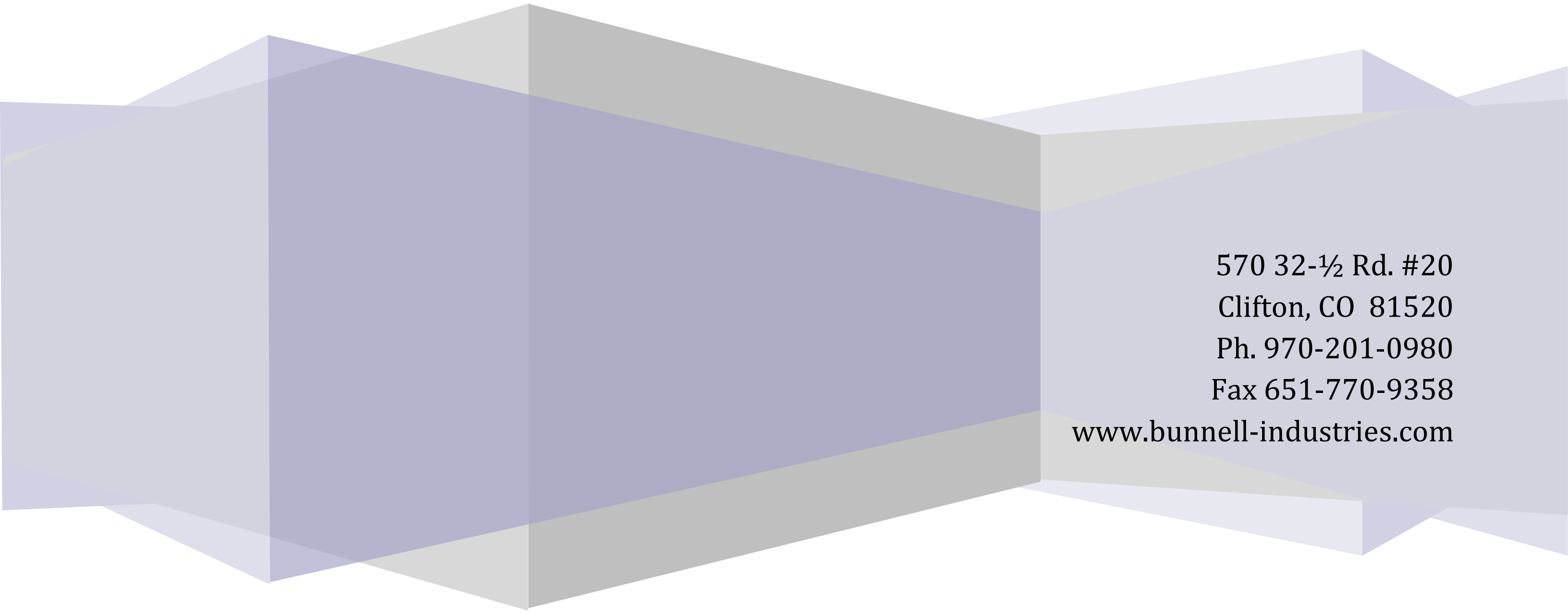
Bunnell Industries

Super-Fluidity Material (SFM)



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Super-Fluidity Material (SFM)

About Super-Fluids

Our super-fluid exhibits a quantum physical behavior. SFM is material in micro-clusters.

A micro-cluster is a small chemically inert cluster of atoms that has a definite crystalline structure. Micro-clusters exist as a molecular species which can substitute and mimic various elements.

Super-fluids are composed of a group of atoms which are all in the same quantum state. Such a group of atoms consequently behaves in some ways, as a single atom.

A super-fluid is a liquid that ***flows without viscosity or inner friction.***

Super-fluids have tunneling properties in their quantum state.

A super-fluid circulated around a space type suit or around the interior of a container would provide the same quantum effect as our All-Purpose Medicine (APM) or Super-Conductive Material (SCM). It would also react as well as APM in the body for bi-location and astral travel purposes.

With the tunneling properties in a suit or container, it will cover all of the area plus tunnel into anything or anybody which may be enclosed by the SFM.

Properties of SFM

Our quantum state SFM contains an odd number of particles, three (3) in each nucleus of each atom. Our SFM cooper pairs and the particles in each nucleus add up to an even number, making it a type of particle known as a boson. Groups of bosons can fall into the same quantum state, and therefore super-fluidity is achieved.

When electrons are cooper paired, they cease to behave as particles and begin to behave more like light.

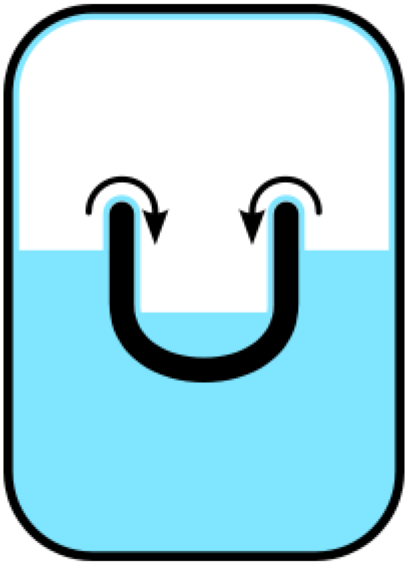
SFM is cooper paired and both atoms in the diatom behave as one atom. It will then resonance couple with other diatoms nearby. This resonance coupled quantum oscillation is like the quantum oscillation of open-ended string energy.

Common Uses of SFM

- Use an ionic form of SFM in a half-evaporated liquid.
- It may be used to flow through pipes or other walled enclosures.
- Use in hydraulics or other cases where low viscosity is required.

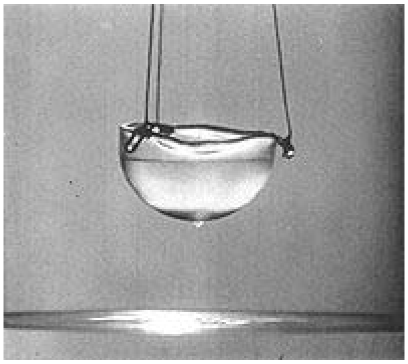
NOTE: *THE FOLLOWING ARE "COMMON DEFINITIONS" PERTAINING TO THE BASIC SCIENCE BEHIND OUR SUPER-FLUIDITY MATERIAL. HOWEVER, WE HAVE FURTHER ADVANCED THIS SCIENCE AND RESEARCH TO ACHIEVE OUR VERY UNIQUE SFM.*

Super-fluidity



Helium II will "creep" along surfaces in order to find its own level - after a short while, the levels in the two containers will equalize. The Rollin film also covers the interior of the larger container; if it were not sealed, the helium II would creep out and escape.

Superfluidity is a phase of matter or description of heat capacity in which unusual effects are observed when liquids, typically of helium-4 or helium-3, overcome friction by surface interaction when at a stage (known as the "lambda point" for helium-4) at which the liquid's viscosity becomes zero. Also known as a major facet in the study of quantum hydrodynamics, it was discovered by Pyotr Kapitsa, John F. Allen, and Don Misener in 1937 and has been described through phenomenological and microscopic theories. In the 1950s Hall and Vinen performed experiments establishing the existence of quantized vortex lines. In the 1960s, Rayfield and Reif established the existence of quantized vortex rings. Packard has observed the intersection of vortex lines with the free surface of the fluid, and Avenel and Varoquaux have studied the Josephson effect in superfluid ^{4}He.



The liquid helium is in the superfluid phase. As long as it remains superfluid, it creeps up the inside wall of the cup as a thin film. It comes down on the outside, forming a drop which will fall into the liquid below. Another drop will form - and so on - until the cup is empty.

Contents

Some theories

L. D. Landau's phenomenological and semi-microscopic theory of superfluidity of ^{4}He earned him the Nobel Prize in Physics in 1962. Assuming that sound waves are the most important excitations in ^{4}He at low temperatures, he showed that ^{4}He flowing past a wall would not spontaneously create excitations if the flow velocity was less than the sound velocity. In this model, the sound velocity is the "critical velocity" above which superfluidity is destroyed.

(^{4}He has a lower flow velocity than the sound velocity, but this model is useful to illustrate the concept.) Landau also showed that the sound wave and other excitations could equilibrate with one another and flow separately from the rest of the ^{4}He called the "condensate".

From the momentum and flow velocity of the excitations he could then define a "normal fluid" density, which is zero at zero temperature and increases with temperature. At the so-called Lambda temperature, where the normal fluid density equals the total density, the ^{4}He is no longer superfluid.

To explain the early specific heat data on superfluid ^{4}He, Landau posited the existence of a type of excitation he called a "roton", but as better data became available he considered that the "roton" was the same as a high momentum version of sound.

Bijl in the 1940s[1], and Feynman around 1955 [2], developed microscopic theories for the roton, which was shortly observed with inelastic neutron experiments by Palevsky.

Landau thought that vorticity entered superfluid ^{4}He by vortex sheets, but such sheets were shown to be unstable.

Lars Onsager and, later independently, Feynman showed that vorticity enters by quantized vortex lines. They also developed the idea of quantum vortex rings.

Background

Although the phenomenologies of the superfluid states of helium-4 and helium-3 are very similar, the microscopic details of the transitions are very different. Helium-4 atoms are bosons, and their superfluidity can be understood in terms of the Bose statistics that they obey. Specifically, the superfluidity of helium-4 can be regarded as a consequence of Bose-Einstein condensation in an interacting system. On the other hand, helium-3 atoms are fermions, and the superfluid transition in this system is described by a generalization of the BCS theory of superconductivity. In it, Cooper pairing takes place between atoms rather than electrons, and the attractive interaction between them is mediated by spin fluctuations rather than phonons. (See fermion condensate.) A unified description of superconductivity and superfluidity is possible in terms of gauge symmetry breaking.

Superfluids, such as supercooled helium-4, exhibit many unusual properties. (See Helium#Helium II state). Superfluid acts as if it were a mixture of a normal component, with all the properties associated with normal fluid, and a superfluid component. The superfluid component has zero viscosity, zero entropy, and infinite thermal conductivity. (It is thus impossible to set up a temperature gradient in a superfluid, much as it is impossible to set up a voltage difference in a superconductor.) Application of heat to a spot in superfluid helium results in a wave of heat conduction at the relatively high velocity of 20 m/s, called **second sound**.

One of the most spectacular results of these properties is known as the thermomechanical or "fountain effect". If a capillary tube is placed into a bath of superfluid helium and then heated, even by shining a light on it, the superfluid helium will flow up through the tube and out the top as a result of the Clausius-Clapeyron relation. A second unusual effect is that superfluid helium can form a layer, 30 nm thick, up the sides of any container in which it is placed. See Rollin film.

A more fundamental property than the disappearance of viscosity becomes visible if superfluid is placed in a rotating container. Instead of rotating uniformly with the container, the rotating state consists of quantized vortices. That is, when the container is rotated at speed below the first critical velocity (related to the quantum numbers for the element in question) the liquid remains perfectly stationary. Once the first critical velocity (the speed of sound in the superfluid) is reached, the superfluid will very quickly begin spinning at the critical speed. The speed is quantized, that is, a superfluid can only spin at certain "allowed" or critical speed values. In simplified terms, if the container is rotated to a certain allowed speed, the superfluid will rotate very quickly along with the container, otherwise, if the speed is too slow, then the superfluid will not move at all, unlike how a normal fluid like water will rotate along with its container from the start. (compare this to the london moment)

Applications

Recently in the field of chemistry, superfluid helium-4 has been successfully used in spectroscopic techniques as a quantum solvent. Referred to as Superfluid Helium Droplet Spectroscopy (SHeDS), it is of great interest in studies of gas molecules, as a single molecule solvated in a superfluid medium allows a molecule to have effective rotational freedom, allowing it to behave exactly as it would in the "gas" phase.

Superfluids are also used in high-precision devices such as gyroscopes, which allow the measurement of some theoretically predicted gravitational effects (for an example see the Gravity Probe B article).

Recently, one type of superfluid has been used to trap light and slow its speed greatly. In an experiment performed by Lene Hau, light was passed through a Bose-Einstein condensed gas of sodium (analogous to a superfluid) and found to be slowed to 17 m/s (61.2 km/h) from its normal speed of 299,792,458 metres per second in vacuum.[3] This does not change the absolute value of *c*, nor is it completely new: any medium other than vacuum, such as water or glass, also slows down the propagation of light to *c*/*n* where *n* is the material's refractive index. The very slow speed of light and high refractive index observed in this particular experiment, moreover, is not a general property of all superfluids.

The Infrared Astronomical Satellite IRAS, launched in January 1983 to gather infrared data was cooled by 720 litres of superfluid helium, maintaining a temperature of 1.6 K (-271.4 -°C).

Recent discoveries

Physicists have recently been able to create a Fermionic condensate from pairs of ultra-cold fermionic atoms. Under certain conditions, fermion pairs form diatomic molecules and undergo Bose–Einstein condensation. At the other limit, the fermions (most notably superconducting electrons) form Cooper pairs which also exhibit superfluidity. This recent work with ultra-cold atomic gases has allowed scientists to study the region in between these two extremes, known as the BEC-BCS crossover.

Additionally, super*solids* may also have been discovered in 2004 by physicists at Penn State University. When helium-4 is cooled below about 200 mK under high pressures, a fraction (~1%) of the solid appears to become superfluid.[4] By quench cooling or lengthening the annealing time, thus increasing or decreasing the defect density respectively, it was shown, via torsional oscillator experiment, that the supersolid fraction could be made to range from 20% to completely non-existent. This suggested that the supersolid nature of helium-4 is not intrinsic to helium-4 but a property of helium-4 and disorder. [5] [6] Some emerging theories posed that the supersolid signal observed in helium-4 was actually an observation of either a superglass state [7] or intrinsically superfluid grain boundaries in the helium-4 crystal. [8]

Notes

1. **^** Bijl, A; Michels A (1941). "Properties of liquid helium II". *Physica* **8** (7): 655-675. doi:10.1016/S0031-8914(41)90422-6.
2. **^** Braun, L. M., ed (2000). *Selected papers of Richard Feynman with commentary*. World Scientific Series in 20th century Physics. **27**. World Scientific. ISBN 978-9810241315. Section IV (pages 313 to 414) deals with Liquid Helium. http://www.google.com/books?id=qnwkqcVixucC&printsec=frontcover&dq=feynman&lr=
3. **^** Lene Vestergaard Hau, S. E. Harris, Zachary Dutton, Cyrus H. Behroozi Light speed reduction to 17 metres per second in an ultracold atomic gas Nature 397, 594-598 (18 February 1999)
4. **^** Moses Chan's Research Group. "Supersolid." *Penn State University,* 2004.
5. **^** Sophie, A; Reppy J (2006). "Observation of Classical Rotational Inertia and Nonclassical Supersolid Signals in Solid 4 He below 250 mK". *Phys. Rev. Lett* **97**: 165301.
6. **^** Sophie, A; Reppy J (2007). "Disorder and the Supersolid State of Solid 4 He". *Phys. Rev. Lett* **98**: 175302.
7. **^** Boninsegni, M; Svistunov (2006). "Superglass Phase of 4 He". *Phys. Rev. Lett* **96**: 135301.
8. **^** Pollet, L; Troyer M (2007). "Superfuididty of Grain Boundaries in Solid 4 He". *Phys. Rev. Lett* **98**: 135301.

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- Antony M. Guénault: *Basic superfluids.* Taylor & Francis, London 2003, ISBN 0-7484-0891-6
- James F. Annett: *Superconductivity, superfluids, and condensates.* Oxford Univ. Press, Oxford 2005, ISBN 978-0-19-850756-7

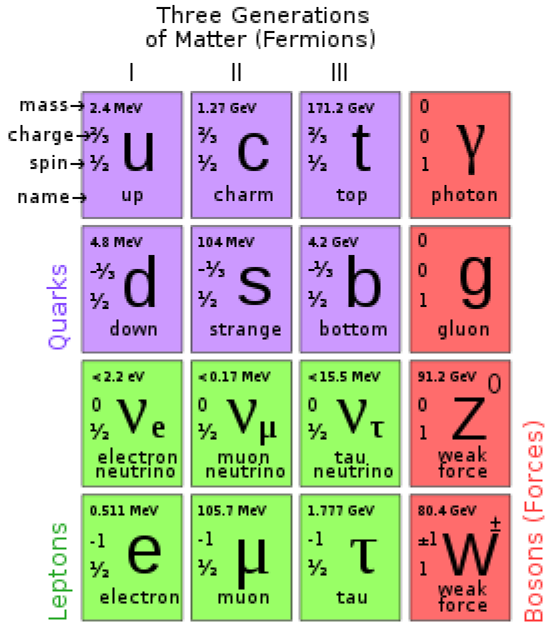
External links

- Liquid Helium II,Superfluid:demonstrations of Lambda point transition/viscosity paradox /two fluid model/fountain effect/creeping film/ second sound.
- Video including superfluid helium's strange behavior
- Superfluid phases of helium
- Lancaster University, Ultra Low Temperature Physics - Superfluid helium-3 research group.
- http://www.aip.org/png/html/helium3.htm
- http://www.aip.org/pt/vol-54/iss-2/p31.html
- http://web.mit.edu/newsoffice/2005/matter.html
- http://physicsweb.org/articles/world/11/6/3/1
- superfluid hydrodynamics

Retrieved from "http://en.wikipedia.org/wiki/Superfluid"

Boson

In particle physics, bosons are particles which obey Bose–Einstein statistics; they are named after Satyendra Nath Bose and Albert Einstein. In contrast to fermions, which obey Fermi-Dirac statistics, several bosons can occupy the same quantum state. Thus, bosons with the same energy can occupy the same place in space. Therefore bosons are often force carrier particles while fermions are usually associated with matter, though the distinction between the two concepts is not clear cut in quantum physics.



The Standard Model of elementary particles, with the gauge bosons in the last column.

Bosons may be either elementary, like the photon, or composite, like mesons. All observed bosons have integer spin, as opposed to fermions, which have half-integer spin. This is in accordance with the spin-statistics theorem which states that in any reasonable relativistic quantum field theory, particles with integer spin are bosons, while particles with half-integer spin are fermions.

While most bosons are composite particles, in the Standard Model, there are five bosons which are elementary:

- the gauge bosons (γ · g · $W^{\pm}$ · Z);
- the Higgs boson (H^0).

Unlike the gauge bosons, the Higgs boson has not yet been observed experimentally.[1]

Composite bosons are important in super-fluidity and other applications of Bose–Einstein condensates.

Definition and basic properties

By definition, bosons are particles which obey Bose-Einstein statistics: when one swaps two bosons, the wave function of the system is unchanged.[2] Fermions, on the other hand, obey Fermi-Dirac statistics and the Pauli exclusion principle: two fermions cannot occupy the same quantum state as each other, resulting in a "rigidity" or "stiffness" of matter which includes fermions. Thus fermions are sometimes said to be the constituents of matter, while bosons are said to be the particles that transmit interactions (force carriers), or the constituents of radiation. The quantum fields of bosons are bosonic fields, obeying canonical commutation relations.

The properties of lasers and masers, superfluid helium-4 and Bose–Einstein condensates are all consequences of statistics of bosons. Another result is that the spectrum of a photon gas in thermal equilibrium is a Planck spectrum, one example of which is black-body radiation; another is the thermal radiation of the opaque early Universe seen today as microwave background radiation. Interaction of virtual bosons with real fermions are called fundamental interactions, and these result in all forces we know. The bosons involved in these interactions are called gauge bosons.

All known elementary and composite particles are bosons or fermions, depending on their spin: particles with half-integer spin are fermions; particles with integer spin are bosons. In the framework of nonrelativistic quantum mechanics, this is a purely empirical observation. However, in relativistic quantum field theory, the spin-statistics theorem shows that half-integer spin particles cannot be bosons and integer spin particles cannot be fermions.[3]

In large systems, the difference between bosonic and fermionic statistics is only apparent at large densities—when their wave functions overlap. At low densities, both types of statistics are well approximated by Maxwell-Boltzmann statistics, which is described by classical mechanics.

Elementary bosons

All observed elementary particles are either fermions or bosons. The observed elementary bosons are all gauge bosons: photons, W and Z bosons and gluons.

- Photons are the force carriers of the electromagnetic field.
- W and Z bosons are the force carriers which mediate the weak nuclear force.
- Gluons are the fundamental force carriers underlying the strong nuclear force.

In addition, the standard model postulates the existence of Higgs bosons, which give other particles their mass via the Higgs mechanism.

Finally, many approaches to quantum gravity postulate a force carrier for gravity, the graviton, which is a boson of spin 2.

Composite bosons

Composite particles (such as hadrons, nuclei, and atoms) can be bosons or fermions depending on their constituents. More precisely, because of the relation between spin and statistics, a particle containing an even number of fermions is a boson, since it has integer spin.

Examples include the following:

- A meson contains two fermionic quarks and is therefore a boson;
- The nucleus of a carbon-12 atom contains 6 protons and 6 neutrons (all fermions) and is therefore a boson;
- The atom helium-4 (^{4}He) is made of 2 protons, 2 neutrons and 2 electrons and is therefore a boson.

The number of bosons within a composite particle made up of simple particles bound with a potential has no effect on whether it is a boson or a fermion.

Fermionic or bosonic behavior of a composite particle (or system) is only seen at large (compared to size of the system) distance. At proximity, where spatial structure begins to be important, a composite particle (or system) behaves according to its constituent makeup. For example, two atoms of helium-4 cannot share the same space if it is comparable by size to the size of the inner structure of the helium atom itself (~10^{-10} m)—despite bosonic properties of the helium-4 atoms. Thus, liquid helium has finite density comparable to the density of ordinary liquid matter.

Bosons have integer spin. The fundamental forces of nature are mediated by gauge bosons, and mass is hypothesized to be created by the Higgs boson. According to the Standard Model (and to both linearized general relativity and string theory, in the case of the graviton) the elementary bosons are:

Name	**Symbol**	**Antiparticle**	**Charge (e)**	**Spin**	**Mass (GeV/c^2)**	**Interaction mediated**	**Existence**
Photon	γ	Self	0	1	0	Electromagnetism	Confirmed
W boson	W^-	W^+	−1	1	80.4	Weak interaction	Confirmed
Z boson	Z	Self	0	1	91.2	Weak interaction	Confirmed
Gluon	g	Self	0	1	0	Strong interaction	Confirmed

Higgs boson	H^0	Self?	0	0	> 112	None	Unconfirmed
Graviton	G	Self	0	2	0	Gravitation	Unconfirmed

Note that the graviton is added to the list although it is not predicted by the Standard Model, but by other theories in the framework of quantum field theory.

The Higgs boson is postulated by electroweak theory primarily to explain the origin of particle masses. In a process known as the Higgs mechanism, the Higgs boson and the other fermions in the Standard Model acquire mass via spontaneous symmetry breaking of the SU(2) gauge symmetry. In some theories the Higgs mechanism does not require the existence of a Higgs boson. It is also the only Standard Model particle not yet observed (the graviton is not a Standard Model particle). Assuming that the Higgs boson exists, it is expected to be discovered at the Large Hadron Collider. Moreover, the Minimal Supersymmetric Standard Model (MSSM) predicts several Higgs bosons.

Notes

1. ^ Standard Model of Particle Physics, SLAC Large Detector (SLD) group, Stanford Linear Accelerator Center.
2. ^ Srednicki (2007), pages 28-29
3. ^ Sakurai (1994), page 362

References

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- C. Amsler et al. (2008). "Review of Particle Physics". Physics Letters B 667: 1. doi:10.1016/j.physletb.2008.07.018. (All information on this list, and more, can be found in the extensive, biannually-updated review by the Particle Data Group)
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