M SQUARED

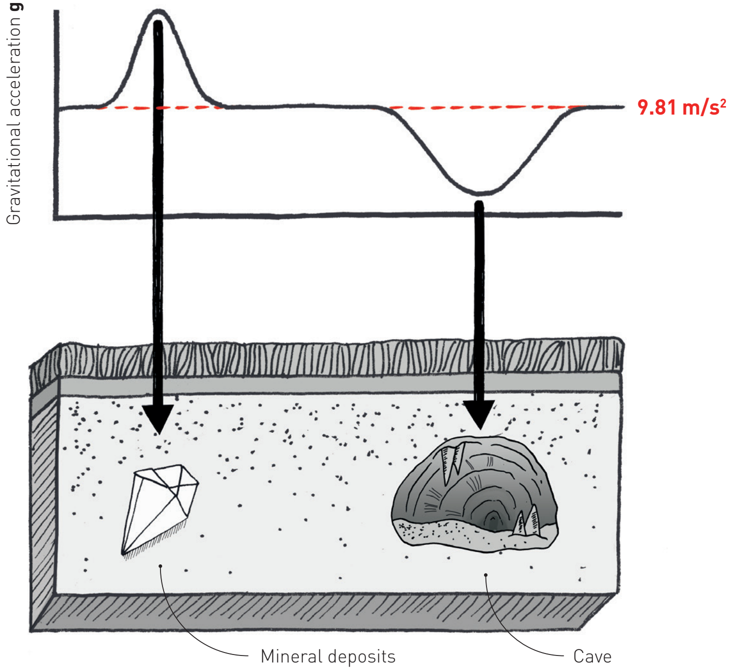
QUANTUM GRAVIMETRY

UK'S FIRST COMMERCIAL QUANTUM GRAVIMETER

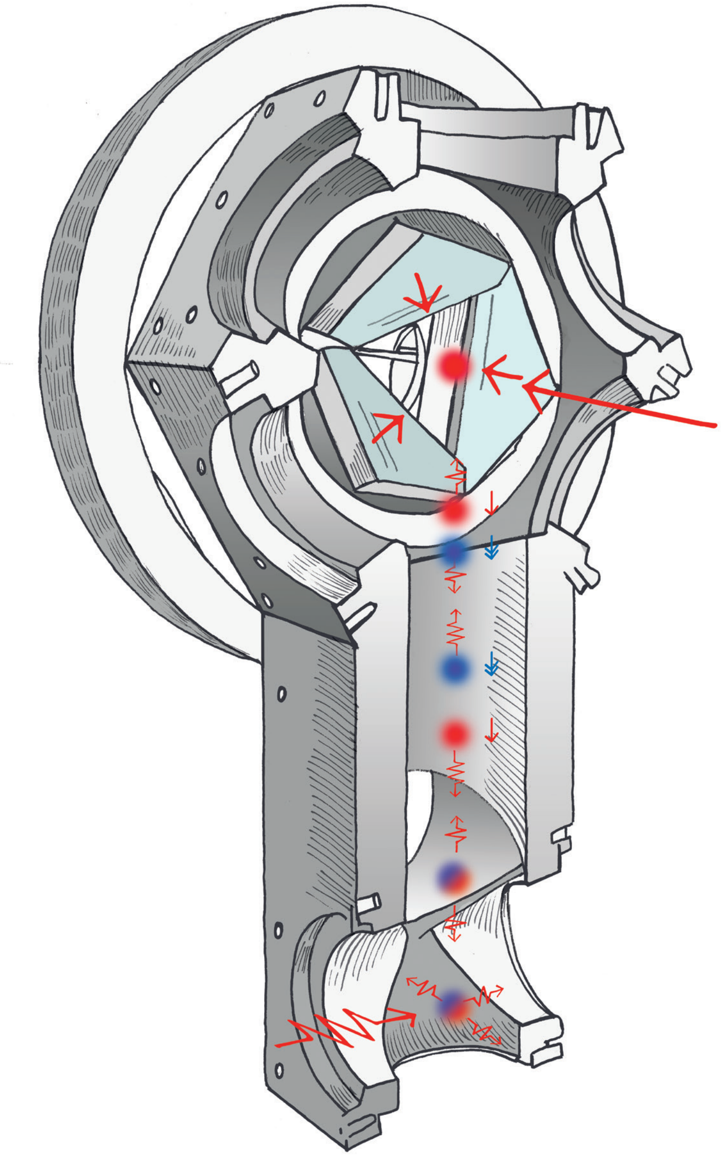
M Squared is developing quantum sensors for real-world applications. Our quantum gravimeter, the first to be built by a company in the UK, uses quantum interference of matter waves to measure the local value of gravitational acceleration, or 'small **g**', with very high precision. Read on to find out why quantum gravimetry is useful, how it works, and what applications it will be used for in the age of quantum sensing.

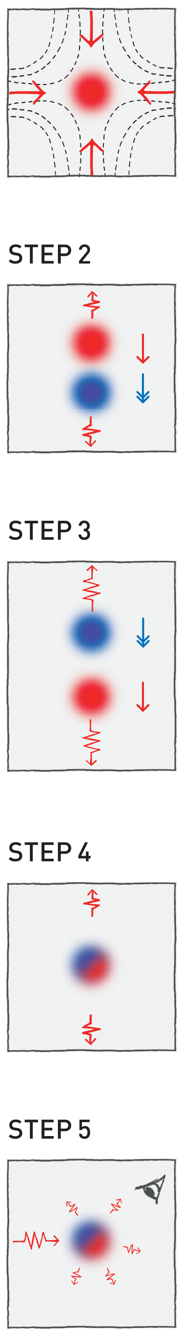
WHY A QUANTUM GRAVIMETER IS USEFUL

On the surface of the Earth, objects are accelerated downwards at a rate of approximately **g** = 9.81 m/s². As the precise value is slightly lower or higher depending on the mass and density of objects in the local underground environment, using a quantum gravimeter to measure **g** is an ideal method of detecting subterranean objects and voids.



HOW THE QUANTUM GRAVIMETER WORKS





STEP 1

Atoms trapped and cooled
Atoms are trapped and cooled to near absolute zero by a combination of magnetic and optical fields before being released to fall under gravity.

STEP 2

Quantum superposition created
A pulse of laser light splits the falling cloud into a quantum superposition of two momentum states. One of the states receives a momentum kick from the laser pulse so that the two halves of the superposition start to spatially separate.

STEP 3

Momentum states reversed
A second laser pulse reverses the momentum states in the superposition, causing them to move closer together again. This 'mirroring' is required so that the two halves of the superposition will eventually overlap again for the next step...

STEP 4

Quantum interference
A third laser pulse recombines the atom clouds, producing quantum interference between the two momentum states. Depending on the local value of **g**, these states interfere constructively or destructively, dictating the final quantum state of the cloud.

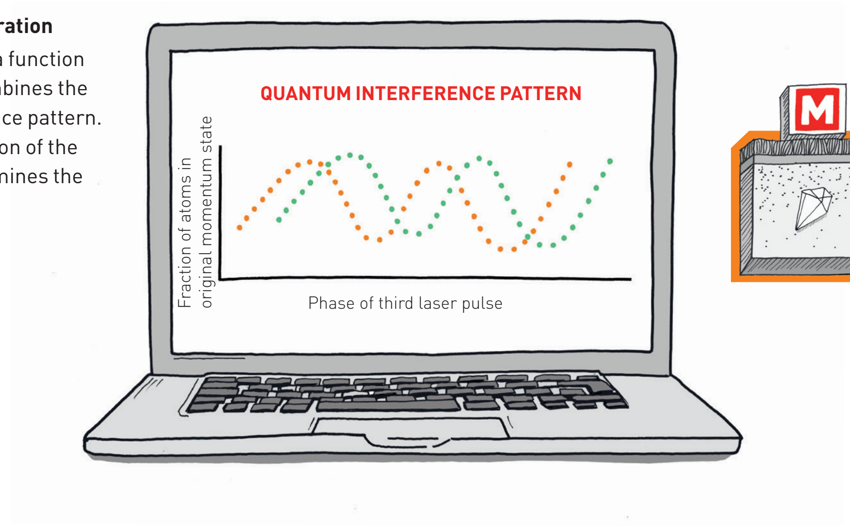
STEP 5

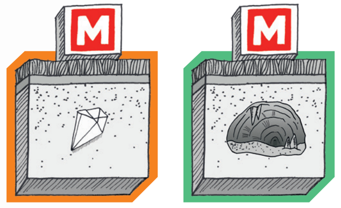
Measurement of final quantum state
A laser beam irradiates the falling cloud. As only one momentum state absorbs and re-emits photons, the amount of scattered light can be measured to determine what fraction of the atoms are in the original momentum state.

STEP 6

Calculation of gravitational acceleration

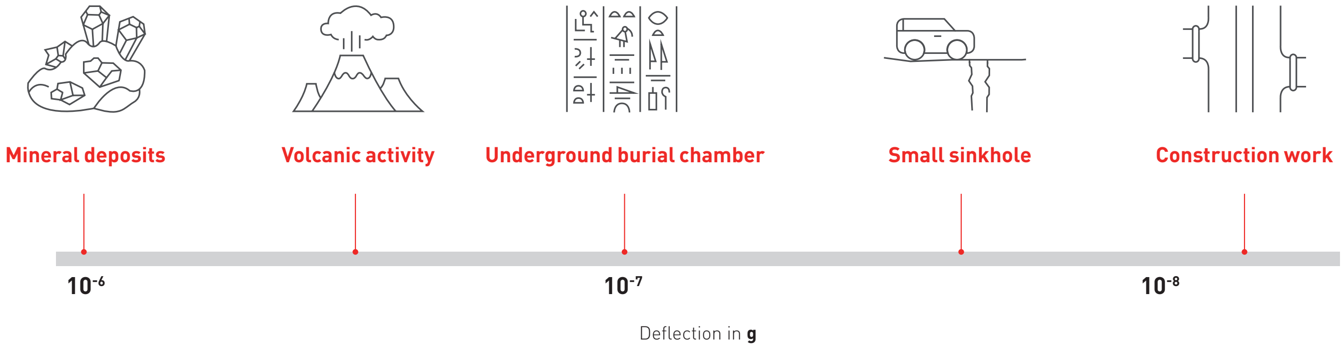
Carrying out this measurement as a function of the phase of the pulse that recombines the atom clouds produces an interference pattern. The phase of this pattern (the location of the peak and trough of the wave) determines the local value of **g**.





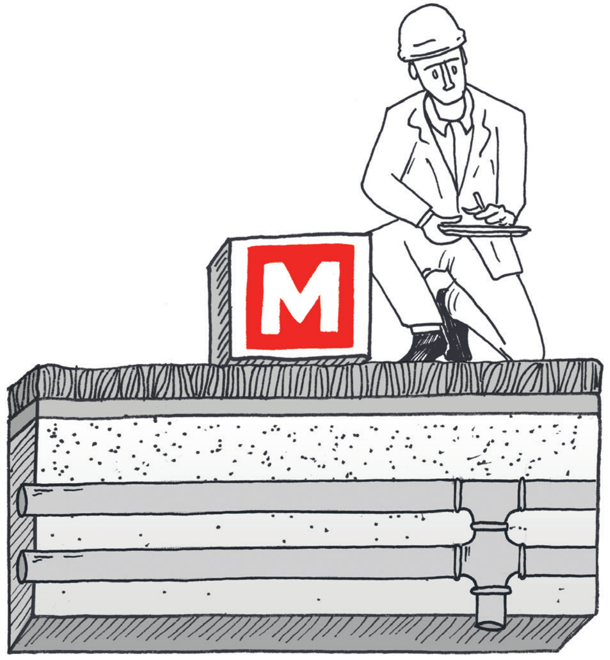
SENSITIVITY REQUIREMENTS OF QUANTUM GRAVIMETRY APPLICATIONS

The measured value of **g** only changes by a very small amount due to objects or voids below the Earth's surface. For example, a gas pipe buried one metre below the surface will change the local value of **g** by around a millionth of one percent. By exploiting quantum superposition and interference, a quantum gravimeter is able to detect these tiny changes in **g**. As the sensitivity of a quantum gravimeter increases, it can be used to detect a greater range of underground objects and phenomena...

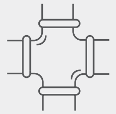


A QUANTUM SENSOR FOR REAL-WORLD APPLICATIONS

M Squared is developing a commercial quantum gravimeter that is not only highly sensitive but also compact and robust, making it suitable for operation in real-world applications where operating conditions may be more challenging than in well-controlled laboratory settings.

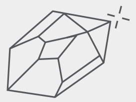


APPLICATIONS



Underground infrastructure assessment

Locating underground structures, such as water and gas pipes buried deep underground, to enhance ground survey analyses and minimise disruption from civil engineering works



Mineral exploration and extraction

Mapping out deposits of oil or gas beneath the earth's surface to enable more efficient resource exploitation with lower environmental impact

Earth observation

Monitoring seismic activity and helping to predict natural disasters like tsunamis or volcanic eruptions

Archaeological surveying

Non-invasive surveying of sites of archaeological interest

CONTACT

Whether you are looking for information or you'd like a question answered, don't hesitate to reach out to us by phone or email. Our quantum team at our innovation headquarters will be more than happy to help you.

T: +44 (0)141 945 0500
E: innovation@m2lasers

m2lasers.com | @m2lasers

GLOBAL LOCATIONS

UK HEADQUARTERS

M Squared
1 Kelvin Campus, West of Scotland
Science Park, Glasgow,
G20 0SP
United Kingdom

UK – LONDON

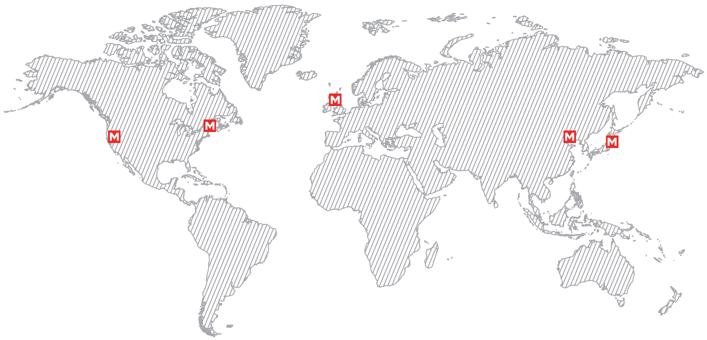
M Squared
14 East Bay Lane, The Press Centre,
Here East, Queen Elizabeth Olympic Park,
Stratford, London E15 2GW
United Kingdom

USA – WEST COAST

M Squared Inc.
3rd Floor,
228 Hamilton Avenue,
Palo Alto,
CA 94301 USA

USA – EAST COAST

M Squared Inc.
Cambridge Innovation Center,
1 Broadway, 14th Floor,
Cambridge,
MA 02142 USA



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