kg. The on-going upgrade (Advanced LIGO) will achieve within a factor of 2 from the SQL for measuring an effective mass of 10 kg. Third-generation detectors (for which R&D is underway) may beat the SQL significantly in order to achieve another large gain in sensitivity.

In the first part of my talk, I will discuss how quantum fluctuations in LIGO's massive mirrors might enforce the SQL; I will then describe quantum-optics techniques that will allow us to circumvent the SQL: by manipulating the mirrors' dynamics via light pressure that is tailored in special ways, and/or by using signal readout schemes that avoid looking at the mirrors' quantum fluctuations. In the second part of my talk, I will discuss how to modify LIGO's experimental protocol so as to maximize sensitivity to the mirrors' quantum fluctuations, thereby converting gravitational-wave-related experiments into a playground for studying, and testing, the quantum mechanical behavior of macroscopic objects.

PUBLICATIONS:

1. "Verification of TG-61 dose for synchrotron-produced monochromatic x-ray beams using fluence-normalized MCNP5 calculations", Thomas A. D. Brown, Kenneth R. Hogstrom, **Diane Alvarez**, **Kenneth L. Matthews, II**, and Kyungmin Ham, Med. Phys. **39**, 7462 (2012); http://dx.doi.org/10.1118/1.4761870 (*8 pages*).

2. "Dose-response curve of EBT, EBT2, and EBT3 radiochromic films to synchrotron-produced monochromatic x-ray beams", Thomas A. D. Brown, Kenneth R. Hogstrom, **Diane Alvarez**, **Kenneth L. Matthews, II**, Kyungmin Ham, and Joseph P. Dugas, Med. Phys. **39**, 7412 (2012); http://dx.doi.org/10.1118/1.4767770 (*6 pages*).