



## Pressure dependence of the sound velocity of $^4\text{He}$ in aerogel

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### Abstract

Acoustic properties have been studied in  $^4\text{He}$ –aerogel system. The longitudinal ultrasound velocity and attenuation have been measured in 92.6 and 94.0% porous aerogels at elevating pressures from the saturated vapor pressure to the melting point for both normal and superfluid phase. The temperature dependence of the sound velocity was similar to that of bulk liquid. The superfluid transition temperature was determined by a dip in velocity and a sharp peak in attenuation. The sound velocity was analyzed using a hydrodynamic theory for both phases. The pressure and temperature dependencies of the sound velocity in the normal phase can be rather well explained by a simple hydrodynamic theory. However, at the lowest temperature where no normal component is expected, the sound velocity behavior differs significantly from the case of bulk case. It is shown that coupling mechanism between acoustic phonons in the liquid and aerogel matrix other than viscosity is necessary to elucidate the sound velocity below 1 K.

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**Keywords:** C. Ultrasonic measurements; D. Acoustical properties; D. Phonons

### 1. Introduction

The properties of fluids in porous media have been intensively studied both experimentally and theoretically from the points of view of fundamental physics as well as technological applications. The studies of liquid  $^4\text{He}$  properties in Aerogel, Xerogel and Vycor glass have revealed that the superfluid transition temperature is suppressed and the nature of the transition differs from that of bulk  $^4\text{He}$  [1,2].

Acoustic experiments with  $^4\text{He}$  are important in order to understand porous media. Liquid  $^4\text{He}$  offers unique advantages due to the existence of the superfluid phase, which is known to support more than one sound mode. Below phase transition, only the superfluid component can move in a rigid porous media because the normal component is clamped by its viscosity. This results another

sound mode, fourth sound and it can be used to determine the superfluid fraction.

Warner and Beamish [3] measured transverse ultrasound of alumina ceramics filled with  $^4\text{He}$ . Longitudinal and transverse ultrasound velocity have been measured in  $^4\text{He}$  filled Vycor glass [4]. They argued that the Biot model [5] can quantitatively elucidate the experimental results in both phases.

In the present work, the longitudinal ultrasound velocity and attenuation have been measured for 92.6 and 94.0% porous aerogels in a wide pressure range from the saturated vapor pressure to the melting pressure. Experimental results with various porosity aerogels at saturated vapor pressure have been published elsewhere [6,7]. Another paper in these proceedings describes the phase diagram of the  $^4\text{He}$  in 94.0% aerogel. The sound velocity was analyzed using a hydrodynamic theory in both normal and superfluid phases. The pressure and temperature dependence of the sound velocity in the normal phase can be explained by a simple hydrodynamic theory. At lowest temperatures where no normal component is expected the sound velocity behavior differs from the case of bulk liquid. So one has to think about some additional coupling mechanism to explain the experimental results at these low temperatures.

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