CCT working document

International comparison of the ITS-90 above the silver point and comparison of metal-carbon eutectic fixed points

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The following document gives a summary of the results of:

a) a comparison of ITS-90 between 1492 °C and 2474 °C using metal-carbon eutectic blackbody cavities of Re, Ir, Pt and Pd
b) a comparison of the metal-carbon eutectic blackbodies of Ir, Pt and Pd of NPL and NMIJ

A full report can be found in [1].

1. INTRODUCTION

Four metal-carbon eutectic blackbody sources, those of Pd-C, Pt-C, Ir-C and Re-C, were constructed by NPL and transported to NMIJ. Two separate comparisons were performed. Firstly a comparison of the ITS-90 using all four fixed points and secondly the NPL fixed points of Pd-C, Pt-C and Ir-C were compared with those constructed by NMIJ.

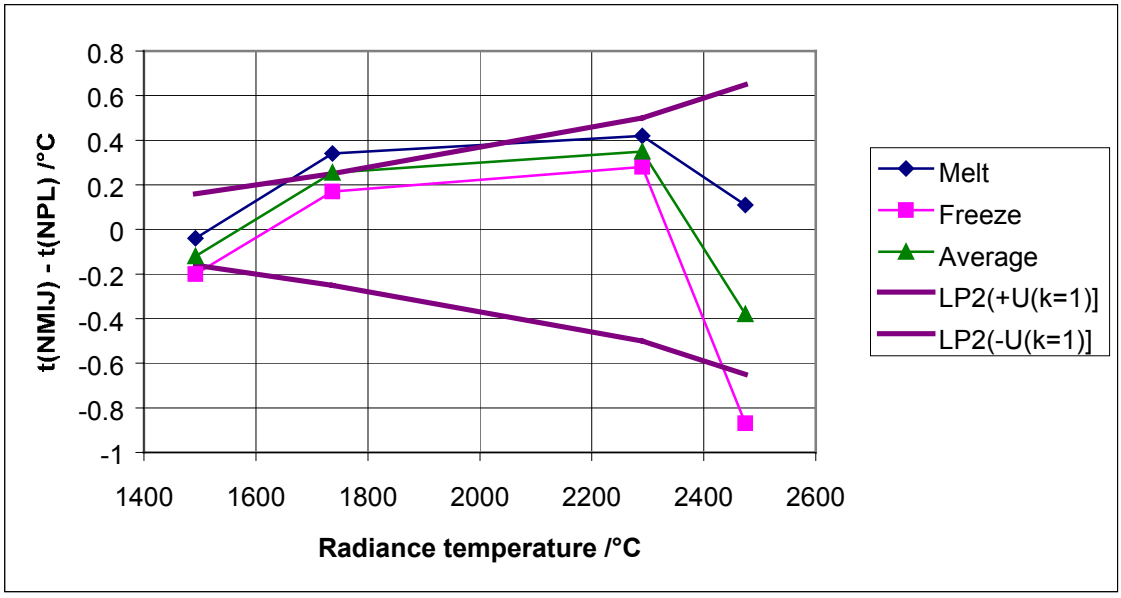
2. RESULTS

The actual melting takes place over a range of values. However a unique value for the melt temperature can be obtained by finding the minimum in the first derivative for the curve. This value is repeatable at the ~20 to 30 mK level, even for the highest temperatures (Re). The freeze value is straightforward being the peak out of the under-cool with the rather arbitrary cut off of all values <40 mK of the peak being excluded.

2.1 THE SCALE EQUIVALENCE BETWEEN NPL AND NMIJ

The scale equivalence between the two institutes was determined by comparing the ITS-90 radiance temperature values obtained by NPL for the melts and freezes with those of NMIJ. The results are shown in Figure 1.

Figure 1: The comparison of the scale of NMIJ with that of NPL



As can be seen the difference in the ITS-90 between the two institutes is very small. The uncertainty curve labelled LP2(U(k=1)) is the one standard uncertainty for the scale realisation of the ITS-90 by NPL using a linear pyrometer (LP2). NMIJ has similar uncertainties so the scale difference is well within the combined uncertainties of the measurements even at the k=1 level.

These measurements indicate that these blackbodies are viable devices for the comparison of radiance temperature scales.

On the basis of these comparison measurements the formal ITS-90 equivalence can be expressed by the quantity Quantified Demonstrated Equivalence ($QDE_{0.95}$). This is given in Table 1 below.

Table 1: The $QDE_{0.95}$ for the comparison of ITS-90 between NPL and NMIJ

Metal-carbon eutectic	Nominal temperature /°C	$QDE_{0.95}$ /°C
Pd-C	1492	1.08
Pt-C	1737	1.59
Ir-C	2290	3.12
Re-C	2474	3.78

The $QDE_{0.95}$ values for this comparison are completely dominated by the uncertainty in the ITS-90 scale realisation of the respective laboratories. This indicates that these uncertainties may be conservative and could, on the basis of these measurements, be reduced.

2.2 THE COMPARISON OF THE METAL-CARBON EUTECTICS

The fixed points of Pd-C, Pt-C and Ir-C were compared and the results shown in Table 2. The NMIJ Re-C point was not available during the time of the comparison.

Table 2: The comparison of the melt and freeze temperatures of NPL and NMIJ metal-carbon eutectic blackbody cavities.

Metal-carbon eutectic	Transition temperature /°C	t(NMIJ)–t(NPL) /°C (melt)	T(NMIJ)-t(NPL) /°C (freeze)	Comparison Uncertainty /°C (k=2)
Pd-C	1492	+0.02	+0.53	0.20
Pt-C	1737	+0.74	+0.54	0.32
Ir-C	2290	-0.93	-0.51	0.47

The differences between the cells were found to be, at worst 930 mK. This is thought to be due to the effect of different impurities in the metal used to construct the respective fixed-points. The uncertainty components in the comparison are the correction for size of source effect for differing target sizes (3 mm at NPL, 4 mm at NMIJ), the changing transmission of the furnace window, uncertainty in the emissivity correction and the measured fixed-point repeatability.

3. SUMMARY

These fixed points are repeatable to 20 to 30 mK even at the highest temperatures (2474 °C) fulfilling the recommendation of the joint CCT/CCPR working group which encouraged national laboratories to seek to develop a high temperature fixed point above 2500 K with a repeatability of 100 mK.

The ITS-90 of NMIJ and NPL has been compared using metal-carbon eutectic blackbody cavities as transfer standards. The differences obtained were very small (<0.5 °C between 1492 °C and 2474 °C) indicating that the sources can be successfully used for scale comparison. In addition the differences were much smaller than the individual laboratories uncertainties showing that both laboratories are conservative rather than realistic in their uncertainty assessment.

The results given in Section 2.2 show that the cells of NPL and NMIJ are not in exact agreement with one another. Research into the causes of this discrepancy is in progress at both NPL and NMIJ. This work will be taken forward under the auspices of the Growth Programme project HIMERT.

4. ACKNOWEDGEMENTS

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5. REFERENCE

[1] Machin, G., Yamada, Y., Lowe, D., Sasijima, N., Sakuma, F., Fan Kai, To be published: *Proceedings of Tempmeko '01 conference held in Berlin June 01*

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