

The progress on realization and dissemination of redefined kelvin at NIM

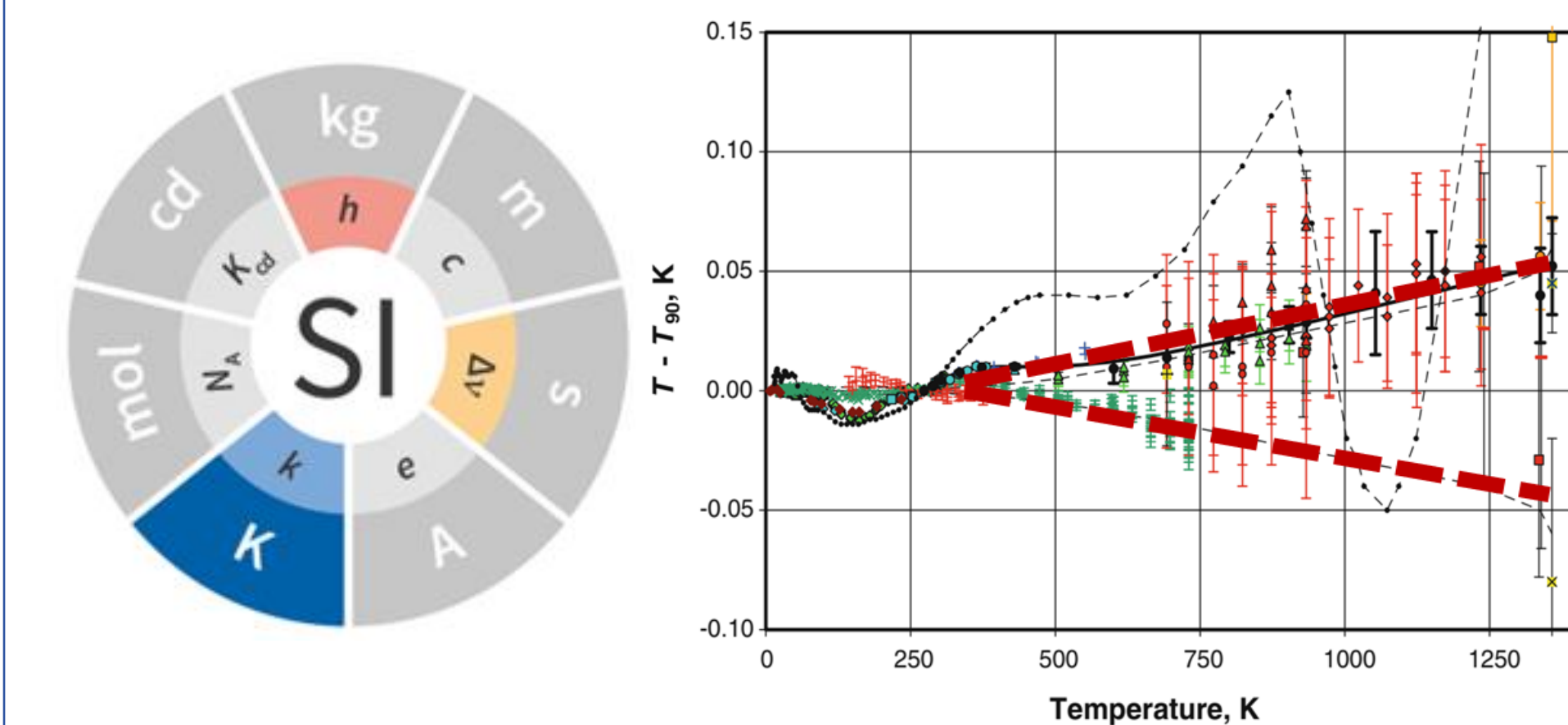


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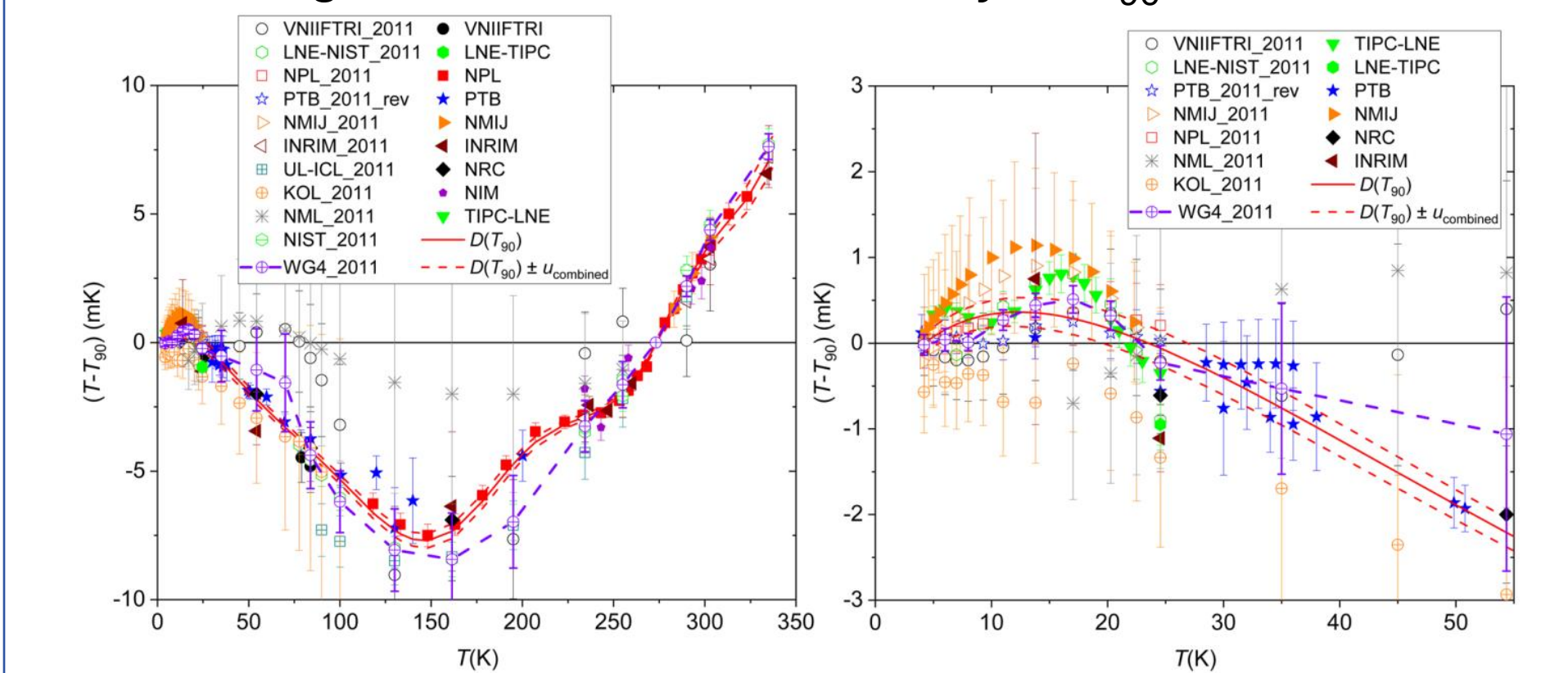


Introduction

The redefinition of kelvin based on the Boltzmann constant



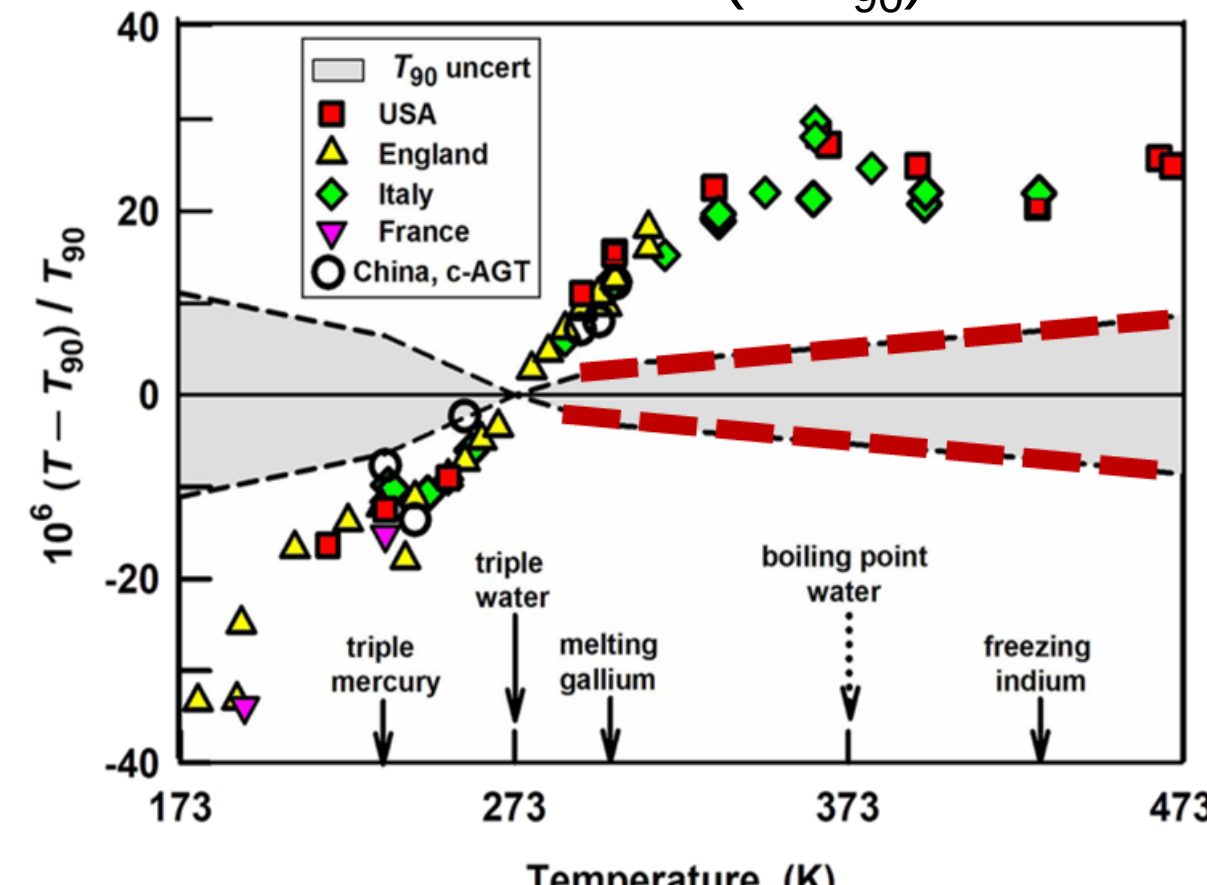
The difference between T and T_{90} ($T-T_{90}$) increases and becomes greater than the uncertainty of T_{90}



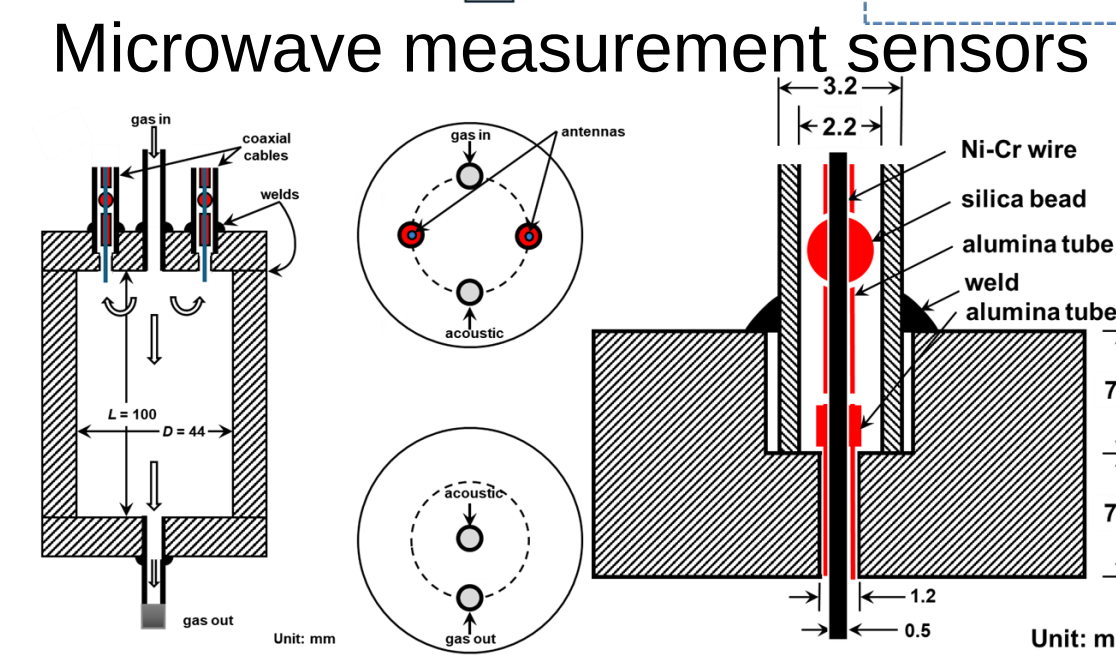
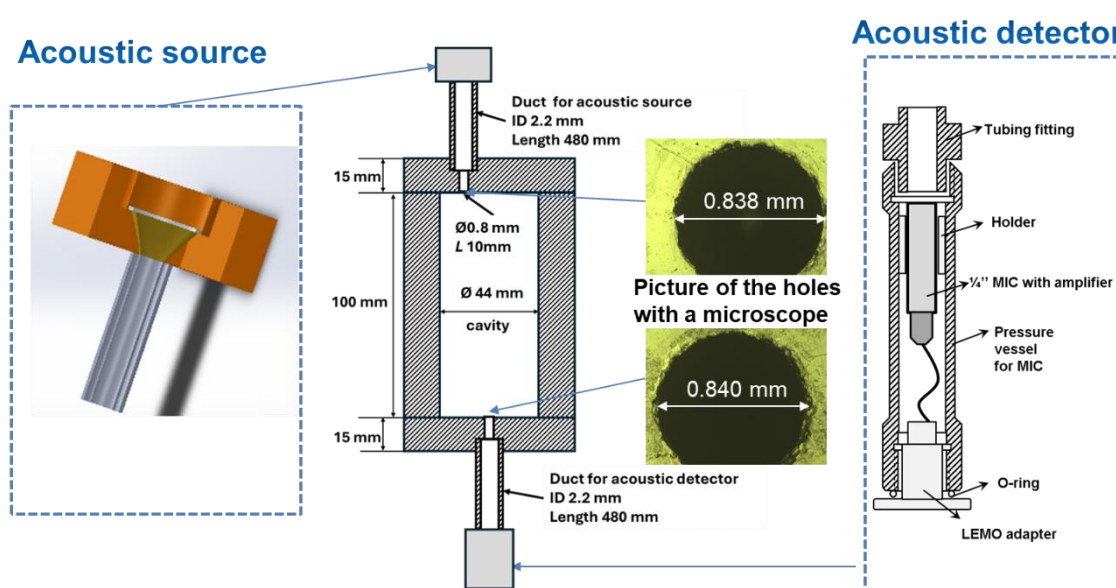
Different thermometry has been investigated to understand the ($T-T_{90}$) to provide necessary data to the thermometry community for the improvement of the temperature scale.

Cylindrical Acoustic Gas Thermometry

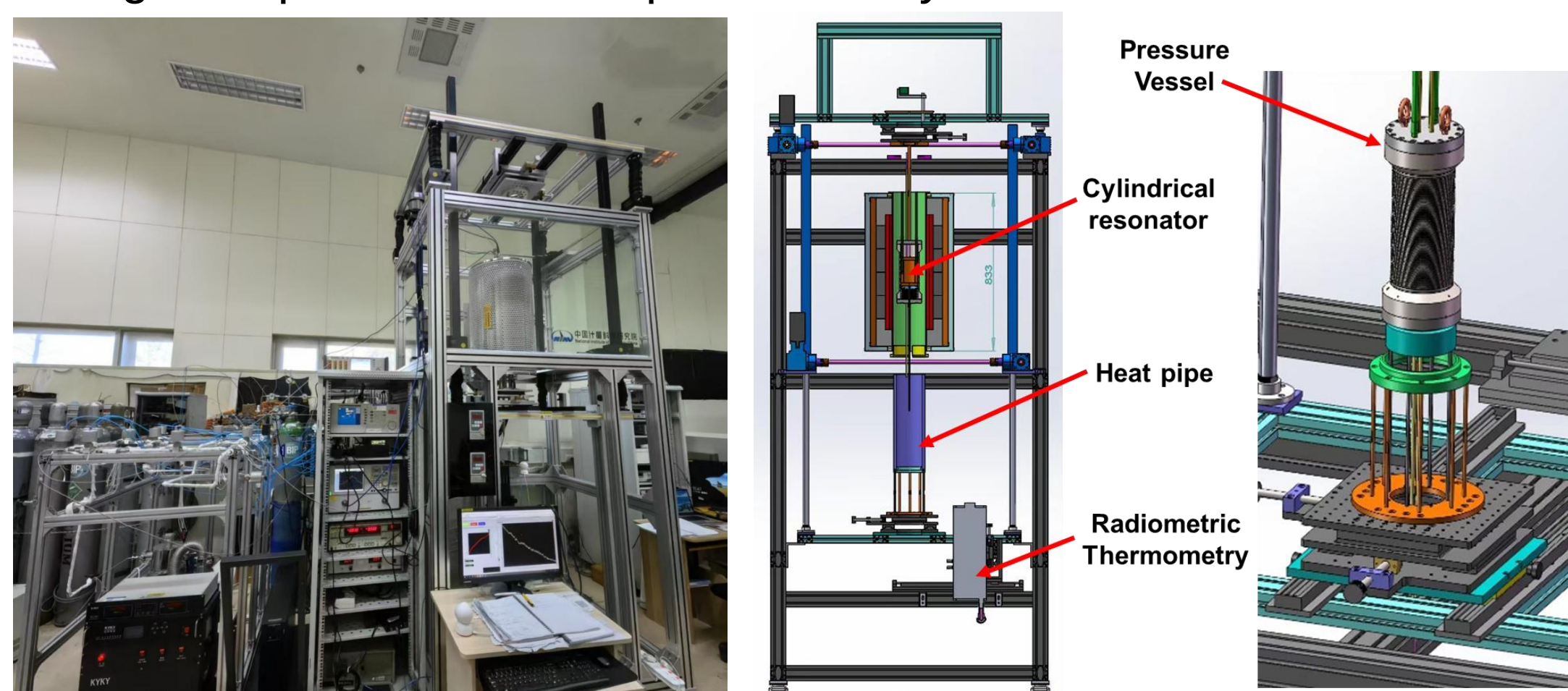
Acoustic gas thermometry (AGT) data show the consistent ($T-T_{90}$) results



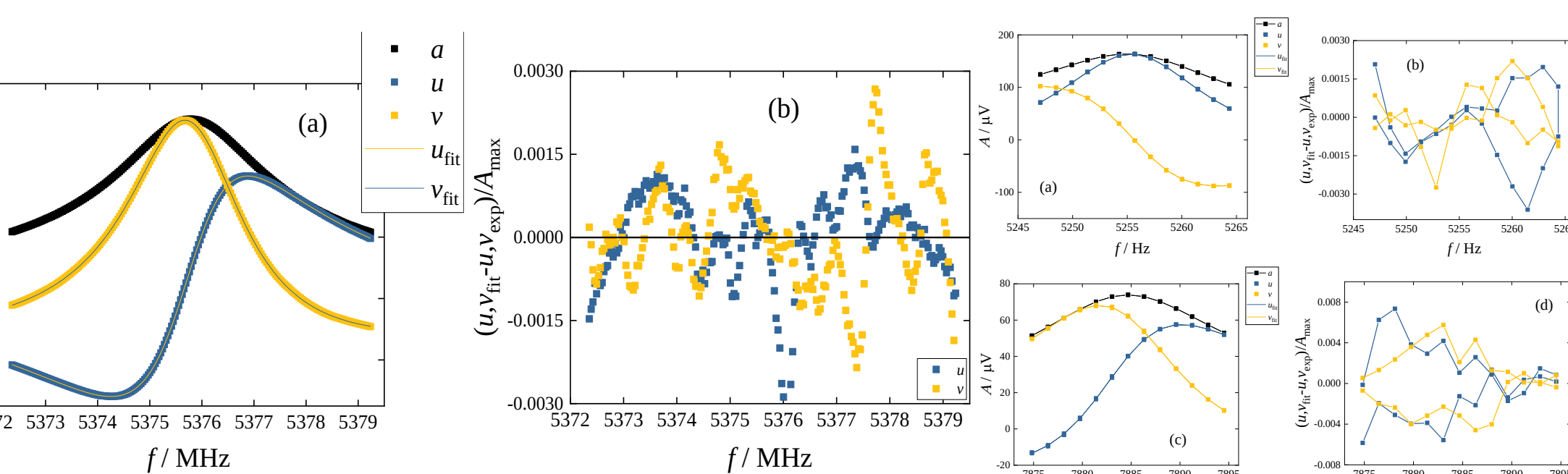
Acoustic measurement sensors



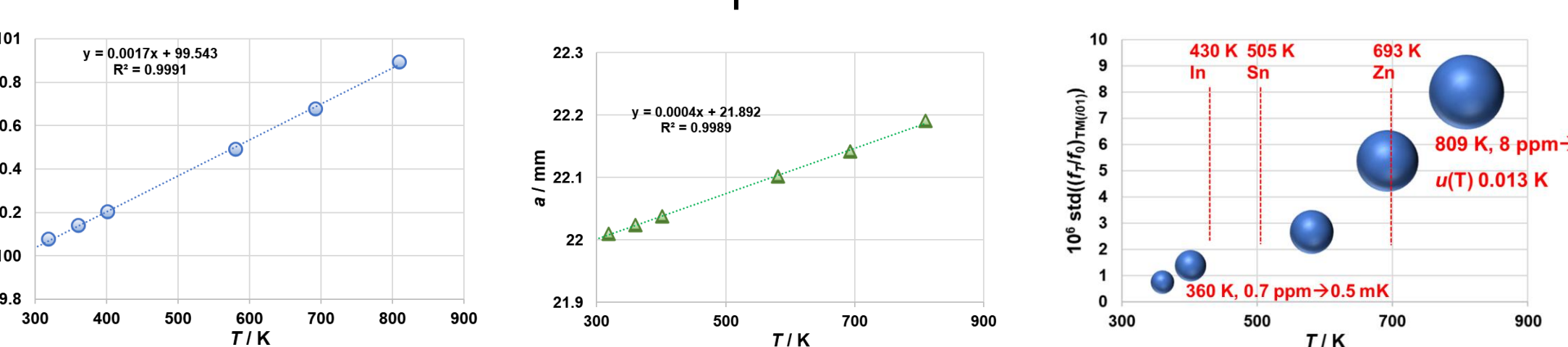
High-temperature AGT experimental system constructed at NIM



Acoustic and microwave results

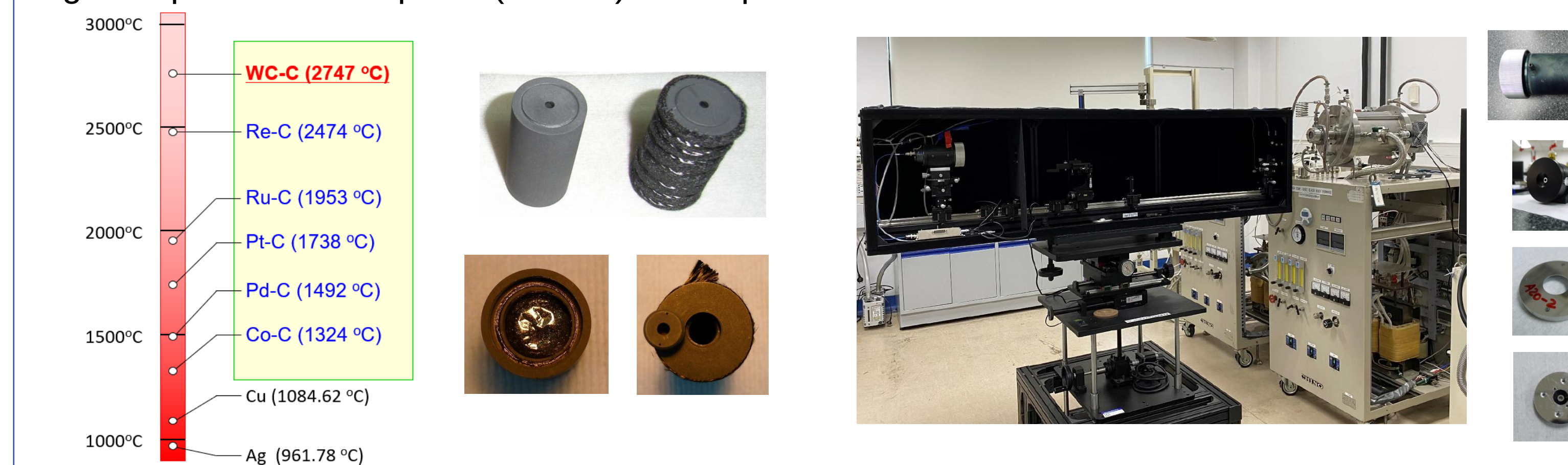


Dimension and thermal expansion of the resonator

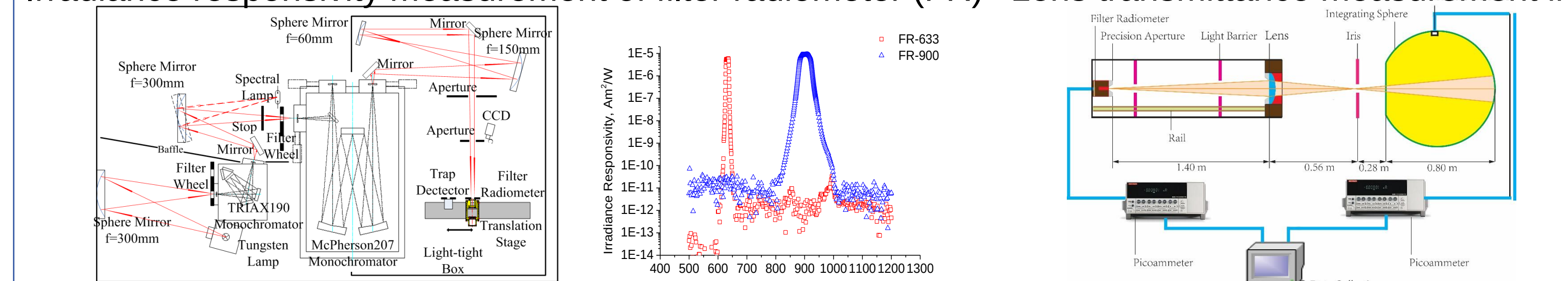


Radiometric Thermometry

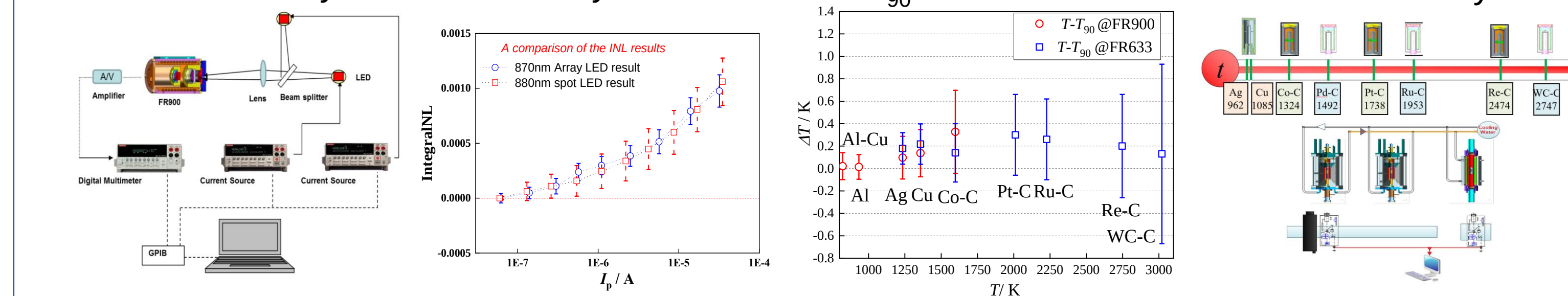
High temperature fixed points (HTFPs) developed at NIM Absolute radiation thermometer (ART)



Irradiance responsivity measurement of filter radiometer (FR) Lens transmittance measurement in situ



Nonlinearity measurement system



Johnson Noise Thermometry

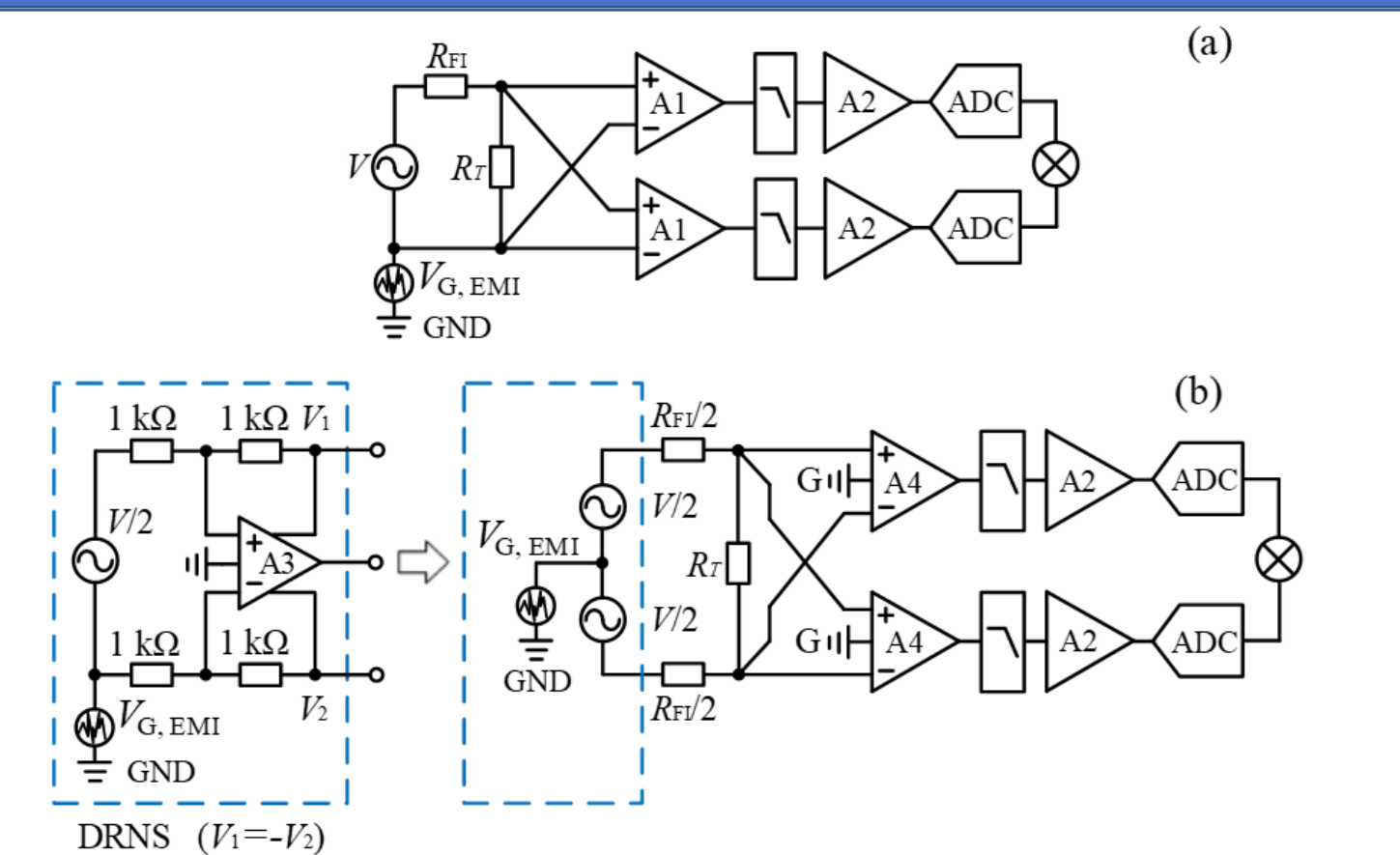


Fig. 1 Structures of (a) single-ended and (b) differential superposition noise thermometers.

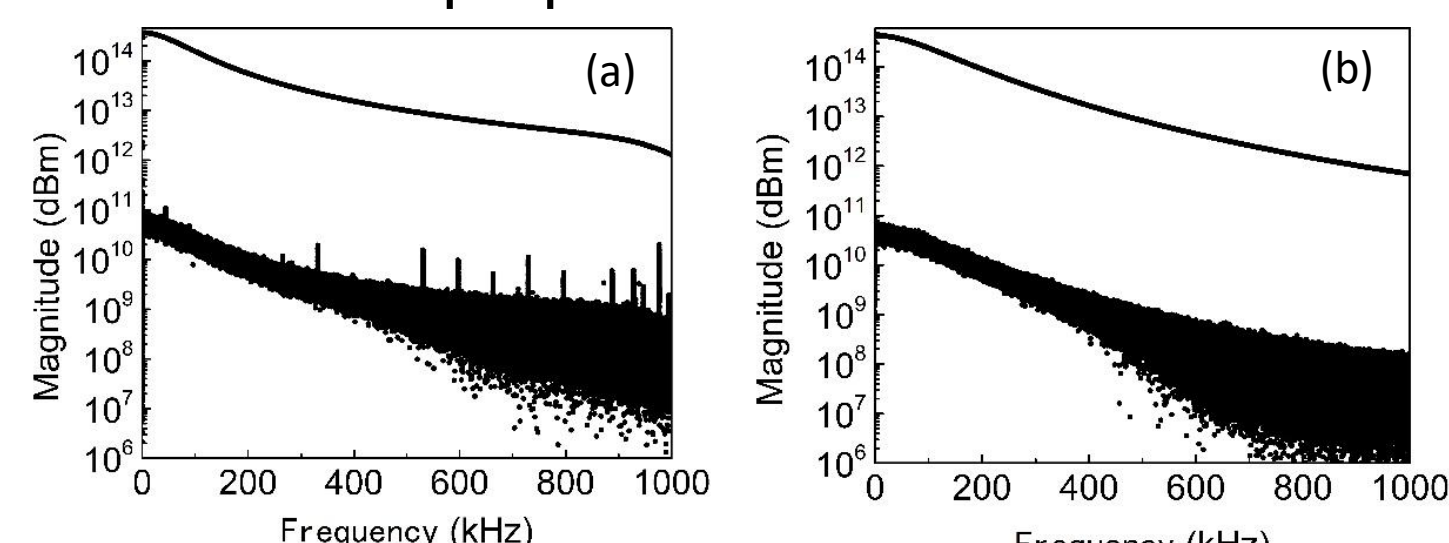


Fig. 2 Spectra of (a) single-ended and (b) differential structures.

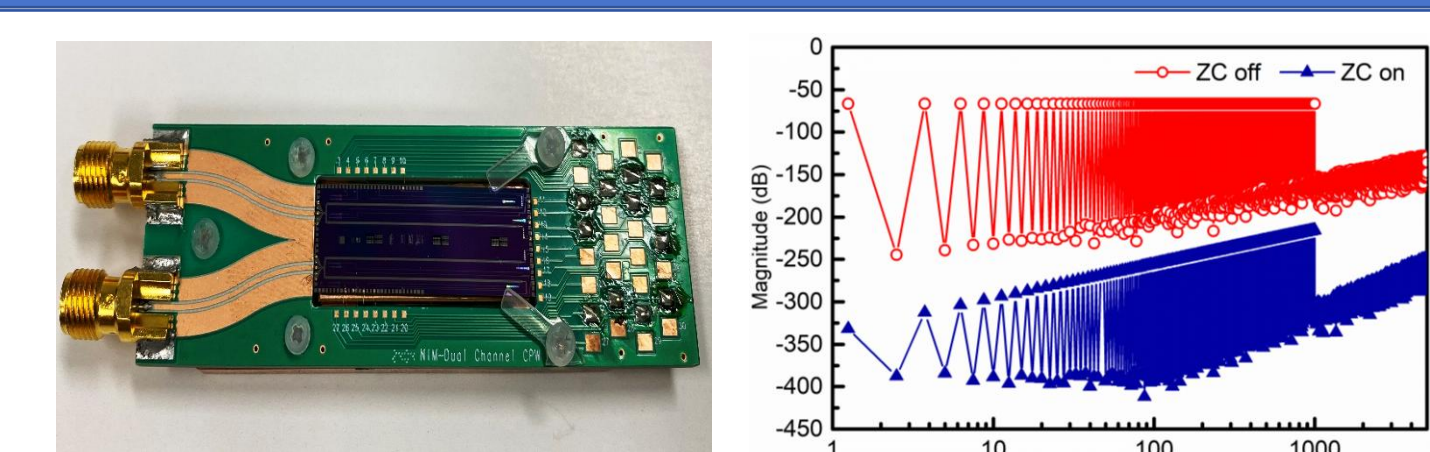
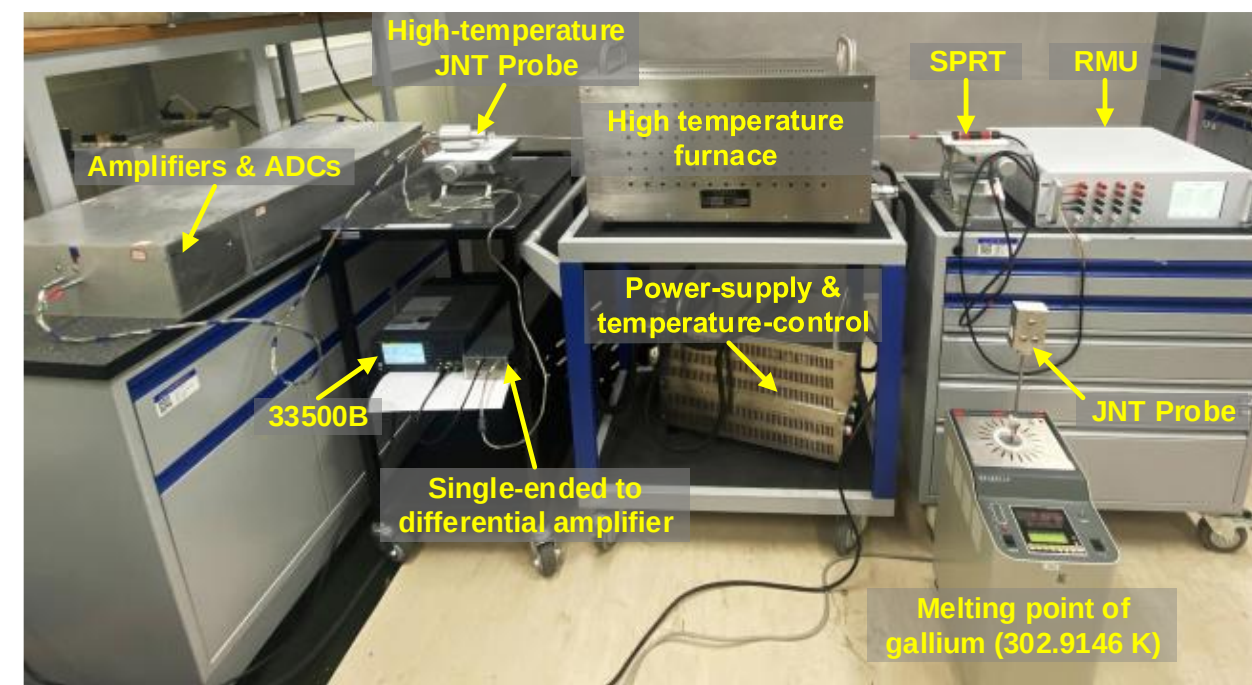


Fig. 4 Quantum voltage chip for calibration.

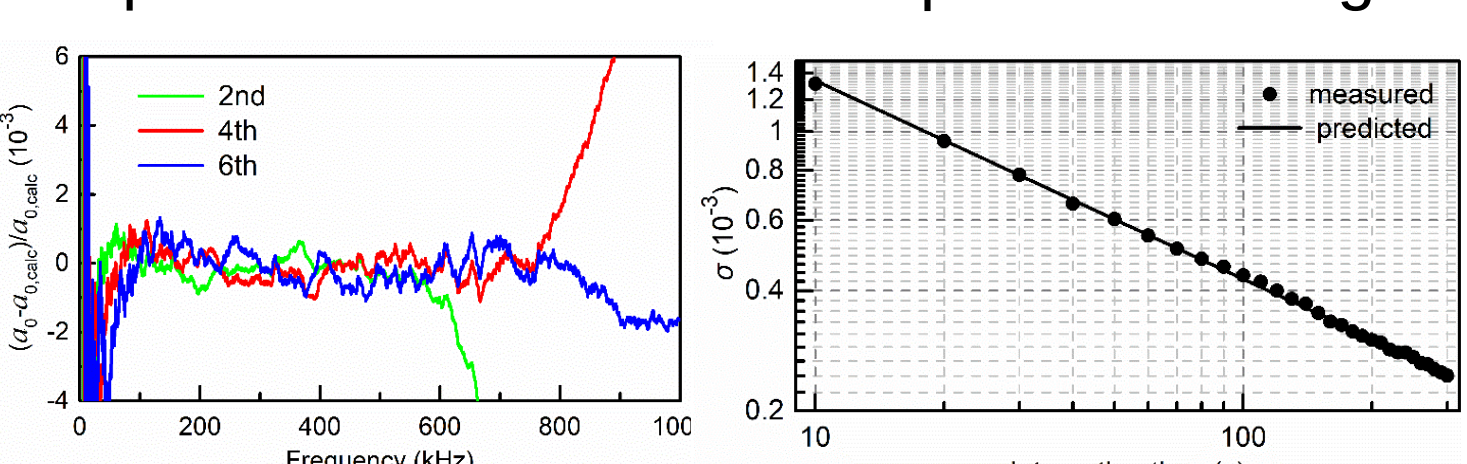


Fig. 5 Code spectra for quantum voltages.

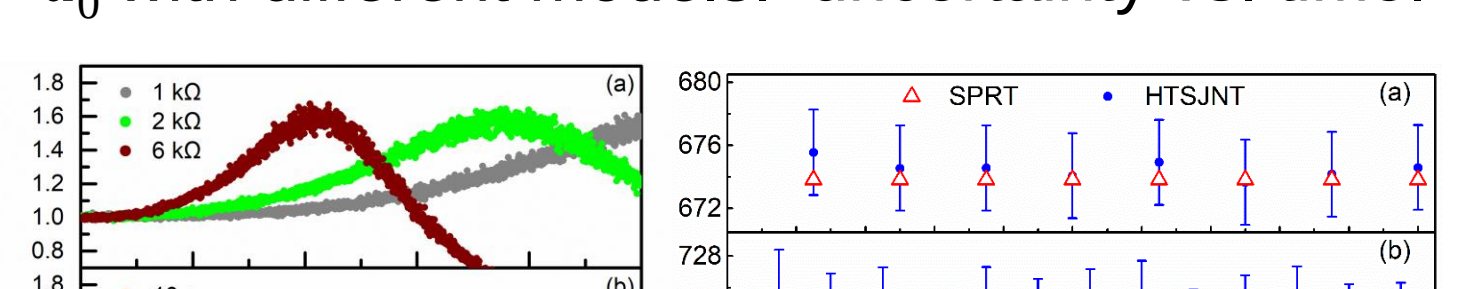


Fig. 6 Relative offset of a_0 with different models.

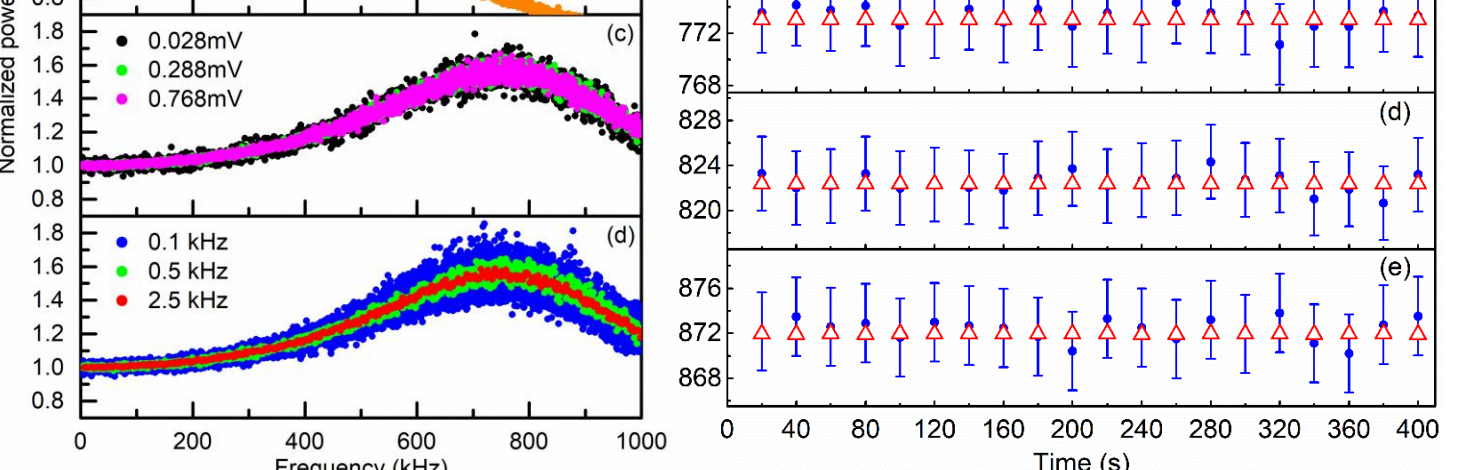


Fig. 8 Influence of different parameters on the power ratio.

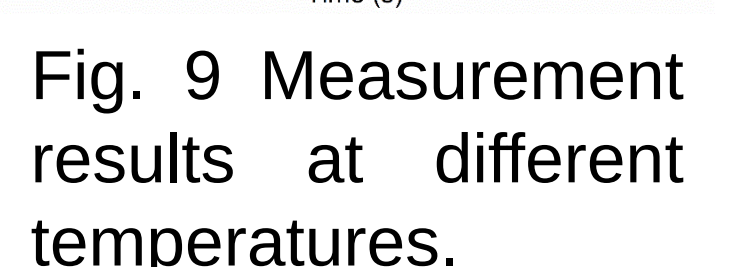
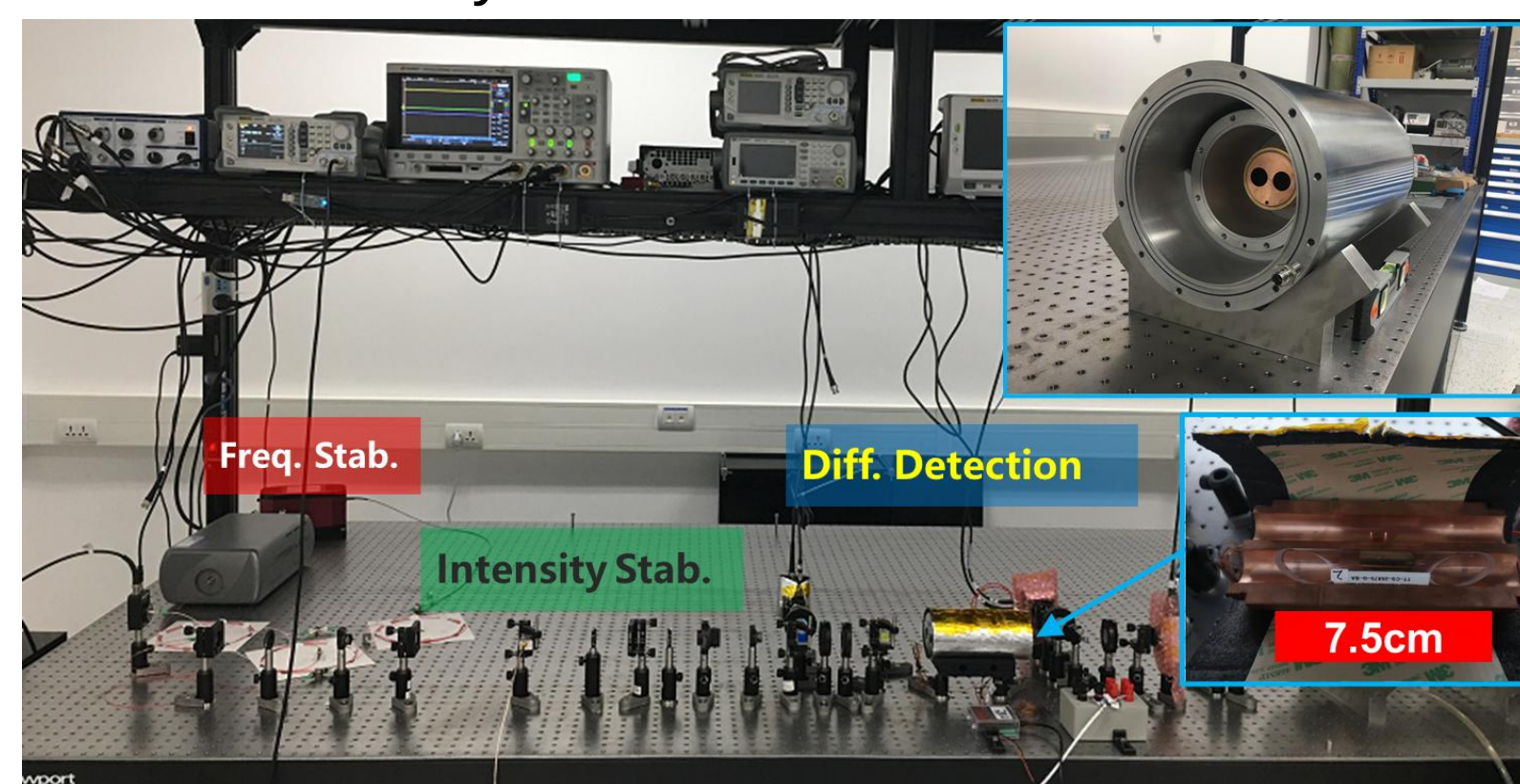


Fig. 9 Measurement results at different temperatures.

Atomic Doppler Broadening Thermometry

Atomic Doppler broadening thermometry (DBT) is potentially an accurate and practical approach for thermodynamic temperature measurement. However, previous reported atomic DBT had a long acquisition time and had only been proved at the triple point of water, 0°C, for the purpose of determination of the Boltzmann constant. This research implemented the cesium atomic DBT for fast room temperature measurement. The Cs133 D1 (6S1/2→6p1/2 transition) line was measured by direct laser absorption spectroscopy, and the quantity of thermal-induced linewidth broadening was precisely retrieved by the Voigt profile fitting algorithm. The results showed the proposed approach had a 4 min single-scan acquisition time and 0.47% total uncertainty.



Type	Source	Value	Abs. Unc.	Distribution	Rela. Unc. (ppm)
Type B	Natural Lw. (MHz)	4.575	0.012	Gaussian	67
	Zeeman Broaden. (MHz)	0.210	0.042	Gaussian	235
	Laser Lorenz Lw. (MHz)	0.010	0.010	Uniform	56
	Gaussian Fitting Lw. (MHz)	357.208	0.412	Gaussian	2307
	Freq. Stability (MHz)	--	0.60	Gaussian	3359
Type A	Laser Gaussian Lw. (MHz)	0.010	0.96	Gaussian	ignore
	Transition Lw. (kHz)	10	可忽略	Gaussian	ignore
	Collisional Lw. (Hz)	450	可忽略	Gaussian	ignore
	Reference PT100 (K)	295.56	0.020	Gaussian	135
	Repeatability(K)	294.37	0.68	Gaussian	2310
Total Uncertainty(k=1)					4693

Conclusion

Cylindrical acoustic gas thermometry has been used to measure $T-T_{90}$ at temperatures from 234 K to 1000 K.

Absolute filter radiometers of 633 nm and 900 nm established at NIM has achieved the capability of thermodynamic temperature measurements at various fixed points ranging from 821 K to 3020 K, with a relative standard uncertainty of less than 2×10^{-4} .

A fully differential superposition Johnson noise thermometer was developed to improve the robustness of the system to electromagnetic interference (EMI). Thermodynamic temperature measurement in the high-temperature region shows that a relative standard uncertainty of less than 0.3 % can be achieved after integration over several tens of seconds. The experiments demonstrated the feasibility of the proposed differential structure.

A Doppler Broadening Thermometry (DBT) system was established based on direct absorption spectroscopy of cesium atoms and proposed an uncertainty evaluation strategy for the room temperature measurement. The relative standard uncertainty of the measurement result reached 0.54% ($k=1$).

Reference

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