Vibronic spectra of atomic bubbles in liquid and solid ^{4}He

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Foreign atoms isolated in liquid and solid helium cryomatrices form nanometer-sized cavities known as atomic bubbles[1]. An electronic transition in the atom is followed by a change in the bubble size that induces interface vibrations that are coupled to matrix phonons.

We have investigated experimentally and theoretically the vibronic spectra of atomic bubbles formed by Cu, Au and Cs atoms in solid, normal fluid and superfluid ^{4}He matrices and have observed two regimes of bubble-phonon interactions. The excitation of the dopant's outer-shell electrons results in quasiclassical bubble dynamics, *i.e.* by the creation of a large number of lattice phonons. The spectrum of such vibronic transition is several nanometers broad and strongly blueshifted. Conversely, the excitation of inner-shell electrons creates only a small number of phonons in the quantum regime. The spectral profile in this case consists of a narrow unshifted zero-phonon line (ZPL) and a red-shifted phonon wing (PW). The shift and the width of PW are larger in solid helium than in liquid, reflecting the differences of the phonon spectra in the two phases.

Our spectroscopic observations are in agreement with predictions of a hydrodynamic model that treats helium as a continuous liquid. Taking the matrix compressibility into account results in a strong bubble-phonon coupling that leads to a very fast damping of the bubble vibrations.

[1]P. Moroshkin, A. Hofer, and A. Weis, Phys. Rep. **469**, 1 (2008).