Superconducting persistent currents (i) produce the most stable relative gravity meter in existence

The iGrav SG provides continuous high-precision gravity data for studying a wide variety of geophysical phenomena

**Super stable**
- Drift < 5 nm/s²/month and constant
- Scale factor constant to better than 0.01% for years

**Super precise**
- 1 nanoGal ($10^{-2}$ nm/s²) resolution in frequency domain
- < 3 nm/s² resolution for 2 minute averaging

**Super low noise**
- < 10 (nm/s²)²/Hz in seismic band (1 to 8 mHz)
PORTABLE, EASY, MORE AFFORDABLE

The iGrav® Superconducting Gravity Meter is a more moveable and less expensive version of its predecessor, the Observatory Superconducting Gravimeter (OSG), used in the Global Geodynamics Project1,2 and for more than 30 years worldwide.

Like the OSG, the iGrav uses a superconducting shield, sphere, and coils3. 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.

The iGrav:

- **Requires minimal infrastructure**
  A small concrete pad, 1.5 kW power, and an Internet connection for remote access is sufficient.

- **Requires minimal training**
  Sphere levitation is done in minutes with user-friendly control software.

- **Consumes no liquid helium (LHe)**
  The refrigeration and Dewar system liquefies 16 L of liquid He from 9000 L (350 cu ft) He gas, transported in a standard gas cylinder.

- **Has a simplified coldhead stand and frame**
  Coldhead insertion and alignment is straightforward.

- **Is mobile**
  The iGrav can be moved while the sphere is levitating, without a drift or change in scale factor (see Figure below).

- **Is less expensive**
  Approximately half the price of OSG.

- **Is controlled remotely**
  System monitoring, control and data downloads via internet or other TCP/IP connection.

Two iGrav SGs were moved from Poway, CA, to GWR (in San Diego), and then to Tucson, AZ.

Difference in the signals remained <0.5 µGal. We can therefore conclude:

- No drift caused by moving the iGravs.
- The calibration remains constant to within 0.01%.

No drift is removed in the analysis at any of these sites!
The iGrav SG can be used as an ultra-high-precision continuous gravity reference for observatory measurements, short term deployment, or differential gravity measurements.

The figures to the right show an example of using gravity to measure water-storage change at a groundwater recharge facility in Tucson, Arizona (See Kennedy J et al. 2014; reference 4 below).

Orange lines show residual gravity from iGrav 004, operating at recharge pond RB 207, and iGrav 006, operating next to pond RB 206 500 m to the south. Extensive AG measurements (orange points with error bars) verify the drift-free operation of both iGrav SGs. Blue lines show ground water level for wells SA-011A and SA-015A; blue points and error bars are co-located AG measurements. These data show how gravity variations can vary dramatically at an active hydrological site over short times and short spatial distances.

### APPLICATIONS

The iGrav SG provides continuous high-precision gravity data for studying a wide variety of geophysical phenomena, including:

- **Volcano monitoring** — both slow deformation and explosive activity
- **Hydrological** — e.g. non-invasive ground water monitoring
- **Geothermal** — mass movement dependence on injection and extraction
- **Subsidence** — caused by oil, gas, or water extraction
- **Long-term tectonic effects** — either post-glacial uplift or subsidence
- **Active faults** and regions of active vertical displacement
- **Hazard-reduction geophysics**
- **Silent or slow-slip earthquakes**

### FEATURES

- **Consumes no liquid helium**
  Never buy or transport LHe again!
- **Cryogenic environment**
 Insensitive to local pressure, temperature, or relative humidity. Even moving the iGrav does not affect its calibration factor or (negligible) drift rate.
- **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 recommended coldhead maintenance interval.
- **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**
  System monitoring, control, and data acquisition via an Internet or other TCP/IP connection.
- **Simplified initialization and operation**
  Minimally trained personnel can set up and operate the iGrav in a day.

### PORTABLE

The complete iGrav SG can be moved in the back of a 2000 Honda CRV with a cargo space of 2 m² (72 ft²). At a site prepared with a pier, electrical power, and an internet connection, the iGrav SG can be up-and-running in 5 hours or less.
SPECIFICATIONS

iGrav® Gravity Sensor (single-sphere Niobium-based transducer):
Noise: ................................................................. 3 nm/s²/(Hz)¹/²
Frequency domain: .............................................. Sub-nanoGal (< 10⁻² nm/s²) signals observed
Time domain: ................................................... 1 to 3 nm/s² signals observed, 1-minute filtering
Scale factor: ....................................................... Stable to better than 1 part in 10⁴ for decades
Linearity: ............................................................. Linear to 1 part in 10⁸
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
iGrav® Monitor: ................................................ Data acquisition, FTP data transfer
Sensor control panel and data plotting
Email alarm and warning messages
User-selected variables
Easy concatenation into continuous time series
Lossless data compression
Data saved in TSoft-compatible format

Cryogenic Orthogonal Tilt Meters and TCS-6 Tilt Compensation System:
Sensitivity / dynamic range: ................................ 0.1 μRadians / 60 mRadian
Controlled alignment with set vertical: ...................... 0.1 μRadian
Dynamic range of controlled system: ........................ 2.5 μRadian

Dewar:
Height (including cold head)/ Diameter: ...................... 102 cm (40 inch) / 36 cm (14 inch)
Weight (including sensor and electronics): .................. 30 kg (65 lbs)
Volume: ........................................................... 16 L liquefied from 9000 L (350 cu ft) gas
Base plate & thermal levelers: ................................ 55 cm (21.5 inch) diameter / 7 kg (16 lbs)

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 iGrav electronics only

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

References:

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

PRICES AND OPTIONS

Contact GWR INSTRUMENTS, INC. for prices and options

GWR INSTRUMENTS, INC.
5985 Pacific Center Blvd., San Diego CA 92121, USA
Tel: (858)425-7655  Fax: (858) 452-6965  Email: information@gwrinstruments.com
http://www.gwrinstruments.com

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