*i*OSG™ SUPERCONDUCTING GRAVITY METER

The *i*OSG, using a heavier mass and a new, high-Q sensor, offers unprecedentedly low noise across all frequencies from decadal variations to the microseism band

Significantly lower noise than the OSG:

- Heavier test mass lowers instrumental noise by 6 dB compared to OSG
- Raising the instrumental Q by reducing electromagnetic damping further lowers the noise by 6-18 dB
- New feedback system with remotely adjustable poles and filters yields lower noise without sacrificing sensor stability

***Super* stable**

Drift rate < 0.5 μGal/month and constant
Scale factor constant to <0.01% over decades

***Super* precise**

0.1 nanoGal (10^{-3} nm/s^2) resolution in frequency domain
< 0.3 nm/s^2 resolution for 2 minute averaging

***Super* low noise**

< 1 (nm/s^2)^2/Hz in seismic band (1 to 8 mHz)

OBSERVATORY SUPERCONDUCTING GRAVIMETERS

The ***i*OSG** Superconducting Gravity Meter is the latest, lowest-noise observatory-quality SG. It builds on the industry-leading OSG that has formed the core of the Global Geodynamics Project (GGP) network of observatory gravimeters.[1,2]

Like the OSG, the ***i*OSG** uses a superconducting shield, sphere, and coils[3]. Supercurrents flowing in the coils produce a magnetic field which levitates the sphere. The levitating sphere and magnetic field replace the function of the mass and mechanical spring found in other relative gravity meters. The perfect stability of the supercurrents produces a completely stable, non-mechanical, zero-mass, zero-length, non-degrading spring.

FEATURES

- **Consumes no liquid helium** - Compact, 35-liter cryogenic Dewar and closed-cycle cryocooler that eliminates the need to deal with liquid helium (LHe)
- **Integrated data acquisition and control electronics** - Microprocessor-integrated electronics reside in dewar head and control tilt and temperature. High resolution gravity data is logged in real time by 24 bit A/D that resides on gravity board in dewar head. Time stamp is provided directly from GPS signal.
- **Low maintenance** - 10,000 hour interval between cryocooler servicing, and serviceability without data interruption for years-long, continuous data records
- **Simple power supply system -** Electronics integrated with Dewar operate on 24 V DC supply. Uninterruptable power supply (UPS) is provided as an option.
- **Remote control** - Remote instrument control and data acquisition via internet or other TCP/IP connection

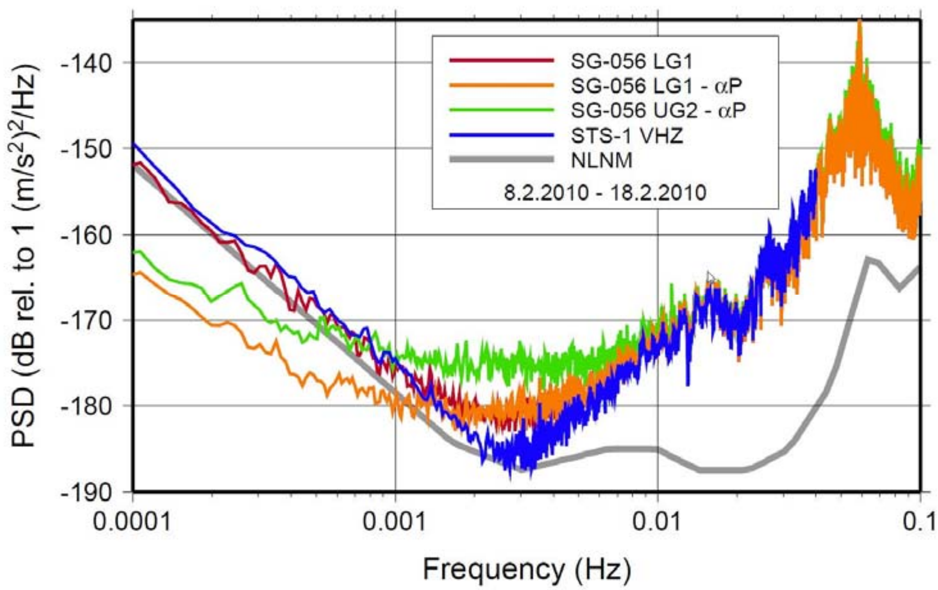


Figure courtesy of R. Widmer-Schnidrig

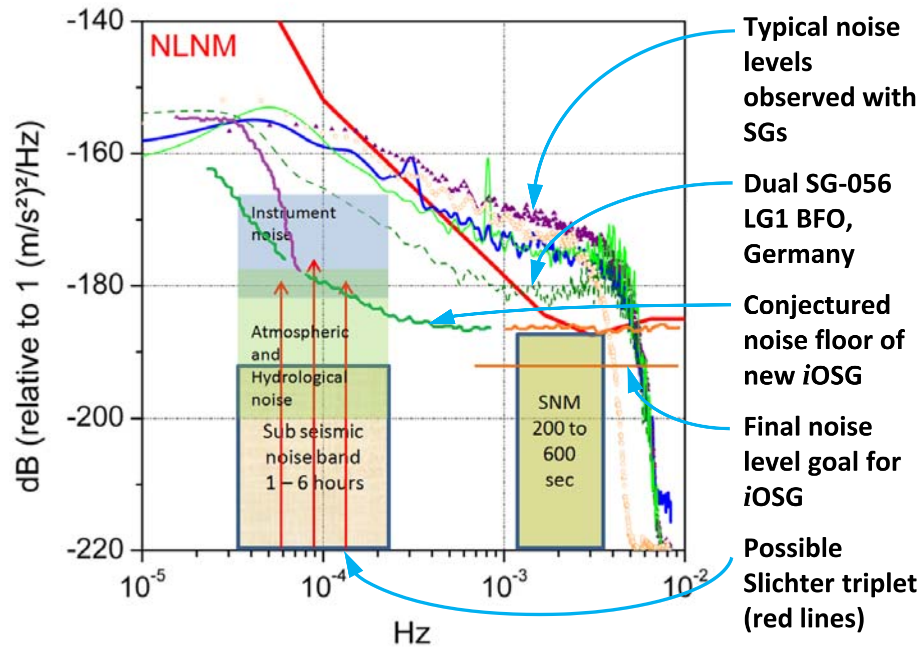
Noise spectra of 10 quiet days for OSGs at the Black Forest Observatory (BFO), Germany. SG-056 LG is the sensor with higher levitated mass, showing lower noise than the standard OSGs. The "- αP" designation indicates time series with the gravitational effect of atmospheric pressure variations removed. Spectra of the BFO STS-1 long period seismometer and of the New Low Noise Model, based on the lowest noise ever observed by STS-1 sensors anywhere, are included for comparison.

APPLICATIONS

The Global Geodynamics Project (GGP) is a global network of SGs that has offered important new insights into geodynamic processes on time scales ranging from tenths of seconds to two decades (and counting).

The ***i*OSG** offers substantial noise reductions, enabling measurements limited by true earth noise. This opens the possibility of new discoveries (e.g., observation of the Slichter modes) as well as improved accuracy and precision in measurements of parameters governing known geodynamic processes.[4]

The new ***i*OSG** is intended for new GGP sites and to replace previous SG models as they are retired from existing GGP sites.



The goal of the *i*OSG is to attain an instrumental noise level less than 0.3 (nm/s^2)^2/Hz, which is below the NLNM

This will enhance the search for the Slichter Triplet and improve resolution for low frequency seismology

The ultra-low-noise *i*OSG SG provides long, continuous, high-precision gravity data for studying a wider variety of geophysical phenomena than ever before, including:

- ✓ **Tidal spectroscopy** — more accurate determination of earth response
- ✓ **Earth core effects** — nearly diurnal free wobble; Slichter modes
- ✓ **Polar motion and LOD** — Chandler wobble, variable moment of inertia
- ✓ **Long-term tectonic effects** — either post-glacial uplift or subsidence
- ✓ **Seismic normal modes** — more accurate structure determination
- ✓ **Active faults** and other regions of active vertical displacement
- ✓ **Silent or slow-slip earthquakes**

http://www.eas.slu.edu/GGP/maps/world5r.pdf

SPECIFICATIONS

*i*OSG Gravity Sensor (single-sphere Niobium-based transducer):

Noise:	< 1 $(nm/s^2)^2/Hz$
Frequency domain:	0.1 nanoGal (< 10^{-3} nm/s^2) signals observed
Time domain:	< 0.3 nm/s^2 signals observed, 1-minute filtering
Scale factor:	Stable to better than 1 part in 10^4 for decades
Linearity:	Linear to 1 part in 10^7
Insensitivity:	Cryogenic environment insensitive to temperature, pressure and humidity

System Electronics:

Gravity control electronics:	Sphere position controlled to < ±1 Å
Cryogenic temperature control:	Sensor body controlled to < ±2 μK
Barometer:	Setra Model 270
Data acquisition:	24-bit ΔΣ ADC; gravity oversampled 8x/sec
GPS timing:	SEL-2401 Satellite Synchronized Clock

System Software:

Remote system access and control:	Via Internet or other TCP/IP connection
Operating system:	Windows 7
*i*Grav® Monitor:	Data acquisition, FTP data transfer Sensor control panel and data plotting Email alarm and warning messages
Data compression and storage:	User-selected variables Easy concatenation into continuous time series Lossless data compression Data saved in TSoft-compatible format

Cryogenic Biaxial Tilt Meter and TCS-6 Tilt Compensation System:

Sensitivity / dynamic range:	0.1 μRadians / 60 mRadians
Controlled alignment with set vertical:	0.1 μRadians
Dynamic range of controlled system :	2.5 μRadians

Dewar:

Height (including cold head)/ Diameter:	137 cm (54 inch) / 41 cm (16 inch)
Weight (including sensor and electronics):	45 kg (100 lbs)
Volume:	36 L liquefied from 20,000 L (675 cu ft) gas

Refrigeration:

Coldhead:	Sumitomo SRDK-101D
First stage:	3.0/5.0 W at 60 K (50 Hz)
Second stage:	0.1 W at 4.2 K (50/60 Hz)
Ambient operating temp.:	5 to 28° C recommended (10% capacity loss from 28 to 35° C)
Dimensions / Weight:	Width-10 cm x length-23 cm x height-44 cm / 7.2 kg
Coldhead service:	Mandatory factory reconditioning at 10,000-hour interval
Compressor:	Sumitomo CNA-11C, Indoor, air-cooled
Operating temperature:	4 to 28 ° C recommended (10% capacity loss from 28 to 35° C)
Operating pressure:	2.2 to 2.3 MPa
Dimensions / Weight:	39 cm (width) x 450 cm (length) x 61 cm (height) / 75 kg
AC power: phase / voltage/ frequency:	single phase / 100, 120, 220-230, 240 VAC / 50, 60 Hz
Current @ 100VAC:	Max. 13.9 A / steady state 12.4 A at 50 Hz Max. 15.1 A/ steady state 13.3 A at 60 Hz
Compressor service:	Mandatory adsorber replacement at 30,000-hour interval

Options:

Uninterruptible power supply (UPS):	Solar-Craft DC-UPS 24-100 for backing up ***i*OSG electronics only**

Specifications subject to change without notice – 12/02/2014

References:

1. Global Geodynamics Project (http://www.eas.slu.edu/GGP/ggphome.html)
2. Hinderer J and Crossley D (2004) Scientific achievements from the first phase (1997-2003) of the Global Geodynamics Project using a worldwide network of superconducting gravimeters. *J. Geodyn.* **38**: 237-262.
3. Goodkind J M (1999) The superconducting gravimeter. *Rev. Sci. Instrum.* **70**(11): 4131-4152
4. Crossley D, Hinderer J and Riccardi U (2013) The measurement of surface gravity. *Rep. Prog. Phys.* **76**; doi:10.1088/0034-4885/76/4/046101

And more than 100 additional references listed at: http://www.gwrinstruments.com/published-papers.html

PRICES AND OPTIONS

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