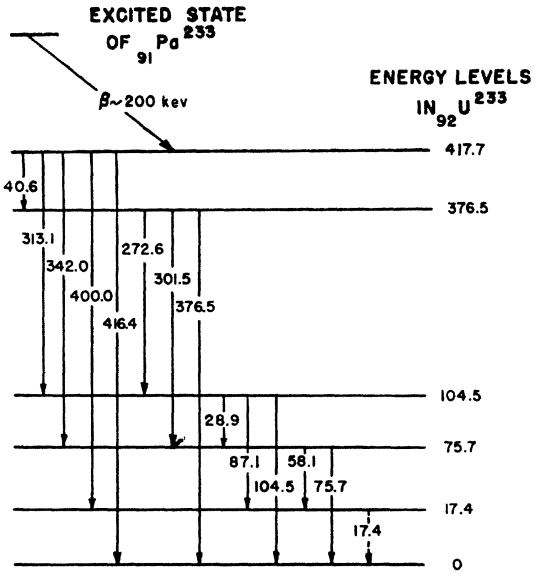

FIG. 2. Proposed level scheme (kev) for U^{233} following beta-emission from Pa^{233}.

self-consistent. Unfortunately, this gamma-ray lies below the lower detection limits of the apparatus.

The facilities of the Argonne National Laboratory were kindly put at our disposal for this work.

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† Phoenix Project Fellow, University of Michigan.

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Superfluidity and Thermomechanical Effect in the Absorbed Helium II Film

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July 7, 1950

DURING measurements on the adsorption of He gas below 2.19°K, in which the formation of the Rollin film from the unsaturated vapor was indicated,[1] the observed speed of approach to equilibrium suggested that superfluidity occurs even in the adsorbed film, without the presence of bulk liquid. This was investigated by measuring the rate of flow through superleaks, in the manner previously described for liquid HeII,[2] except that the superleaks were usually connected to a copper-stainless steel chamber containing 75 g of adsorbent (Fe_2O_3), the assembly being one of considerable heat capacity. Several different leak geometries were used, either 0.013- or 0.008-cm diameter×2.5-cm long Pt wires sealed into Pyrex glass, or a leak made by pressing together two optically flat stainless steel circular plates of 1 cm diameter, the bottom plate having a central exit hole of 0.08 cm diameter. The widths of the leaks were determined by gas flow measurements at the helium boiling point; they varied from 1 to 9×10^{-5} cm. The onset of superfluidity could be established by measuring the quantity of He passing through the leaks in a given time as a function of the temperature T and the saturation P/P_0, P being the pressure in the adsorption system, and P_0 the vapor pressure of the liquid.

Superfluidity does indeed occur in the adsorbed films, and in a rather striking manner. The temperature at which superflow is observed is not only a function of P/P_0 (i.e., the number of adsorbed layers), but is also determined by the pressure difference (Δp) across the superleak. With a small pressure difference across the leak ($\Delta p \ll P$), it is found that superflow occurs at all saturations above $P/P_0 \sim 0.15$, corresponding to $1\frac{1}{2}$ statistical layers, at all temperatures[3] below 2.186°K.

These results suggest that superfluidity occurs (within our accuracy of ±0.002°) at the λ-temperature of the bulk liquid, independent of the number of layers adsorbed, i.e., that the temperature at which the properties of HeII appear is independent of the number of layers.[4] This could be confirmed by a simple experiment. The adsorption system was loaded with a certain P/P_0 at HeII temperatures, and was slowly warmed; the saturation stayed substantially constant up to the normal λ-point, then changed practically discontinuously when passing the λ-point. The effect has been observed down to $P/P_0=0.35$, and is especially conspicuous at $P/P_0>0.95$ (more than 30 layers adsorbed). The pressure difference between the adsorption system and the bath (~3 cm on a differential oil manometer) disappears abruptly when warming through the λ-point, and reappears again on cooling back to the HeII region. These results suggest the possibility that the transition HeII—HeI becomes first order in the adsorbed layers.

The superflow is extremely sensitive to the slight fluctuations of the bath temperature. A normal rate of flow from the adsorption system to the collection system could be either greatly *increased* or even *reversed* by raising or lowering the bath temperature by a few ten-thousandths of a degree.

A typical experiment is shown in Fig. 1, for a system at 2.173°K and $P/P_0=0.26$ (~2 adsorbed layers), in which the bath vapor pressure variation (dotted curve) and the change of pressure in the collection system (solid curve) are plotted against time. The

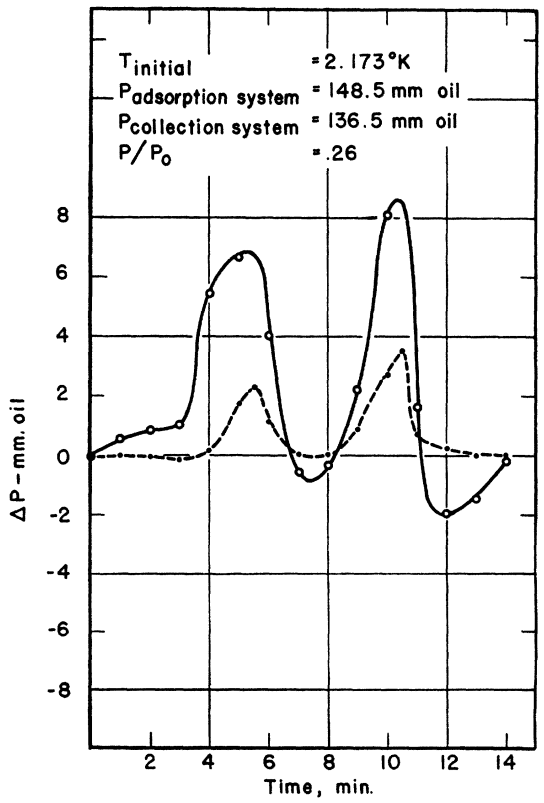

FIG. Variations of the bath vapor pressure and the pressure change in the collection system.

bath temperature was deliberately varied periodically, the resulting pressures (and temperatures) being read on differential oil manometers. A trend of the solid curve toward increasing pressures means superflow *out of*, and toward decreasing pressures superflow *into*, the adsorption system.

The observed flow behavior is presumably due to the inability of the adsorption system to stay in phase with the fluctuations of the bath temperature, so that a temperature gradient is set up across the leak. It is indeed almost impossible to thermostat the bath sufficiently well to prevent the effect. The phenomenon is completely analogous to the fountain effect in bulk liquid HeII, and these preliminary measurements show that the thermomechanical effect here observed is of the same order of magnitude as in the bulk liquid.

Measurements are being continued to establish, if possible, the order of the transition HeII—HeI in adsorbed films, and in particular to measure accurately the thermomechanical effect in adsorbed layers in order to determine $\Delta P/\Delta T$ for comparison with the theory of the fountain effect in liquid HeII.

[1] E. Long and L. Meyer, Phys. Rev. **76**, 440 (1949).
[2] Giauque, Stout, and Barieau, J. Am. Chem. Soc. **61**, 654 (1939); Osborne, Weinstock, and Abraham, Phys. Rev. **75**, 988 (1949).
[3] However, with vacuum initially at the exit of the leak, superflow is detected only at temperatures lower than the normal λ-point, the "onset" temperature being a function of P/P_0, and ranging from 1.40°K at $P/P_0=0.50$ to 2.03°K for $P/P_0=0.95$. This result is probably related to the fact that under these conditions the pressure near the exit of the leak is far lower than the equilibrium pressure for 1½ layers. However, all the leaks gave, with a given saturation, exactly the same sharp "onset" temperature, with or without the presence of adsorbent at the inlet of the leak.
[4] This is not inconsistent with the specific heat data of H. P. R. Frederikse, Physica **XV**, 860 (1949). Frederikse evidently measured the specific heat at substantially constant amount adsorbed, due to the use of a closed vessel of small dead-space volume, whereas the present experiments are performed at constant pressure.

Gamma-Spectrum of Ta^{182}

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July 3, 1950

THE gamma-spectrum of Ta^{182} has been examined in a thin lens beta-spectrometer. A preliminary survey in 1949 using the Oak Ridge National Laboratory spectrometer indicated that there were numerous gamma-rays in the interval from 0.325 to 1.13 Mev where none had previously been reported.[1] The spectrum has now been examined again on the NEPA spectrometer and 27 electron lines have been found.

The tantalum was prepared by irradiation in the Oak Ridge pile and then allowed to decay for six months. A piece of uranium approximately 100 mg/cm² thick was used as a radiator. The counter had a conventional mica end window.

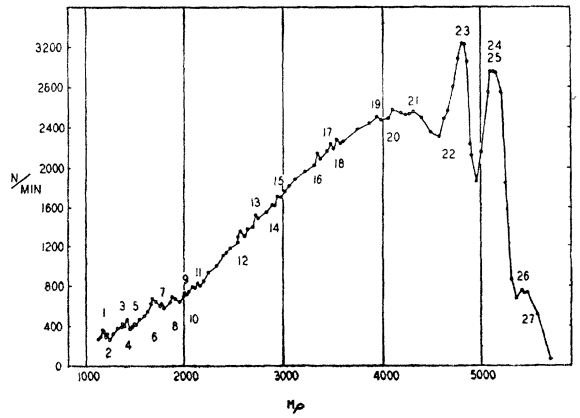

FIG. 1. Gamma-ray spectrum of Ta^{182}.

TABLE I. Electron lines from Ta^{182}.

Line No.	Energy (kev)	Identification
1	109	K_1
2	117	K_2
3	145	K_3
4	153	K_4
5	165	K_5
6	205	K_6 and L_1
7	227	K_7
8	247	K_8
9	277	K_9
10	297	K_{10} and L_6
11	306	K_{11}
12	411	K_{12}
13	450	K_{13}
14	492	K_{14}
15	509	K_{15}
16	613	K_{16}
17	648	K_{17}
18	665	K_{18}
19	777	K_{19}
20	820	K_{20}
21	878	K_{21}
22	971	L_{21}
23	1018	K_{22}
24	1100	K_{23}
25	1116	K_{24} and L_{22}
26	1189	L_{23}
27	1204	L_{24}

Figure 1 shows the electron spectrum obtained. Table I lists the electron lines, their energies, and identification. Table II lists the gamma-rays and their energy. It is quite possible that some of the low energy lines may be L shell lines from gamma-rays whose K shell lines were too low in energy to be observed.

TABLE II. Observed gamma-rays.

Gamma-ray No.	Energy from K	L (Mev)
1	0.224	0.227
2	0.232	
3	0.260	
4	0.268	
5	0.280	
6	0.320	0.319
7	0.342	
8	0.362	
9	0.392	
10	0.412	
11	0.421	
12	0.526	
13	0.565	
14	0.607	
15	0.624	
16	0.728	
17	0.763	
18	0.780	
19	0.892	
20	0.935	
21	0.993	0.993
22	1.133	1.138
23	1.215	1.211
24	1.231	1.226

[1] Beach, Peacock, and Wilkinson, Phys. Rev. **76**, 1585 (1949).

Radioactivity of Ni^{59} and Ni^{63}

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July 6, 1950

A PREVIOUS communication[1] described an investigation by the proportional counter technique of the long-lived activity of nickel after pile irradiation. This was first undertaken to examine the positron activity ascribed to Ni^{59} by Segrè,[2] Rosenfeld[3] and others. Our experiments failed to reveal this activity but a soft negative β^--activity of upper energy limit 63±2 kev was shown to belong to Ni^{63}. The form of the spectrum was compared with Fermi theory.