Master thesis proposal

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Title: Brillouin gain spectroscopy of superfluid helium-4 using a single pulsed laser.

Keywords: Brillouin spectroscopy, superfluid helium-4

Scientific description:

Low temperature helium 4 is a model system for the study of condensed matter because quantum effects play an important role and because it can be prepared experimentally with remarkable purity. A consequence of this last property is that one can achieve metastable states of helium-4 very far from thermodynamic equilibrium. The Quantum Liquid and Solid Group of Laboratoire Kastler Brossel has developed an experimental set-up to produce metastable states of liquid and solid helium-4 using focused acoustic waves (1 MHz) and to measure the density and the compressibility of the helium in the metastable state. The compressibility measurement is a measurement of the speed of sound in the liquid and is done using a Brillouin pump/pulse laser spectroscopy technique. If the frequency of the probe laser and that of the pump laser are shifted by the "Brillouin frequency", energy from the pump laser is transferred to the probe laser.

Until now, this measurement is performed with two independent lasers: the pump laser is pulse Q-switch Nd:Yag laser of pulse duration of about 200 ns and the probe laser is a continuous wave (CW) single frequency diode laser. This laser configuration has an important inconvenient: the spectral linewidth of the beat-note between the two lasers which gives the spectral resolution of the Brillouin frequency measurement is about 5 MHz. This value does not allow for a measurement of the natural Brillouin linewidth which is about 1 MHz for superfluid helium-4. However, due to the low value of the value of the speed of sound in liquid-helium-4 (~ 240 m/s), the Brillouin shit is quit small (~ 300 MHz). This allows, from a single laser, to produce both the pump beam and the probe beam by frequency shifting a part of the laser with an acousto optic modulator. As the probe and the pump beams originated from the same laser, the beat note between note between them is considerably lowered and will fall under the natural Brillouin linewidth. It is the goal of this internship to develop such single laser Brillouin gain spectrometer for superfluid helium-4. This spectrometer then can be used to probe the metastable states of liquid and solid helium-4 during a longer term PhD project.

Techniques/methods in use: pump pulse laser spectroscopy, cryogenics,
Applicant skills: educated and motivated master student, with a taste for experimental physics
Industrial partnership: N
Internship supervisor: Jules Grucker, grucker@lkb.ens.fr
Internship location: Laboratoire Kastler Brossel, 24 rue lhomond, 75005 Paris
Possibility for a Doctoral thesis: Y