exail at a glance

80
YEARS OF EXPERIENCE

250+
MILLION EUROS OF TURNOVER

80%
OF TURNOVER ACHIEVED ABROAD

1500+
EMPLOYEES

15+
QUANTUM GRAVIMETERS OPERATING WORLDWIDE

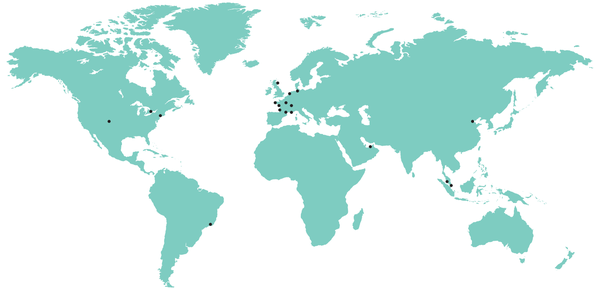
20%
OF TURNOVER REINVESTED EACH YEAR IN R&D

30+
ONGOING PATENTS

100+
LASER SYSTEMS DELIVERED FOR COLD-ATOM TECHNOLOGIES

24/7
TECHNICAL SUPPORT

our global footprint



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ABSOLUTE QUANTUM GRAVIMETER

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

Thanks to the advances of Quantum Technologies, Exail is able to provide a turn-key transportable quantum sensor measuring gravity at a level of 10^{-8} m/s². 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 International Bureau of Weights and Mesures (BIPM) 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.

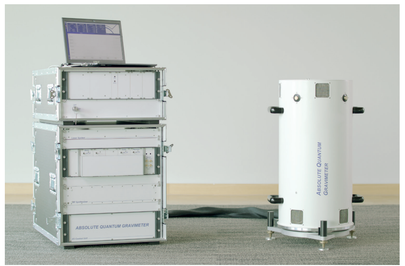
HIGH-PRECISION GRAVITY MEASUREMENTS

The 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^{-9} m/s² (1 µGal) 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



AQG 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 µGal/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	≤ 2 µGal
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 AQG DATA

The AQG 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 µGal (Fig. 2) and drift-free long- term continuous gravity monitoring with ultra-high sensitivity (Fig. 3).

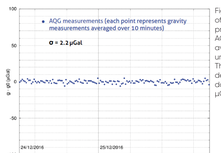


Fig. 1. Example of gravity data provided by the AQG for a short averaging time in a urban environment. The standard deviation of the data-set is 2.2 µGal.

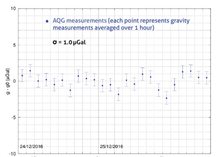


Fig. 2. Example of gravity data provided by the AQG for a long averaging time in a urban environment. The standard deviation of the data-set is 1.0 µGal.

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.

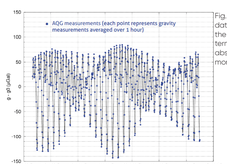


Fig. 3. Example of data provided by the AQG for long-term continuous absolute gravity monitoring.

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

FEATURES OF THE FIELD AQG

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 m²	0.25 m²
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-µGal 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 AQG houses a classical 3D accelerometer, a pressure gauge, tiltmeters, temperature sensors and a GPS receiver