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Bilateral Comparison of 10 kΩ Standards between the NML (Forbairt) and the BIPM, April 1998

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A comparison of the reference standards of electrical resistance of the BIPM and the National Metrology Laboratory (NML, Forbairt), Dublin, Ireland was carried out from 2 February to 8 June 1998. Two BIPM 10 kΩ travelling standards, Tegam model SR104, s/n K201 11 96 30 104 designated "BI111", and K 205 33 97 30 104, designated "BI205", were shipped by air freight. The BIPM measurements were carried out by comparison with 100 Ω reference resistors whose values are known with respect to the BIPM Quantized Hall Resistance (QHR) standard. The current in the 10 kΩ standards during the measurements is 100 μA The combined standard uncertainty of the link from the travelling standards to the QHR is less than 0.015 cΩ, corresponding to 1.5 parts in 10^8 of the nominal value. The NML used a Measurements International Limited 6000A resistance bridge to compare the 10 kΩ travelling standards with its 1 kΩ reference resistors. For these measurements the current in the 10 kΩ resistors was 0.91 mA. The values of the 1 kΩ resistors are known in terms of the NML 1 Ω reference group which is maintained with respect to $R_{K\text{-}90}$ by means of periodic calibrations and comparisons with the BIPM. Results of all measurements were corrected for the temperature dependence of the resistance. The reference temperature is 23°C. The NML measurements, carried out near 22 °C, are referred to 23°C.

Figure 1 shows the results of the measurements of standard BI205 in both laboratories. The measurements were analyzed using a linear least-squares fit to the resistance as a function of time. The straight dashed lines on the graph show the predicted values. The results are referenced to the mean date of the NML measurements, 22 April 1998. In this way, the values and uncertainties of the NML measurements are essentially the same whether we use a least-squares fit or a simple average.

The BIPM value and uncertainty for the reference date are also calculated from a linear least-squares fit. Figure 2 shows the results for travelling standard BI111.

Table 1 lists the results of the 10 kΩ comparison and the component uncertainty contributions. In combining the uncertainties we apply the usual method of combining variances to calculate the uncertainty of the mean value of the result. Thus, the final result is calculated from the mean of the results from each travelling standard. Its type A variance is the sum of the type A variances of the travelling standards divided by the square of the number of travelling standards. The total variance is the sum of 1) the type A variance, 2) the type B variances and 3) the variance of the transfer uncertainty.

The final results of the comparison are presented as the difference between the value assigned to a 10 kΩ standard by the NML, R_{NML}, and that assigned by the BIPM, R_{BIPM}, on the reference date. The result is

at 10 kΩ: $R_{NML} - R_{BIPM} = 0.23$ cΩ; $u_c = 0.75$ cΩ on 1998/04/22,

where u_c is the combined type A and type B standard uncertainty from both laboratories. The relative difference $(R_{NML} - R_{BIPM})/10\ \text{k}\Omega = 2.3 \times 10^{-7}$.

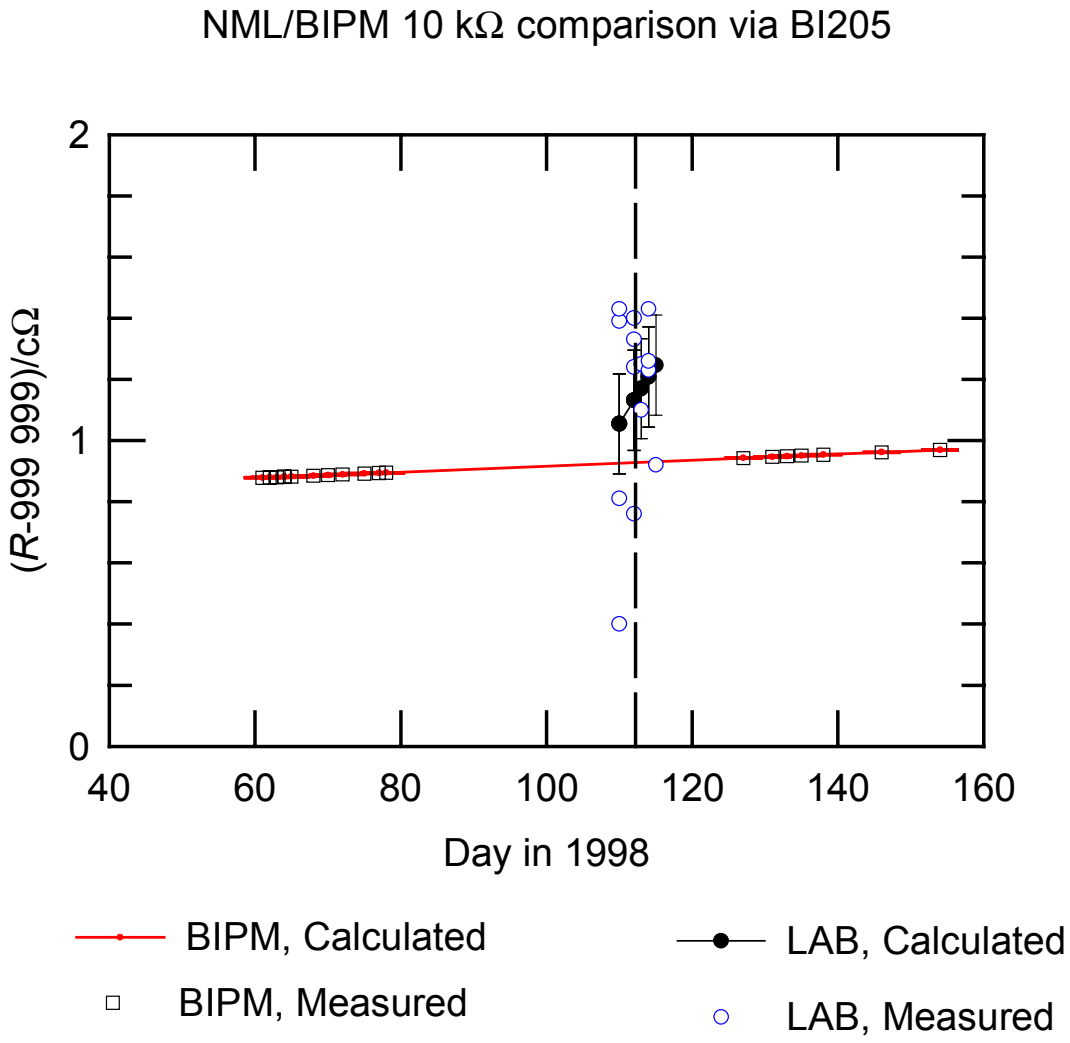

Figure 1. Results of the measurements of BI205 including the BIPM measurements carried out before and after shipping the travelling standard. These results were used in the calculation of the final comparison result. The lines represent the linear least-squares fit to the results of each laboratory. The uncertainty bars represent the type A standard uncertainty. The vertical line near the center represents the mean date of the comparison

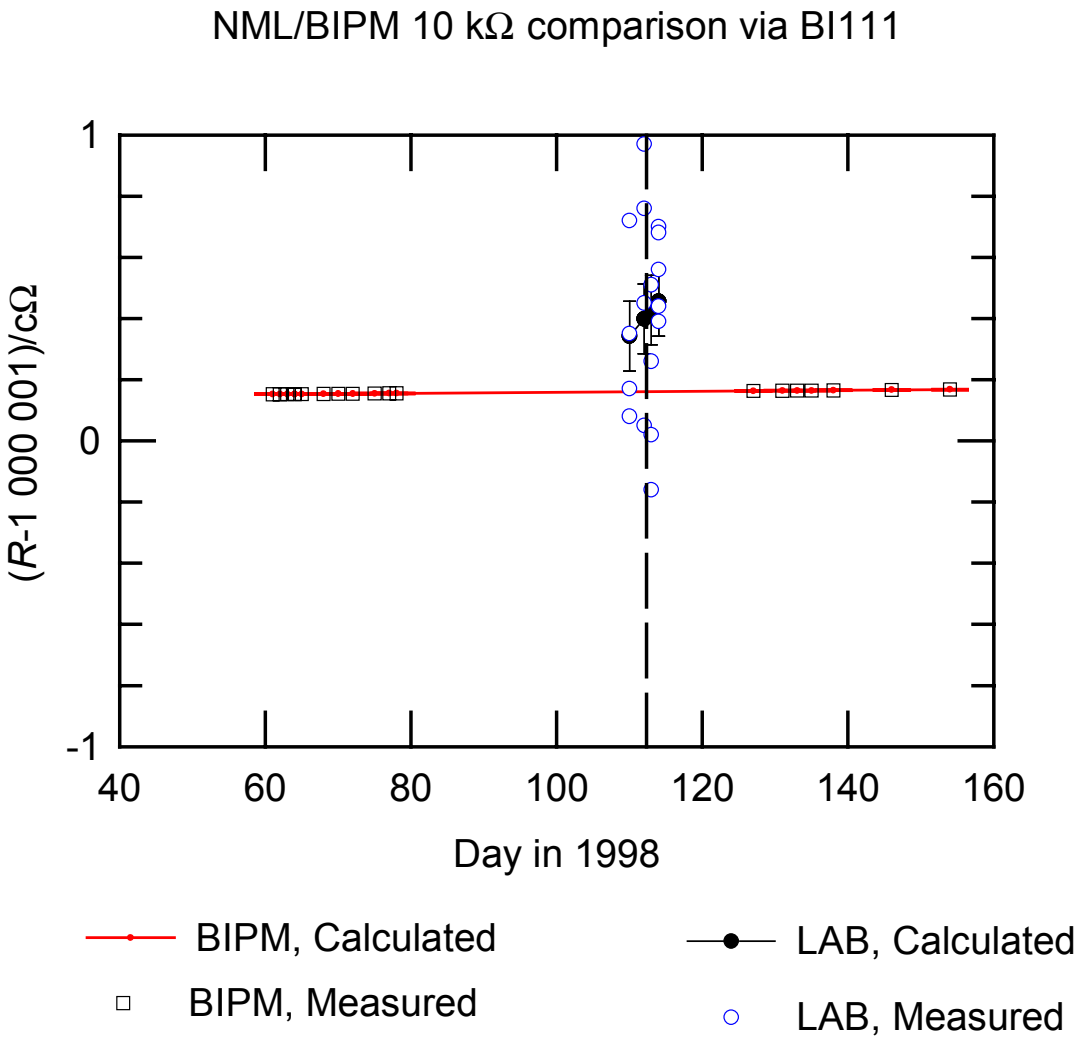

Figure 2. Results of the measurements of BI111 including the BIPM measurements carried out before and after shipping the travelling standard. These results were used in the calculation of the final comparison result. The lines represent the linear least-squares fit to the results of each laboratory. The uncertainty bars represent the type A standard uncertainty. The vertical line near the center represents the mean date of the comparison

Table 1. Results of the NML/BIPM bilateral comparison of 10 kΩ standards using BIPM SR-104 travelling standards. Mean Date: 22 April 1998.

10 kΩ comparison: units are cΩ (parts in 10^6)

		BI205 at 10 kΩ	BI111 at 10 kΩ
1	NML value, drift model	1000000.14	1000001.41
2	NML unc (A), drift model	0.08	0.08
3	NML unc (B)	0.75	0.75
4	BIPM value, drift model	999999.93	1000001.16
5	BIPM unc (A), drift model	0.01	0.01
6	BIPM unc (B)	0.01	0.01
7	$R_{NML} - R_{BIPM}$	0.21	0.25
8	unc (A) of $R_{NML} - R_{BIPM}$	0.06	
9	mean $R_{NML} - R_{BIPM}$	0.23	
10	unc of transfer	0.02	
11	Total unc of comparison	0.75	
12	mean date yy/mm/dd	98/04/22	

References to Table 1.

1. Results from a linear least-squares fit to the NML data.
2. The type A standard uncertainty following from the least-squares fit to the NML data.
3. The type B uncertainty estimated by the NML.

4-6. Same as 1-3. But for the BIPM results.

7. The comparison result following from each travelling standard.
8. The combined type A uncertainty in 7; the root-sum-square of the contributions from both laboratories.
9. The mean of the results on line 7.
10. The standard deviation of the mean of the results from the two travelling standards.
11. The root-sum-square combination of items in lines 3,6,8 and 10.
12. The mean date of the comparison, the mean date of the NML measurements.