Contribution ID: **602** Type: **Oral (Student, In Competition) / Orale (Étudiant(e), inscrit à la compétition)**

Optomechanical Micro-Macro Entanglement.

Thursday 18 June 2015 10:30 (15 minutes)

Vigorous efforts are currently being undertaken to bring quantum effects such as superposition and entanglement to the macroscopic level. One prominent goal in this context is the creation of entanglement between a microscopic and a macroscopic system, following Schrödinger's famous thought experiment that involved a decaying nucleus and a cat. A natural setting for testing these predictions would be quantum optomechanics, where we study the interaction of light with mechanical devices at the quantum level. In our work (R. Ghobadi, S. Kumar, B. Pepper, D. Bouwmeester, A. I. Lvovsky, and C. Simon, "Optomechanical Micro-Macro Entanglement", Phys. Rev. Lett. 112, 080503 (2014)), we propose to create and detect optomechanical entanglement by storing one component of an entangled state of light in a mechanical resonator, and then retrieving it. Successful demonstration of entanglement for the retrieved light then demonstrates the existence of optomechanical entanglement in the intermediate state. We propose to first create purely optical micro-macro entanglement by amplification (displacement in the phase space) of one component of an initial microscopic entangled state as was recently demonstrated. For optomechanical micro-macro entanglement, we convert the photons in the amplified component into phonons. The phonons are then reconverted into photons. Next, we de-amplify (again by displacement in the phase space) these photons and verify entanglement using homodyne detection. We show that this method also makes it possible to create an optomechanical "cat state", which is a superposition of macroscopic states. We apply this general approach to two mode squeezed states where one mode undergoes a large displacement in phase space. Based on an analysis of the relevant experimental imperfections, the scheme appears feasible with current technology.

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Session Classification: R1-1 Optomechanics – minisymposium I (DCMMP-DAMOPC) / Optomécanique – minisymposium I (DPMCM-DPAMPC)

Track Classification: Division of Atomic, Molecular and Optical Physics, Canada / Division de la physique atomique, moléculaire et photonique, Canada (DAMOPC-DPAMPC)