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ATTENUATION OF A STATIC POLARIZATION ECHO BY $^4$He FILM

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Abstract. - We have measured by the phonon echo technique the attenuation of an adsorbed $^4$He film on silica powder against pressure at 35 MHz and low temperatures. The attenuation curves present the typical shape of a multilayer adsorption isotherm of type II according to the BET classification. Because of relatively high RF power no onset of superfluidity has been observed in these films. The attenuation decreases with temperature following the normal viscosity and thermal conductivity contributions to the ultrasonic absorption by $^4$He.

1. Experiment. - $SiO_2$ powder ($\bar{d} - 70 \mu m$) is introduced in a copper capacitive cell to which we apply a sequence of three RF pulses ($f - 35$ MHz) supplied by a Matec 6600 pulse modulator and receiver. The first two pulses (15 $\mu$sec separation time and 2 $\mu$sec width) produce the dynamic polarization echo $e_2$ and the third pulse, the static polarization (or memory) echo $e_3$ when it is applied a long time after the first two $^1$. Because of stability the memory echo has been chosen for monitoring the attenuation produced by an adsorbed $^4$He film on the individual particles. The film is built up when $^4$He gas is admitted in the capacitive cell. The attenuation is measured by a Matec attenuation recorder as a function of the cell gas pressure for different temperatures.

The adsorption isotherm measurement is done with 13 g of $SiO_2$ powder in a copper cell of 11 cm$^3$ volume. By admitting precise amounts of $^4$He gas, the volume adsorbed by the powder is obtained by measuring the pressure variation in the cell. The adsorption isotherm is obtained by plotting the total volume adsorbed as a function of the cell equilibrium pressure which takes a few minutes (3 - 5) to establish for both measurements.

2. Results. - The attenuation curves obtained for different temperatures are presented in Figure 1. They are the result of an adsorbed $^4$He film on the individual particles and not an effect of gas loading losses which would give a linear variation with pressure $^2$. In Figure 1, there is first a rapid increase of attenuation for $p/p_0 < 0.1$, then a flattening up to 0.7 and a rapid increase when saturation pressure is approached.

An example of an adsorption isotherm of $^4$He on the same powder is shown in

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Figure 2. Because of small specific surface of adsorbant, residual gas effects contribute to the adsorbed volume especially at low pressures and high temperatures.

3. Discussion. - By comparing attenuation and adsorption isotherm results we conclude that we are really measuring the attenuation produced by the adsorbed $^4$He film on the individual particles. According to the classification of adsorption isotherms of BET$^3$ our results show evidence of multilayer adsorption. There is first at $p/p_0 < 0.1$ completion of the first (or two) monolayer compressed in the van der Waals field of the substrate which gives a rapid increase of attenuation and also volume adsorbed. Up to $p/p_0 \sim 0.7$ the completion of the first normal monolayer proceeds showing a flattening and for $p/p_0 > 0.7$ multilayer formation is going on with a fast increase in attenuation and volume adsorbed. At saturation pressure, liquefaction occurs: attenuation is maximum and volume adsorbed goes to $\infty$. According to the slab theory of FH$^H$ the volume adsorbed should be a linear function (slope $- 1/3$) of $\ln (p_0/p)$ on a log-log scale when multilayer formation proceeds. One may verify that it is indeed the case by looking at Figures 3 and 4 where such plots have been done for both sets of results. The data align fairly well along the line $- 1/3$ with a slower approach for adsorbed volume because of gas effects at low pressures.

In Figure 1, the attenuation decreases with temperature which is the usual variation associated with the normal viscosity and thermal conductivity contributions to the ultrasonic absorption$^5$. No onset of superfluidity is observed in these films because too much RF power is needed in phonon echo experiment. In figure 2 adsorbed volume is not only a film effect but there is a contribution from residual gas which will be discussed in a later paper.
In conclusion, we have shown that an adsorption isotherm model proceeding from a multilayer formation explains our phonon echo attenuation results. It shows that such a technique may be used to monitor the adsorption isotherm of $^4$He at low temperatures with an interesting sensitivity to detect monolayers.

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REFERENCES

1) See the article of Fossheim et al, Phys. Rev. B 17, 964 (1978).