Coupling of Rayleigh-Like Waves with Zero-Sound Modes in Normal $^3$He

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The Landau kinetic equation is solved in the collisionless regime for a sample of normal $^3$He excited by a surface perturbation of arbitrary $\omega$ and $k$. The boundary condition for the nonequilibrium particle distribution is determined for the case of specular reflection of the elementary excitations at the interface. Using the above solution, the energy flux through the boundary is obtained as a function of the surface wave velocity $\omega/k$. The absorption spectrum and its frequency derivative are calculated numerically for typical values of temperature and pressure. The spectrum displays a sharp, resonant-like maximum concentrated at the longitudinal sound velocity and a sharp maximum of the derivative concentrated at the transverse sound velocity. The energy transfer is cut off discontinuously below the Fermi velocity. An experimental measurement of the energy transfer spectrum would permit a determination of both zero-sound velocities and the Fermi velocity with spectroscopic precision.

1. INTRODUCTION

Acoustic studies of materials, and liquid $^3$He in particular, are traditionally performed using as the transducer elements piezoelectric plates, functioning as plane wave resonators. While the efficiency of such resonators is reasonably high, the transducer itself imposes no condition on the wave vector of the excitations generated in the material under study. Theorists, on the other hand, often begin their analysis by assuming that a plane wave perturbation of arbitrary $\omega$ and $k$ can be applied to a medium, with little thought as to how an experimentalist might accomplish this feat. It is, however, possible to apply a periodic perturbation of arbitrary frequency and specified wave vector to the surface of the medium. In principle, the
perturbation may be electric (using interdigital electrodes), magnetic (using a serpentine or zigzag coil),\textsuperscript{6} or mechanical (using the above in conjunction with piezoelectric or magnetostrictive materials).

For orientation purposes we consider the mechanical case (see Fig. 1). Figure 1a depicts a running surface displacement of the form

$$u(r, t) = u e^{-i\omega t + ik_x x}$$

In general such a disturbance can couple to a bulk wave having a space