X-ray Induced Electrostatic Charging of Helium Films	X22B

K.Penanen, P.S.Pershan, M.Regan, and I.F.Silvera (Harvard)

It is well known that free electrons can be held onto the free surface of liquid helium through either their own image charges or through the effect of an externally applied electric field. The resultant electrostatic pressurecauses films to thin. We have measured x-ray specular reflectivity from static films of isotopic mixtures of helium with an intense x-ray beam in the temperature range between 0.37 K and 1.3 K. Normally, no significant thickness variation with x-ray intensity is expected over a wide range of temperatures when the film is superfluid. We have found that even modest x-ray intensities affect the thickness of films containing only trace amounts of ^{3}He. Figure 1 shows the measured ratio $R/R_{Fresnel}$ for a mixture with trace amounts of ^{3}He at 0.47K for three different intensities. The thickness for small intensities is of order 200 Å, in agreement with the theory and pure ^{4}He data for higher temperatures taken by Lurio *et al.* At higher intensities the film thins, with poorly defined thickness due to variation of the intensity with the incident angle. At higher concentrations of ^{3}He the period of the interference fringes becomes irregular and the determination of the film thickness becomes problematic. Figure 2 demonstrates this point. We believe that the effect is due to x-ray produced photoelectrons, which thermalize in the vapor and then reside on the surface, attracted by both the film and a charged substrate. The temperature and concentration dependence is then due to the transport properties of the electrons at the surface. It may be possible to study the 2-D electron gas produced in this way by diffraction techniques.

This research was supported by Grants No. NSF-DMR-89-20490 and No. NSF-DMR-88-12855. NSLS, Brookhaven National Laboratory, is supported by DOE Contract No. DE-AC02-76CH00016

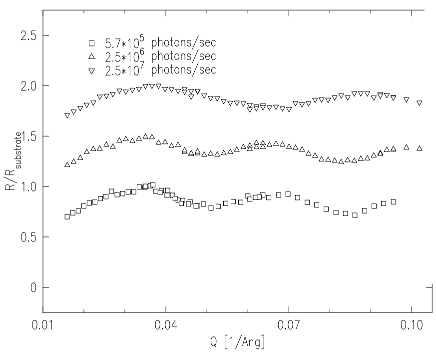

Figure 1. X-ray dosage effect on a film containing trace amounts of ^{3}He

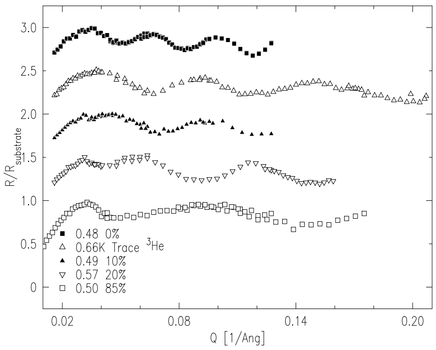

Figure 2. Structure factor as a function of the wave vector transfer $Q = \frac{4\pi}{\lambda}\sin\theta$ for a range of temperatures and bulk ^{3}He concentrations. The curves were separated by 0.5 for clarity.