Melting curve of $^3\text{He}$ with 0.2% $^4\text{He}$ impurity.

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We investigated the melting curve of $^3\text{He}$ containing of 0.2% $^4\text{He}$ (such $^3\text{He}$ are produced at our works) from 0.05 to 0.7 K. Cell design is shown in Figure 1, in which a parallel-plate capacitor senses the displacement of the diaphragm. The interior volume of $^3\text{He}$ chamber is 154 mm$^3$ and contains about 50% of volume of sintered copper powder. The BeCu diaphragm have the diameter 15 mm and thickness 0.6 mm, minimal spacing between capacitor plates is about 6 μm. The sensitivity of such gauge was about 1 Pa, but calibration at 1 K was not so good, because our external pressure standard had uncertainties approximately 1 kPa.

Figure 1. $^3\text{He}$ melting-pressure cell.
In copper body of the cell was placed carbon resistance thermometer (in Figure 1 is not shown), which was calibrated from 2 K to 0.05 K in other refrigerator relative to magnetic powder CMN thermometer, which (in one’s turn) was calibrated at point 0.05 K relative to $^{60}$Co gamma-anisotropy thermometer. The uncertainties of these magnetic scale is not more then 1 mK.

Making corrections for hydrostatic head in the fill capillary, we are described P$_m$-T data for our $^3$He sample with polynomial such as in PLTS-2000 [1]. The equation adopted for our melting pressure P$_m$ is:

$$P_m/\text{MPa} = \sum_{i=3}^{9} A_i (T/\text{K})^i$$

with the following coefficients:

- $A_{-3} = 2.7452234 \cdot 10^{-4}$
- $A_3 = 4.9025185 \cdot 10^3$
- $A_{-2} = -2.2158311 \cdot 10^{-2}$
- $A_4 = -1.5897102 \cdot 10^4$
- $A_{-1} = 0.7393473 \cdot 10^0$
- $A_5 = 3.5040167 \cdot 10^4$
- $A_0 = -9.8654414 \cdot 10^0$
- $A_6 = -5.1639017 \cdot 10^4$
- $A_1 = 1.4166019 \cdot 10^2$
- $A_7 = 4.8645161 \cdot 10^4$
- $A_2 = -1.0229806 \cdot 10^3$
- $A_8 = -2.6460530 \cdot 10^4$
- $A_9 = 6.3173899 \cdot 10^3$

Standard error was not more then $1.1 \cdot 10^{-3}$ MPa and for pressure minimum received next values:

$$T_{\text{min}} = 0.31658 \text{ K} , \ P_{\text{min}} = 2.92312 \text{ MPa}$$

that points out that the pressure and temperature of the minimum shift by -8.0 kPa and +1.34 mK. There is also a change in the slope of the melting curve above and below the minimum. In Figure 2 shown as the melting curve of $^3$He with 0.2% $^4$He differ from melting curve of pure $^3$He described by equation of PLTS-2000.

Such behavior of the melting curve for dirty sample may be explain (perhaps)
by existing Andreev-Pushkarov’s clusters of the $^4\text{He}$ in solid $^3\text{He}$ [2].

Figure 2. $^3\text{He}$ melting curve with 0.2% $^4\text{He}$ impurity.

References: