Tilt Experiment with the Autograv Relative Gravimeter CG-5

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Outline

- Introduction to CG-5 (Autograv Scintrex)
- Atmospheric Effects
- Data Analysis
- Experiments (Bonn and Bad-Homburg)
- Tilt Experiments
- Summary & Outlook
Autograv Scintrex CG-5

### CG-5 Autograv Scintrex

<table>
<thead>
<tr>
<th>Feature</th>
<th>Specification</th>
</tr>
</thead>
<tbody>
<tr>
<td>Sensor Type</td>
<td>Fused quartz using electrostatic nulling</td>
</tr>
<tr>
<td>Resolution (Reading)</td>
<td>1 Micro-Gal</td>
</tr>
<tr>
<td>Standard Deviation</td>
<td>5 Micro-Gal</td>
</tr>
<tr>
<td>Operating Range</td>
<td>8000 Milli-Gal</td>
</tr>
<tr>
<td>Drift</td>
<td>0.02 mGal/day</td>
</tr>
<tr>
<td>Tilt Compensation</td>
<td>±200 arcsec.</td>
</tr>
<tr>
<td>GPS receiver</td>
<td>Standard &lt; 15m, CG-5 clock synchronisation</td>
</tr>
<tr>
<td>Key fob</td>
<td>30 m (line of sight)</td>
</tr>
<tr>
<td>Smart Battery (fan)</td>
<td>2 x 6.6 (Ah), Full day op.</td>
</tr>
<tr>
<td>Weight</td>
<td>8 kg. (portable)</td>
</tr>
</tbody>
</table>

**AUTOgrav**: All effective corrections have been automatically considered!
Dis-avdantages:

- Keyboard sensitivity! (2 sec. Pause!)
- Firmware stability! (hanging)
- Single observation [1 Hz] has an accuracy of around 80 Microgal!

- Standard deviation (Time window of 60 sec ~ 5 Micro-Gal)
Atmospheric effects

- Pressure

\[ \Delta g_p = -0.3 \cdot \Delta p \text{ [\(\mu\text{Gal}\)]} \]

Neglectable (if pressure changes are less than 17 [hPa])
Atmospheric effects

- Temperature

\[ TEC = Tempco \cdot Temp \]

-0.122 mGal/mK  Measured in vacumm!
Atmospheric effects

- Precipitation: changes in the mass!

- Atmospheric effects can be neglected in the normal conditions!
Data Correction and Analysis

Corrections:

- Drift (Manual or Automatic)
  ✓ Automatically corrected!

- Tide
  ✓ Internal (Longman-Formula, precision problem!)
  ✓ External (ETERNA precision less than 5 Microgal)

- Tilt (less than 200 arcsec.), recommended less than ±10 arcsec.
  ✓ Automatically corrected!

- Temperatur changes (Internal and External)
  ✓ CG-5 is very sensitive to temperature change
  ✓ Display heating system
  ✓ Tilts more than 200 arcsec. cause strong temp. changes

- Filters
  ✓ Noisy sample filter
  ✓ Seismic noise filter

BLACK BOX!
Drift Experiment (Bonn, May 2013)
Experiment (Bonn, May 2013)

Tilt x, y [arcsecs]

Temperature [mK]

MJD [days]
Experiment in Bad-Homburg Castle

Castle Bad-Homburg
Different CG-5s
Bad-Homburg Experiment (Bonn vs. Koblenz)
Bad-Homburg Experiment (Hamburg vs. BKG)
Tilt

Pisa, Italy
Tilt Experiment

Disc Thicknesses [mm]

23 [mm] 8 [°]

2.9 [mm] 1 [°]
Tilt Experiment procedure (angle & time)

1) Level CG-5 & measure for one [h]  
2) Turn off and Tilt it with the different tilt angles & waiting for 100 [min]

3) Remove disc, turn on, level it and take measurement for at least 24 [h]
Tilt Experiment at Bonn, diff. angles

Tilt 2.9 mm - DT 100 minute

Tilt 5.8 mm - DT 100 minute

Tilt x (arcsec) STD, Tide, ETERNA

Temp. [K]

MJD [days]
Tilt Experiment at Bonn, diff. angles
Tilt Experiment at Bonn, diff. angles
Tilt Experiment at Bonn, diff. angles
Tilt Experiment procedure (angle & time)

1) Level CG-5 & measure for one [h]

2) Turn off and Tilt it with the angle 8 (Disc 23 [mm]) & waiting for 10, 30, 60, 90 [min]

3) Remove disc, turn on, level it and take measurement for at least 24 [h]

Finding the critical time
Tilt Experiment, angle 8° & diff. time

Tilt 23 mm - DT 10 minute

Tilt 23.0 mm - DT 30 minute

Rel. Gravity [mgal]

MJD [days]

STD

Tide\textsubscript{in}

ETERN\textsubscript{a}

Diff.

Internal Tide, ETERNA [mgal]

Temp. [mK]
Tilt Experiment, angle 8 [°] & diff. time
**Functional relationship (tilt time & instrument stabilization)**

### Tilt angle of 8 [°]

<table>
<thead>
<tr>
<th>Tilt time [min]</th>
<th>Offset[mGal] / Stab. Time [hour]</th>
</tr>
</thead>
<tbody>
<tr>
<td>10</td>
<td>-55 / 0.5</td>
</tr>
<tr>
<td>30</td>
<td>-43 / 12.6</td>
</tr>
<tr>
<td>60</td>
<td>-85 / 19.82</td>
</tr>
<tr>
<td>90</td>
<td>-89 / 19.18</td>
</tr>
</tbody>
</table>

\[ s(\Delta t) = 0.81 + 0.66\Delta t - 0.005\Delta t^2 \]
Reasons (CG-5 Sensor ?)

- Electrostatic nulling
- Two plates
- Test mass
- Quartz-Glass spring

Source: IGM (Mr. Schuler)
✓ **Caution** in transport

✓ Check the „USER Check Voltage“ before starting to take measurement
  ✓ If „USER check Voltage“ approaches zero, wait at least 14-20 [h]

✓ Use a **Gyroscope**!

✓ **Other ideas**
Autograv is very sensitive instrument to the tilt!

Critical angle and time, and stabilization function have been found for the Bonn CG-5.

Causes for the tilt offset are not clear exactly!

Shake effect is another important effect, but has not been investigated!
Thank you for your attention!