S2-7: The progress of Joule balance at NIM

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Abstract: To precisely measure the Planck’s constant for the redefinition of the mass unit kilogram, different approaches are anticipated to give at least three independent results with uncertainties lower than 5×10⁻⁸. Inspired by the Kibble balance method, the National Institute of Metrology (NIM, China) proposed a joule balance method in 2006. The main difference of Kibble balance and joule balance is that the induced voltage and velocity measurement in the Kibble balance is replaced by the mutual inductance measurement in the joule balance to avoid the trouble from the dynamic measurement. NIM built its first prototype NIM-1 to verify the principle of the joule balance with a relative uncertainty of 8.9×10⁻⁶ by 2013. The main uncertainties are from the self heating of the coils, force measurement, length measurement and air buoyancy.

To get a better result, since 2013, the new joule balance NIM-2 has been designed with a series of new approaches. An electromagnet has been built to decrease the self heating problem. However, the nonlinearity of the soft iron in the electromagnet makes it difficult to measure the mutual inductance with an accuracy of 10⁻⁸ level. A flux linkage difference measurement method is proposed to solve this problem. At the same time, this approach keeps the advantage of joule balance method, i.e., the accuracy of the flux linkage difference mainly depends on two static positions z₁ and z₂. A mass comparator is used to lower the uncertainty of force measurement. A laser based position locking system is built to decrease the swing and vibration of the suspended coil. Thus the uncertainty of length is reduced. Finally, the main part of the joule balance is put in a vacuum chamber to avoid the problem from the air refractive index and air buoyancy. At present, the joule balance NIM-2 has been constructed and a series of measurements have been carried out. The uncertainty under 5 parts in 10⁷ can be expected by the Jul. 2017.

Further improvement approaches are still in consideration to get an uncertainty of 10⁻⁸ level finally.