

Rotons, superfluidity and crystallization

Sébastien Balibar

Laboratoire de Physique Statistique de l'Ecole Normale Supérieure, associé aux Universités Paris 6 et 7 et au CNRS 24 Rue Lhomond, 75231 Paris Cedex 05, France

In 1938, Fritz London proposed that superfluidity was a macroscopic quantum phenomenon, a consequence of Bose-Einstein condensation. Lev Landau never believed in London's ideas; instead, he introduced quasiparticles to explain the thermodynamics of superfluid ^4He and a possible mechanism for its critical velocity. One of these quasiparticles, a crucial one, was his famous "roton" which he liked to consider as an elementary vortex. At the LT 0 conference (Cambridge, 1946), London criticized Landau and his "imaginary rotons". Despite their rather strong opposition, Landau was awarded the London prize in 1958, four years after London's death.

Today, we know that London and Landau were both approximately right: BEC takes place in ^4He , and rotons exist: in my early experiments on quantum evaporation, I found that rotons show up as directly as photons do in the photoelectric effect. However, rotons are now considered as signs of the proximity of crystalline order in superfluid ^4He . By studying the liquid-solid interface in ^4He , also in ^3He , we showed that helium provides a model system for the general study of crystal surfaces. In our recent studies of nucleation, rotons show their importance again: by using acoustic techniques, we have extended the study of liquid ^4He up to very high pressures where the liquid state is metastable, but the vanishing of the roton gap may destroy superfluidity and trigger an instability towards the crystalline state.

Sorting category: Aa Quantum gases, fluids and solids

Keywords: superfluid helium, solid helium, crystal surfaces, nucleation, London

INVITED PAPER

LT1765