Long-term measurements of atmospheric pressure fluctuations by vibrating wire flowmeter

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Preamble

The operating principle of the flowmeter is based on measurements of deformations of the thermal field of heater in the presence of flow by means of vibrating wires. The advantage of such flow meters in comparison with the known ones using similar thermal principle of operation is the improved accuracy of temperature measurements in comparison with resistive thermometers or thermocouples. The use of thin wires can also increase the speed of the flowmeters. The use of 20-40 mm long wires makes it possible to create wide-aperture receiving orifices for gas flows. A natural property of the developed flowmeters is also their bidirectionality [1].

The following method (R. Reetz) was proposed to create calibrated flows for sensor calibration. From a large water bottle (20 l) filled with water, the water was released through a hose into a vessel on an electronic balance with the data recorded. To prevent dripping, the hose was immersed in the vessel on the balance. A hole was made on the top stopper of the bottle on which a flow meter was mounted. Based on the water mass growth data on the balance, the air flow through the flowmeter was reconstructed, which was used to calibrate the sensor. After the water was completely drained, the bottle was found to be connected to the atmosphere only through the flowmeter. Fig. 1 shows the corresponding experimental data.

It can be seen that the water discharge ended at the first strip of Fig. 1 and further the bottle was connected to the external atmosphere through the flow meter. When the pressure in the atmosphere changed, there was a corresponding change in the pressure in the bottle, resulting in air flows through the flow meter. On all days of the experiment, an increase in the noise of the flow readings was observed at night, when there seemed to be the least amount of noise (July 3-5 were non-working days and no one was in the room, 03.07.2004 was a Saturday).

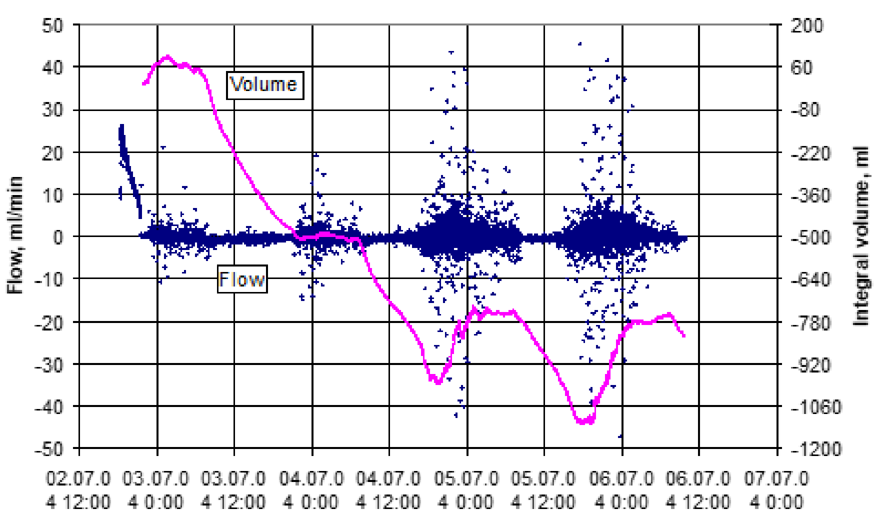


Figure 1. The cyclicity of noisy flows through the flowmeter as a function of time of day (blue dots) can be seen. The integral of the flow over time is shown in violet.

Additional experiments were carried out. In particular, the atmospheric pressure was also recorded by the Baro-vacuum meter GDH 12AN. No changes in the character of the latter readings were observed (see Fig. 2).

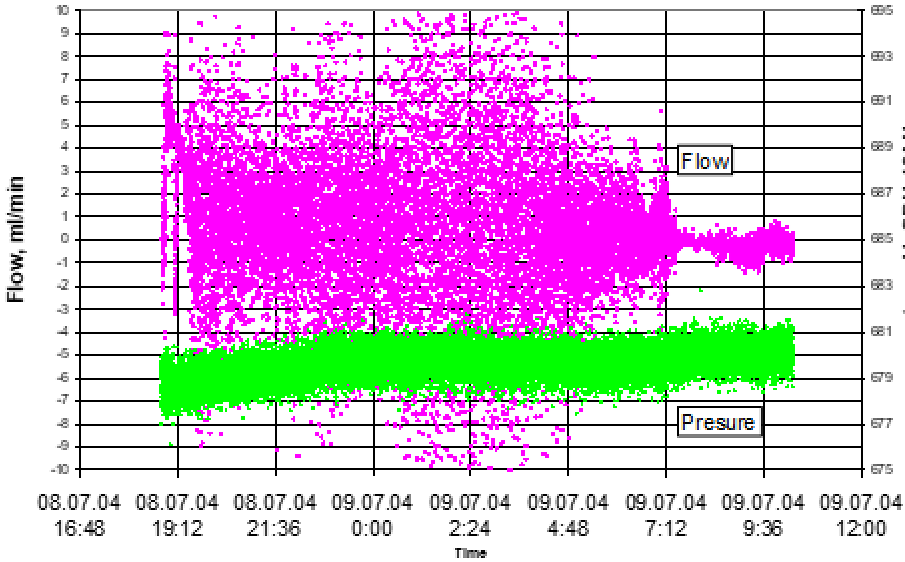


Figure 2. The baro-vacuum meter readings are marked in green and the flowmeter readings in violet. It can be seen that the noise of the baro-vacuum meter readings does not depend on time, while the noise of the flowmeter readings varies greatly around 7:30

The type of noise directly at the sensor frequencies is well illustrated by the Fig.3, with clear anticorrelation of frequencies.

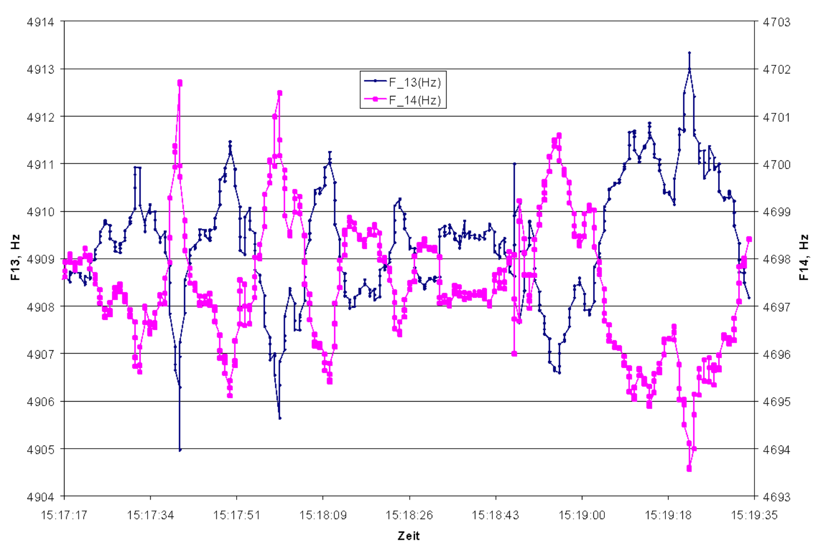


Figure 3. In the region of small flows the frequencies are anticorrelated with each other. The multidirectionality of flows through the flux meter is visible.

The experiments were also continued in 2016.

Project

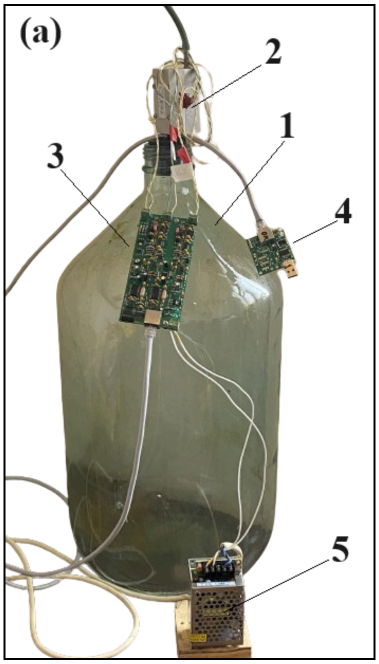
The relationship between atmospheric pressure fluctuations and various other environmental parameters has been discussed in the literature. In [2] a correlation between variations in atmospheric pressure and electric field strength is noted. In [3] is noted that the gravity and local atmospheric pressure have a very similar time fluctuations. In [4] following parameters were measuring simultaneously: deviations of the three-dimensional wind velocity, potential temperature, pressure, moisture, and CO_2 fluctuations. In [5] the atmospheric pressure fluctuations were measured with a laser displacement gauge based on the Michelson interferometry. The change in optical path is expected to be about 2.7 nm when the pressure changes by 1 Pa.

It seems to us that the measurement of variations of atmospheric pressure fluctuations with the help of the flow meter developed by us can be useful also when conducting experiments on the cosmic station, both for observations of thunderstorm activity and wider. Thus, the paper. [6] notes that atmospheric pressure had been observed to fall several millibars with the passage of a "waketrough", a region of low pressure caused by strongly sinking air behind thunderstorms. Pressure jumps also occur with the arrival of cold, gusty winds before the onset of rain.

Thus, observations of atmospheric pressure variations in combination with measurements of other physical parameters may be of interest to the research conducted by the Cosmic Ray Division (CRD) of A.I. Alikhanyan National Laboratory (Yerevan Physics Institute), especially in areas where cosmic ray physics is studied in conjunction with atmospheric physics.

Description of the experimental setup

Fig. 4 shows the main units of the experimental setup: A glass bottle (20 l) is fitted with a rubber plug with a hole for a flowmeter, one end of which is free. The flowmeter consisting of 3 wires, two wire-thermometers and a wire-heater (the flowmeter is described in detail in [1]). The current through the heating wire was set using a stabilized current source.



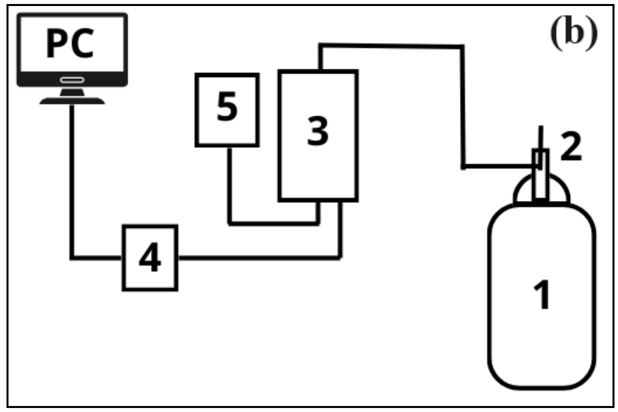


Figure 4. The main units of the experimental setup: 1- glass bottle, 2- flowmeter, 3- wire autogeneration board, 4 - information transfer board connected with the computer, 5 - stabilized power supply. (a) Photo of the experimental setup. (b) Block diagram of the experimental setup.

The experimental setup should be synchronized with other installations of the station. The issues of data synchronization and forwarding and their visualization are planned to be solved in cooperation with other project participants.

Literature

1. M.A. Aginian, S.G. Arutunian, G.S. Harutyunyan, E.E. Gukasyan, E.G. Lazareva, A.V. Margaryan, L.A. Poghosyan, M. Chung, D. Kwak, and R. Reetz, Gas Flowmeter Based on Vibrating Wires, Journal of Contemporary Physics (Armenian Academy of Sciences), 2022, Vol. 57, No. 1, pp. 20–29.
2. А.В. Крашенинников, С.П. Соловьёв, Ю.С. Рыбнов, А.В. Соловьёв, ВАРИАЦИИ АТМОСФЕРНОГО ДАВЛЕНИЯ И ЭЛЕКТРИЧЕСКОГО ПОЛЯ ВО ВРЕМЯ ПОЛЯРНЫХ СИЯНИЙ, Труды конференции РРВ–26, 1–6 июля 2019, Казань, Том II, с. 553–556.

3. X.-G. Hu, L.-T. Liu, J. Hinderer, H.-P. Sun, Wavelet filter analysis of local atmospheric pressure effects on gravity variations, Journal of Geodesy, 16 September 2005, Volume 79, pp. 447–459.

4. Zhuorui Wei, Hongsheng Zhang, Yan Ren, Qianhui Li, Xuhui Cai, Yu Song, Ling Kang, Study on the characteristics of the pressure fluctuations and their contribution to turbulence kinetic energy, Atmospheric Research, 15 August 2021, Volume 258, 105634.

5. Hideaki Iizumi, Hiroaki Kajikawa, An attempt to measure fluctuations of atmospheric pressure with laser interferometer, Measurement: Sensors, December 2021, Volume 18, 100184.

6. T. Schlatter, Weather Queries: Rapid Pressure Changes near Thunderstorms, Directional Lighting, Weatherwise, 40(2) (2010), pp. 99-100.