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Progress Report
Grant # N00014-94-1-0043
Josephson Acoustic Radiation in Superfluid Helium
May 1994

Brief Description:

The goal of the project is to observe an acoustical field generated near a submicron aperture, which serves as the nucleation center for superfluid quantized phase slips. The investigators seek to demonstrate that the frequency of the acoustic signal is given by $f_j = \Delta P / \rho \kappa$ where ρ is the fluid density and κ is the quantum of circulation.

Experimental Approach

The aperture is placed at one end of an acoustic resonator. Superfluid is forced through the aperture under a pressure head ΔP , a parameter which is monitored by a very sensitive pressure transducer. The resonant cavity is terminated with a very sensitive cryogenic microphone.

Apparatus will be developed to push fluid at constant ΔP while the sound amplitude in the cavity is monitored.

Accomplishments During the Past Year

1. A prototype cell has been designed and constructed. Various aspects of the cell have been tested. The apparatus have been designed in a modular form so that individual components can be optimized separately.
2. We have developed a displacement liquid Helium pump to force superfluid through a submicron apertures for times on the order of 100 seconds. The pump consists of a flexible plastic membrane which is metal coated on one side. Application of a voltage between the membrane and a nearby fixed electrode forces the membrane to move, thus pushing superfluid through the aperture.
3. We have assembled and tested the electronics for a sensitive, freely suspended, capacitive microphone. Although we may eventually develop a SQUID based microphone we plan to go as far as possible with the simpler capacitive technology.
4. The resonant acoustical cavity has been tested by employing a piezoelectric volumetric pump to serve as a phantom for the Josephson sound. The oscillating pump creates sound in a sub millimeter sized hole.

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The resonances of the cell were observed and the measured acoustic amplitudes agreed with our calculations.

5. Several Helmholtz resonance were discovered and a linear analysis of the apparatus accounted for all features. This exercise has been very useful to give us confidence that we understand all the subtleties of the acoustics.

6. A first attempt was made to measure the pressure-current characteristic of the cell. We discovered that the pressure sensor was acoustically excited by the fluid pump rendering the pressure measurement noisy and unstable. Work has begun on a stabilization scheme to decouple the fluid pump from the pressure transducer.

This measurement is necessary to permit us to determine when the aperture is producing 2π phase slips. We measure the "critical current" and, if this current varies with temperature in a certain way, we know that single phase slips occur.

7. Ambient noise effects have been studied. We have found that ambient excitation of the acoustic cavity is comparable to the expected signal. This finding has initiated consideration of factors to reduce the ambient acoustical levels, especially those generated by vacuum pumps connected to the cryostat.

8. A ^3He refrigerator has been designed which will run without attendant vacuum pumps. The drawings have been submitted to our shop for fabrication.

Publications

none

Students Associated With the Project

Scott Bachhaus, graduate student researcher

Tara Trumbull, undergraduate assistant

Distribution

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