This project is directed towards the detection of an acoustical field generated near a microaperture, by quantized phase slip events in superfluid $^4$He. The annual report details the accomplishments of the first few months of this work.
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 \( f_j = \frac{\Delta P}{\rho \kappa} \) where \( \rho \) is the fluid
density and \( \kappa \) 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 \( \Delta P \), 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 \( \Delta P \) 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.
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 $2\pi$ 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 $^3$He 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
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Distribution
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