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13. ABSTRACT *(Maximum 200 words)*

This project is directed toward detecting an acoustical field generated near a miscroaperture by quanitzed phase slip events in superfluid ^4He. The annual report details the accomplishments of the past 12 months of this work.

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Progress Report
Grant # N00014-94-1-0043
Josephson Acoustic Radiation in Superfluid Helium
May 1995

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 $\kappa=h/m_4$, 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 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. Preliminary tests indicated that small temperature changes created fountain pressure variations which would interfere with the constant pressure drive. Since fountain pressures decrease substantially with temperature, it was decided to design and construct a refrigerator to maintain the experiment below 0.3K. The adsorption pumped ^{3}He cryostat was developed this year. The refrigerator met all design specifications and is now fully operational.

2. The Josephson frequency is directly proportional to the pressure head applied across the microaperture. Therefore the experiment requires a means of driving superflow at fixed pressure head. During the past year we developed a sophisticated active feedback system to permit constant pressure drive. Because the experimental path has extraneous Helmholtz resonances the feedback system requires several stages of phase shifts to maintain optimum regulation without oscillations. The design of the feedback system involved a close coupling of numerical design and experimental verification. The present design seems to meet our needs.

Although the constant pressure drive is successful we have noticed small variations in the driving signal that are not yet understood. We plan to investigate the source of these variations in the months ahead.

3. We have developed an improved version of a cryogenic valve which is required to isolated the acoustical chamber from the outside environment. The new design employs a beryllium copper seat which is hydraulically forced against a stainless steel ball. Although this design is superior to previous valves in our laboratory, we plan to improve it even further during the next year.

4. The constant pressure flow apparatus has been tested with a micro-aperture to see if the flow is limited by intrinsic phase slip processes. Preliminary data acquired thus far indicates that the flow is intrinsic which is the signature that phase slip events are occurring at the Josephson frequency.

5. In order to anticipate the spectral width of the Josephson acoustical signal it is very useful to understand the stochastic processes which are involved with the creation of individual phase slip events. It is these events that cause the individual pressure pulses that lead to the sound field.

Toward that end we developed a microfabricated silicon flow cell that permits the study of the phase slip process. The experiment has provided the first experimental determination of the phase slip energy barrier. The experiment led to the discovery that this barrier seems to be a universal function of superfluid Helium rather than some surface-specific function. This significant discovery will open the door to find the source of the universal mechanism.

Publications

1. Vortex Nucleation in Superfluid ^{4}He, to be published in Phys. Rev. Lett., June 1995
2. The Determination of the Energy Barrier for Phase Slips in Superfluid ^{4}He, J. Steinhauer, K. Schwab, Y. Mukharsky, J.C. Davis and R. E. Packard, To be published in J. of Low Temp. Phys., **100**, August 1995.
3. The Relationship Between the Josephson Frequency and the Arrhenius Rate for Vortex Nucleation in Superfluid ^{4}He, J. Steinhauer, S. Backhaus and Richard E. Packard. Submitted to Phys. Rev. B.

Contributed Papers

American Physical Society, San Jose CA, March 1995,

1. A Rigorous Test of the Thermal Activation Model of Phase Slip Vortices in Superfluid ^{4}He, J. Steinhauer, K. Schwab, Y. Mukharsky, J. C. Davis and R. E. Packard
2. The pressure dependence of the quantum-tunneling critical velocity in HeII, Y. Mukharsky, K. Schwab, J. C. Davis, J. Steinhauer and R.E. Packard
3. Fabrication and performance of a microfabricated superfluid oscillator, K. Schwab, J. Steinhauer, Y. Mukharsky, J.C. Davis and R.E. Packard

Conference on Quantum Fluids and Solids, Cornell University, Ithaca, NY, June 12-17,1995

1. A new technique for the measurement of intrinsic critical velocities in ^{4}He, S. Backhaus and R.E. Packard
2. Recent Results with a Microfabricated Superfluid Oscillator, Keith Schwab and R. E. Packard

Invited Paper

Conference on Quantum Fluids and Solids, Cornell University, Ithaca, NY, June 12-17,1995

The Creation of Vortices in Superfluid ^{4}He, Richard Packard

Students Associated With the Project

Scott Backhaus, graduate student researcher
Keith Schwab, graduate student researcher, 25% time
Andrew Schecter, graduate student researcher supprted on AASERT supplement.
Tara Trumbull, undergraduate assistant

Distribution

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