



ABSOLUTE QUANTUM GRAVIMETER

iXblue

A free-fall absolute gravimeter based on laser-cooled atoms.

Thanks to the advances of Quantum Technologies, iXblue is able to provide a turn-key transportable quantum sensor measuring gravity at a level of 10^{-8} m/s^2 . The Absolute Quantum Gravimeter (AQG) measures the acceleration of a free-falling test mass in vacuum: the ballistic free-fall of an ensemble of laser-cooled atoms is accurately monitored, and the acceleration of gravity is then inferred. This technique is one of the ballistic free-fall methods proclaimed by the BIPM (Bureau International des Poids et Mesures) as an official primary method for the measurement of gravity.

It is today the only commercial industry-grade gravity meter to enable continuous absolute measurements from a few seconds to several years. Being at the same time easily transportable it can be deployed anywhere on the planet both indoor and outdoor. This makes the AQG highly suitable for a wide range of applications in geophysics reservoir monitoring, geodesy, metrology and sub-surface imaging for civil engineering.

iXblue at a glance

30

YEARS OF
EXPERIENCE

140+

MILLION EUROS
OF TURNOVER

80%

OF TURNOVER
ACHIEVED ABROAD

750+

EMPLOYEES

200+

PRODUCTS

20%

OF TURNOVER
REINVESTED
EACH YEAR IN R&D

**WORLDWIDE
PRESENCE**

DELIVERING OVER

500

CUSTOMERS
EVERY YEAR

24/7

TECHNICAL
SUPPORT

HIGH-PRECISION GRAVITY MEASUREMENTS

The Absolute Quantum Gravimeter (AQG) is the first commercially available gravimeter based on Quantum Technologies and exploits the principle of atom interferometry with laser-cooled atoms. This unique solution is the result of more than 15 years of research conducted by our academic partners (LP2N and LNE-SYRTE).

The AQG comes in two versions: the AQG-A for indoor use and the AQG-B for field measurements.

It offers very attractive features for high-precision gravity measurements:

- absolute gravity measurement at a level of 10^{-8} m/s² (1 μ Gal) in terms of sensitivity, stability and repeatability
- continuous data acquisition from a few seconds to several years
- transportable device allowing to perform surveys, time-lapse measurement of a network of reference stations or stationary measurements with the same instrument



Picture of the Absolute Quantum Gravimeter. The instrument is composed of the sensor head (right side of the image) where the gravity measurement is performed, and the control unit (left side of the image)

AQG SPECIFICATIONS

Sensitivity (at quiet site)	50 $\mu\text{Gal}/\text{Sqrt}(t)$ 5 μGal in 1.5 min 2 μGal in 10 min 1 μGal in 40 min
Cycling frequency	> 1 Hz
Stability	< 1 typically
Repeatability	$\leq 2 \mu\text{Gal}$
Accuracy	few μGal

Continuous absolute measurements from a few seconds to several months. Data averaging time can be changed at will by the user depending on the application and sub- μGal stability can be achieved with longer averaging time.



A TURN-KEY QUANTUM SENSOR

SIMPLE AND COMPACT ARCHITECTURE

The design of the AQG relies on a patented opto-mechanical architecture using a pyramidal retro-reflector. This configuration allows to perform the measurement sequence with a single laser beam instead of up to eight usually, leading to a drastic simplification of the instrument.

HIGH TOLERANCE TO GROUND VIBRATIONS

The AQG efficiently rejects ground vibration noise with an active compensation technique that does not require any mechanical isolation device or superspring.

HIGH RELIABILITY, FIBERED LASER TECHNOLOGY

The laser system developed by Muquans relies on the use of lasers operating at 1560 nm. This approach therefore gives access to a wide variety of high performance fibered optical components, originally developed for high-bit-rate optical communication systems. Thanks to the technological efforts conducted over the last 20 years by the telecom industry, these components present unique features:

- fibered components: no optical alignment required
- extreme optical and electrical performances
- compliance with Telcordia qualification procedures (extended temperature range)
- high reliability (lifetime > 50 000 h).

EXAMPLES OF AQQ DATA

The AQQ is a flexible gravity sensor able to perform: surveys reaching a resolution of a few μGal with short integration time (Fig. 1), reference station and time-lapse measurements at $1 \mu\text{Gal}$ (Fig. 2) and drift-free long-term continuous gravity monitoring with ultra-high sensitivity (Fig. 3).

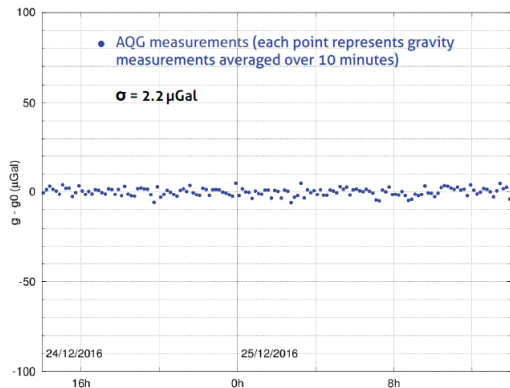


Fig. 1. Example of gravity data provided by the AQQ for a short averaging time in a urban environment. The standard deviation of the data-set is 2.2 μGal .

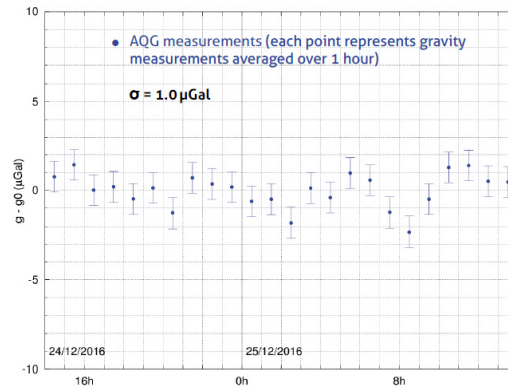


Fig. 2. Example of gravity data provided by the AQQ for a long averaging time in a urban environment. The standard deviation of the data-set is 1.0 μGal .

These values of g are corrected from local tides, atmospheric pressure, tilt deviations and ocean loading. In Fig. 2, error bars correspond to the value of the Allan Deviation of the entire data-set calculated at one hour integration time, which corresponds to the statistical uncertainty of this measurement.

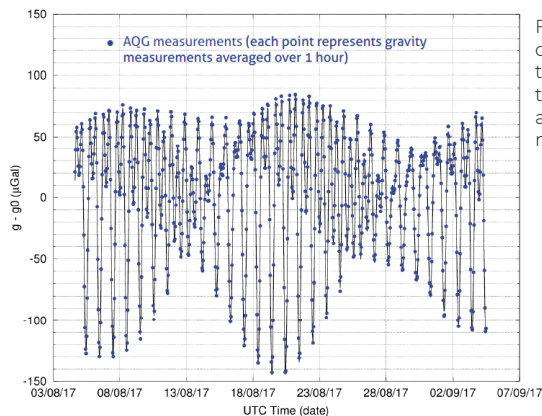


Fig. 3. Example of data provided by the AQQ for long-term continuous absolute gravity monitoring.

This uninterrupted time series has lasted one month and shows local tides. When data are averaged over long durations, the AQQ provides drift-free sub- μGal stability.

FEATURES OF THE FIELD AQQ

GENERAL FEATURES	Control Unit	Sensor Head
Dimensions	2 modules, each: h = 41 cm x w = 59 cm x l = 105 cm	Diam: 40 cm ; Height : 100 cm (tripod incl.)
Floor footprint	1 m ²	0.25 m ²
Weight	Each module < 40 kg	< 40 kg
Power consumption	< 500 W (AC and DC)	
Number of flight cases	5 in total	
Operating temperature	[0°C ; 40°C]	
SPECIFIC FEATURES		
Installation time	15 minutes (no optical alignment, no mechanical assembly, no pumping required prior to measuring)	
Maintenance	Low maintenance effort (no moving parts, no gasket nor belt to replace)	
Robustness to ground vibration	Sub- μ Gal resolution even in urban environments (without spring-based mechanical isolation device)	
Autonomy	Transport and storage for several weeks without any power supply will not affect measurement capability nor require additional pumping (sealed dropping chamber)	
Software	Dedicated and user-friendly data acquisition and system controller software Automated starting procedure Automated self-calibration procedures Remote monitoring and real-time data retrieval	
Data processing	Gravity data is real-time processed with corrections from local tides, atmospheric pressure, tilt variations, ocean loading and polar motion	
Auxiliary sensors	The sensor head of the AQQ houses a classical 3D accelerometer, a pressure gauge, tiltmeters, temperature sensors and a GPS receiver	

REFERENCES

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