QUANTUM LEVITATION MAGLEV KIT

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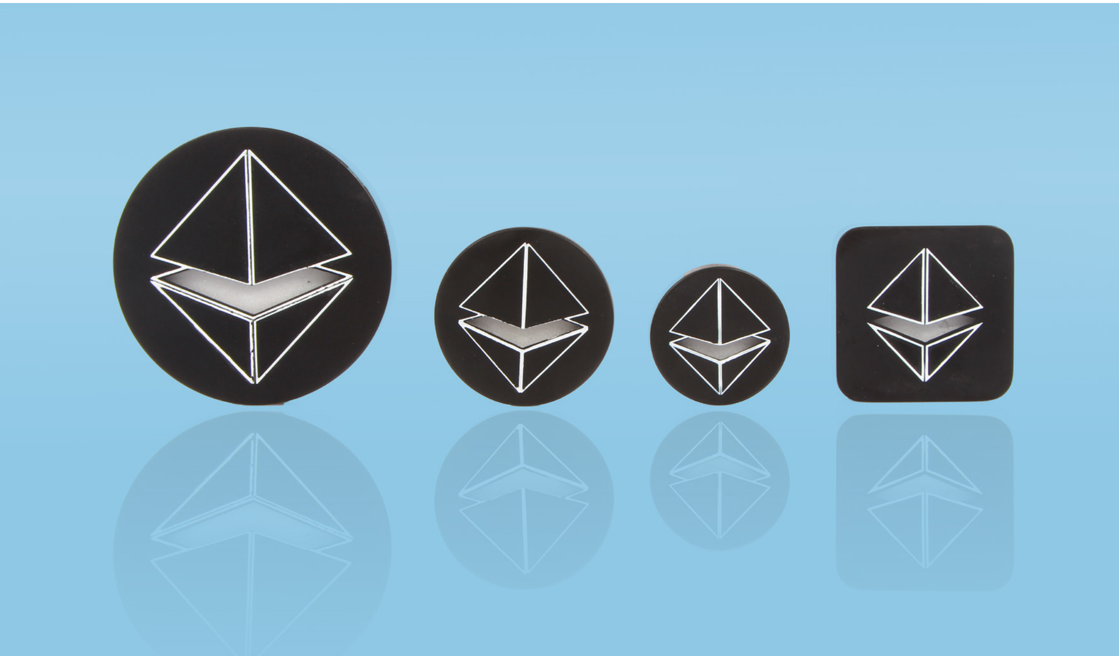
info@QuantumLevitation.com

QUANTUM LEVITATION

Discovered 100 years ago, superconductivity continues to fascinate and attract the interest of scientists and non-scientists all around the globe. Being the only quantum phenomenon visible to the naked eye, it offers a unique window to quantum mechanics.

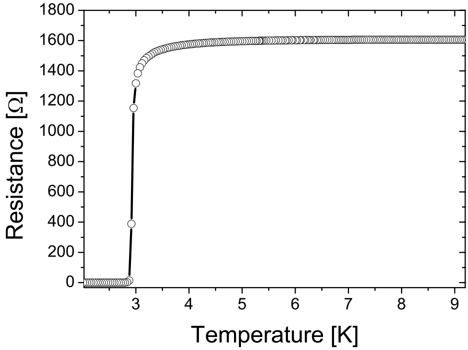
Now you can touch it as well. The collection of 'Quantum Levitation' kits offer a unique opportunity to witness true levitation and feel the quantum locking forces. Designed for Science Education and Demonstrations.

Our kits were specially designed with hands-on experience in mind. Build, touch, witness and learn.



TERMS AND DEFINITIONS

SUPERCONDUCTIVITY



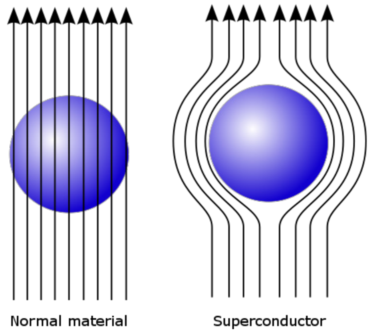
Certain materials, upon cooling below a certain temperature (aka the 'critical temperature' or Tc) lose their electrical resistance completely. The phenomenon was discovered in 1910 by a Dutch physicist named Heike Kamerlingh Onnes who measured the resistance of Mercury at low temperatures. He noticed a sudden drop in the resistance below a certain temperature and (boldly) claimed to have found a new state of matter, which was later named 'Superconductivity'.

Metals such as aluminum, lead, tin become superconductors only at temperatures close to the absolute zero (-273.15C, -459.67F). In 1986 a new family of superconductors was discovered having a much higher Tc, close and even higher than the boiling temperature of liquid nitrogen (-196.15C,-321.07F).

The reason that scientists were and still are, so excited about superconductivity is the fact that having zero electrical resistance (or infinite conductivity) means that electric/magnetic energy is never lost in these materials. Drive a certain current in a superconducting loop and it will continue circulating forever. Dissipation-less phenomenon such as this has never been witnessed in the naturally observable world around us. There is always friction and some energy is lost to heat, mechanical movement, distortion, etc.

MEISSNER EFFECT

The expulsion of the magnetic field from a superconductor is an intrinsic property of any superconductor. Below a certain magnetic field strength the superconductor expels nearly all the magnetic flux. It does this by driving currents near its surface. These currents produce a magnetic field inside the superconductor that cancels out the external field.

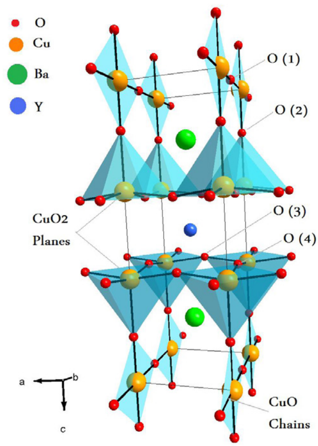


FLUX PINNING

In some cases the magnetic flux becomes locked or "pinned" inside a superconductor. Flux pinning is desirable in high-temperature ceramic superconductors to prevent flux movements which introduce a resistance and dissipate energy. The pinning is achieved through defects in the crystalline structure of the superconductor usually resulting from grain boundaries or impurities.

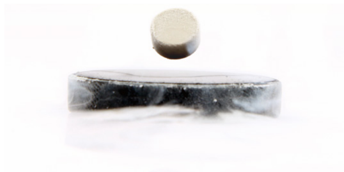
YBCO

An acronym for a ceramic superconductor composed of Yttrium, Barium, Copper and Oxygen. Its molecular formula is YBa2Cu3O7-x. YBCO is a type-II superconductor highly promising for applications due to its critical temperature which is well above the boiling point of liquid nitrogen.



EXPERIMENTS

MEISSNER EFFECT

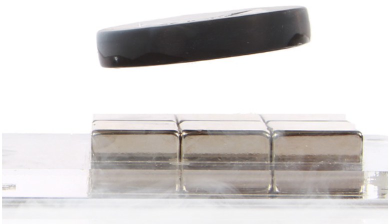


The Meissner effect describes the expulsion of magnetic flux from the superconductor.

EXPERIMENT: Gently lower the cooled levitator into the magnetic field, ~3cm above the permanent magnet. Do not apply too much force. See how it is repelled (falls aside). Now, try to force it a few more millimeters into the field and see how it levitates while still wobbling around.

CONCLUSIONS: In the Meissner state the superconductor is diamagnetic, it has an opposite magnetization. It therefore exhibits unstable magnetic repulsion, like two repelling magnets.

QUANTUM LOCKING



The locking is the key to understanding Quantum Levitation. Show how the levitator is frozen in the vicinity of the magnets.

EXPERIMENT: Take the cooled levitator and place it above the magnet matrix (3x2 rectangle). The superconductor stays “frozen” in air. Using the tweezers, gently try to move it in all directions and feel the resistance due to the pinning force. Show that the superconductor can be placed in any orientation including hanging upside down under the magnet matrix..

CONCLUSIONS: The superconductor is ‘locked’ in space. The locking forces are not just repulsion forces. They can be attractive or repulsive as required in order to keep the superconductor in place.

FRICTIONLESS BEARING

After witnessing quantum locking it's time to further explore its properties.

EXPERIMENT: Lock the levitator above the pair of ring magnets. It will rotate freely around the axis of the magnets but will be locked in any other direction. Shift the superconductor sideways to emphasize that it rotates around the magnet axis and not around its center.

CONCLUSIONS: The superconductor moves freely as long as the magnetic field inside it (magnetic flux) stays the same.

MAGNETIC LEVITATION (MAGLEV)

The main part of the demo.

EXPERIMENT: Place the cooled levitator on top of the circular rail. Show that it moves freely along the track. Show that, similar to the locking demo, you can place the superconductor in various angles and heights. Observe that the locking force (pinning force) is stronger closer to the magnets.

CONCLUSIONS: The large track is like a larger version of the ring magnets. The fact that the magnetic flux does not change along the track allows the superconductor to move around freely.

SUSPENSION

Now we are really flipping out!

EXPERIMENT: Take the magnetic track and flip it over the stand. Carefully place the levitator below the rail with the superconductor side (without the logo) close to the magnets. Show how it moves around freely.

CONCLUSIONS: Moving around in circles is possible due to the circular symmetry of the magnetic field. In all other directions the superconductor is locked. The levitation can, thus, be easily transformed into suspension.

DOUBLE LEVITATION

This is one of the most impressive demos you can make using this kit.

Some practice is necessary in order toachieve an optimal effect.

EQUIPMENT: 2 Quantum Levitator, plastic tweezers, magnetic track

EXPERIMENT: Place one superconductor on the rail as high as possible. Try to fill it with a minimal amount of liquid nitrogen; this will allow a maximal levitation height. Now place the second superconductor as low as possible. Notice that if it is too close to the magnets it will slow down more quickly; so be prepared to give it a boost more often. Another issue to pay attention to is the wrapping: if not neatly wrapped the plastic/aluminum might interfere with the other levitator. Show how the two superconductors move without interfering with each other.

CONCLUSIONS: The superconductors are NOT magnetic (at least not substantially). If they were magnetic, they would have affected each other. This experiment proves that the levitation is not (mainly) due to the Meissner effect. In the Meissner state the superconductor acts as a perfect diamagnet, having a magnetization of equal magnitude and opposite direction to the external field.

WARNING!

The Quantum Levitation experiment uses extremely strong neodymium magnets. These magnets, if not handled carefully, can cause serious injury. Keep the magnets away from magnetic materials and far from sensitive electronics.

HANDLING INSTRUCTIONS

The superconductor inside the Quantum Levitator is sensitive to moisture. If not handled properly it will lose its superconducting properties. You should always let the levitator warm up (< 40^{0}_{C}) and dry after usage. We recommend that you store the levitator in dry place, preferably inside a sealed container with silica gel.