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Automated Burris gravity meter for single and continuous observation

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ABSTRACT

The Burris Gravity Meter™ manufactured by ZLS Corporation, Austin/Texas, USA, is based on the invention of L&R (L. LaCoste and A. Romberg): The ZLS (zero-length spring). A digital feedback system (range of about 50 mGal) is used to null the beam. Now, more than 120 gravity meters of this make exist worldwide and are used successfully in exploration, volcanology, geodetic work and surveying.

The sensor is made of the well-known (L&R) metal-alloy zero-length spring providing a low drift characteristic. The drifts observed are comparable to L&R gravimeters and are less than 0.3 mGal per month, which is much lower than the drifts known for the fused quartz sensors.

The dial is calibrated every 50 mGal over the entire 7000 mGal meter range. Since the gravity value is determined at these points, there are no periodic errors. By a fourth heater circuit temperature effects are totally avoided. The gravity meter is controlled via Bluetooth® either to a handheld computer (tablet) or a notebook computer.

The feedback responds with high stability and accuracy. The nulling of the beam is controlled by the UltraGrav™ control system which incorporates an inherently linear PWM (pulse-width modulated) electrostatic feedback system. In order to improve the handling of the gravimeter we have developed two Windows based programs: AGESfield for single measurements and AGEScont for continuous readings.

1. Introduction

The Burris Gravity Meter™ manufactured by ZLS Corporation, Austin/Texas, USA, is based on the invention of L. LaCoste and A. Romberg: The zero-length spring [1]. The sensor is made of the well-known (L&R) metal-alloy *zero-length spring* because of its low drift characteristics. The drifts observed are comparable to L&R gravimeters and are less than 0.3 mGal[2] per month. Thus, they are much lower than the drifts known for the fused quartz sensors [2]. A digital feedback system (range of about 50 mGal) is used to null the beam. With the help of a dial the measuring range can be adjusted. The dial is calibrated every 50 mGal over the entire 7000 mGal meter range. Taking readings at these points avoids periodic errors. The feedback responds with high stability and accuracy. The nulling of the beam is controlled by the UltraGrav™ control system which incorporates an inherently linear PWM (pulse-width modulated) electrostatic feedback system [3–5].

In order to improve the handling of the gravimeter as well as to achieve a faster running-in we have developed two Windows based programs which serve for the same purpose: *AGESfield* for single measurements and *AGEScont* for continuous readings. This was started by the group of co-author Jentzsch [6]. The new systems allow the operation of a notebook computer with several advantages like large storage space, connection of GPS for

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[1] GRAVITY CONSULT GmbH is a company which emerged from the university research group of the first author; this company represents ZLS Corp. in Europe selling expertise and gravimeters as well as developing hardware.

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[2] 1 mGal corresponds to 10^{-5} m/s^2.

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positioning and time as well as air pressure sensor, and simple data transfer.

By a fourth heater circuit, temperature effects are totally avoided. The gravity meter is controlled via Bluetooth® either to a handheld computer (tablet with UltraGrav™) or a notebook computer (with AGESfield or AGEScont).

Now, more than 120 gravity meters of this make (calibrated and non-calibrated screw) exist worldwide and are used successfully in exploration, volcanology, geodetic work and surveying.

2. Some technical features and experimental results

Due to the calibration of the screw (every 50 mGal over the entire 7000 mGal meter range) no circular errors are involved when measurements are within the range of the feedback system or at the calibrated points. The observed standard deviations are in the order of 3 μGal or better during routine field tests. More details are obtainable from ZLS (http://zlscorp.com/).

Calibrated ultra-miniature electronic levels are used for correction of horizontal misalignment to insure accurate and reliable and reproducible operation of the gravimeter. After adjustment of these levels the result can be incorporated into the control program to provide automatic correction.

The control software of ZLS as well as the software developed by us uses the feedback signal and the dial position (calibrated point) to calculate the gravity value.

The check of the feedback on the vertical calibration line in Hanover, Germany, provided reliable results below the 3 μGal level, and the accuracy of the calibration factor was 10^{-4} [5]. The observed drifts during field measurements are stable (comp. Fig. 1a and b). As can be seen, the drifts are small but a little different due to the fact that we have a mechanical system, the spring. But the stability is much better and the drift is much smaller than reported for the Scintrex meter [7].

The technical features are contained in Table 1. The gravimeter is available with the calibrated screw (worldwide range of 7000 mGal[3]) and the non-calibrated screw with the range of the

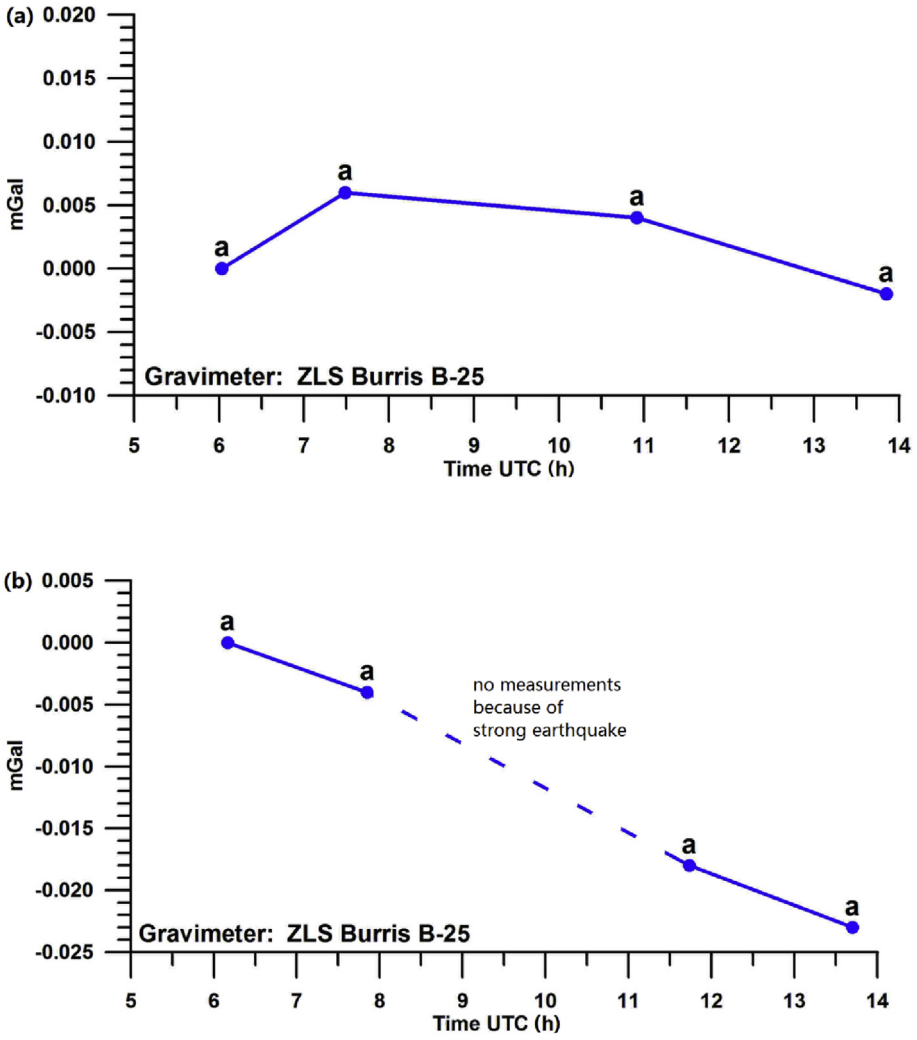

Fig. 1. a-Observations of September 03, 2013 shows the drift after many movements (great number of points and about 150 km car transport). The rounded negative drift rate is between 0.001 mGal/h and 0.002 mGal/h. Positive drift see text. The letter "a" denotes measurements at the base station. b-Daily drift of September 28, 2013, around an earthquake: There is no drift effect of the seismic waves to be seen; the rounded drift rate is −0.003 mGal/h. The letter "a" denotes measurements at the base station. (Both graphs modified after Jentzsch et al., [6]).

[3] Actually, depending on the screw, the usable range expands from about 250 to about 6750 mGal.