Environmental effects in precision measurement: control or rather compensate

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The fundamental precondition of General Relativity is the equivalence of gravitational and inertial mass (Weak Equivalence Principle - WEP). It was suggested by Fischbach et al. only in 1986 - based on the results of torsion balance measurements made by Eötvös et al. in 1906-1908 - that the equivalence principle might be violated. We – the BME-Wigner Experimental Gravity Group – want to find an explanation of the apparent violation by modernizing a precision Eötvös torsion balance and repeating the original experiment with much higher precision.

However, with a resolution increased by 3 orders of magnitude, environmental perturbations (p, T, tilt, seismic and human noise) of the instrument became crucial. Therefore, to be able to compensate them, in the present study I measured and analyzed some of these effects mainly using a Lippmann nrad resolution tiltmeter.

In my study I describe the common error in the temperature measurement practice and the method to increase the resolution by 1-2 orders of magnitude. Moreover, I show the effect of atmospheric pressure change on the operating temperature of the instrument, and describe its mechanism.

I found that in general, pressure changes have, well-measurable effect on instrument temperatures through adiabatic temperature changes and through the effect of so-called self-heating. More importantly, as the control of environmental parameters (p, T) generates at least 2-3 orders of magnitude greater noise than the effects under study, so these kind of high precision results cannot be obtained with active control of environmental parameters, only with the approach of isolation and compensation.

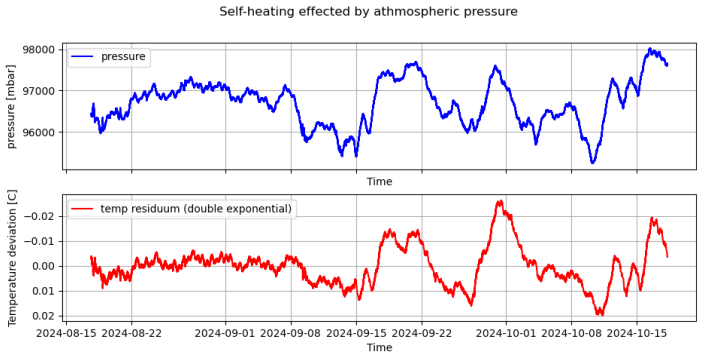

Figure 1: The slight effect of atmospheric pressure change on instrument temperature can be measured and considered.

Acknowledgments

I'd like to thank to the BME-Wigner Experimental Gravity Group and especially dr. Gyula Tóth for his crucial professional work in the Eötvös project, Gábor Papp for supporing the tilt-meter measurements. as well as Prof. Dr. Lajos Völgyesi and dr. Péter Ván for their comments and feedbacks.

References

[1] L. Völgyesi, G. Szondy, G. Tóth, G. Péter, B. Kiss, G. Barnaföldi, L. Deák, C. Égető, E. Fenyvesi, G. Gróf et al., "Preparations for the remeasurement of the Eötvös-experiment", *Proceeding of Science* **343**, 041 (2019).

[2] B. Meurers, G. Papp, H. Ruotsalainen, J. Benedek, and R. Leonhardt, "Hydrological signals in tilt and gravity residuals at Conrad Observatory (Austria)", *Hydrology and Earth System Sciences* **vol. 25**, no. 1 pp. 217–236 (2021).

[3] 3. B. Widrow, I. Kollar, Ming-Chang Liu, "Statistical theory of quantization", *IEEE Transactions on Instrumentation and Measurement* **vol. 45**, issue 2 (1996).