SUPERCONDUCTING AND MEISSNER EFFECT

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ABSTRACT

The main problem is about Arodnap and flying islands. On the planet Arodnap, the average atmospheric temperature is about 60 K and it doesn't fluctuate much during day and night. We may find there some levitating islands, like the ones from the Avatar movie. Of course, the planet Arodnap is fictional. However, we should try to come up with a plausible mechanism of the formation of such islands and to investigate which processes could lead to the formation of specific minerals, that are in charge of these effects? We are going to suggest, based on this mechanism, the features of Arodnap: its geological history, a composition of the atmosphere and crust and so on.

1 Introduction

Superconductivity and the phenomenon of floating object in a magnetic field, is a phenomenon that is emerging for some materials in certain circumstances. The main issue is how to float this material.

Superconductivity is a phenomenon that happens at exactly zero electrical resistance and expulsion of magnetic flux fields which occurs in certain materials, called superconductors . Superconductors are made due to cooling below a characteristic critical temperature. It was discovered by Dutch physicist Heike Kamerlingh Onnes on April 8, 1911, in Leiden. Like ferromagnetism and atomic spectral lines, superconductivity is a quantum mechanical phenomenon. It is characterized by the Meissner effect, the complete ejection of magnetic field lines from the interior of the superconductor during its transitions into the superconducting state. The Meissner effect indicates that superconductivity cannot be understood simply as the idealization of perfect conductivity in classical physic

The electrical resistance of a metallic conductor decreases gradually as temperature is lowered. In ordinary conductors, such as copper or silver, this decrease is limited by impurities and other defects. Even near absolute zero, a real sample of a normal conductor shows some resistance. In a superconductor, the resistance drops abruptly to zero when the material is cooled below its critical temperature. An electric current through a loop of superconducting wire can persist indefinitely with no power source.

In 1986, it was discovered that some cuprate-perovskite ceramic materials have a critical temperature above 90 K (−183 °C). Such a high transition temperature is theoretically impossible for a conventional superconductor, leading the materials to be termed high-temperature superconductors. The cheaply-available coolant liquid nitrogen boils at 77 K, and thus superconduction at higher temperatures than this facilitates many experiments and applications that are less practical at lower temperatures .

2 Theory and Modeling

2-1 Meissner Effect

When a superconductor is placed in a weak external magnetic field and cooled below its transition temperature, the magnetic field is ejected. The Meissner effect does not cause the field to be completely ejected but instead the field penetrates the superconductor but only to a very small distance, characterized by a parameter λ , called the London penetration depth, decaying exponentially to zero within the bulk of the material. The Meissner effect is a defining characteristic of superconductivity. For most superconductors, the London penetration depth is in the order of 100 nm.

The Meissner effect is sometimes confused with the kind of diamagnetism one would expect in a perfect electrical conductor: according to Lenz's law, when a changing magnetic field is applied to a conductor, it will induce an electric current in the conductor that creates an opposing magnetic field. In a perfect conductor, an arbitrarily large current can be induced, and the resulting magnetic field exactly cancels the applied field

The Meissner effect is the spontaneous expulsion which occurs during transition to superconductivity. Suppose we have a material in its normal state, containing a constant internal magnetic field. When the material is cooled below the critical temperature, we would observe the abrupt expulsion of the internal magnetic field, which we would not expect based on Lenz's law (Eq.1)[1].

$$\nabla^2 \mathbf{H} = \lambda^{-2} \mathbf{H} \quad (1)$$

Where H is the magnetic field and λ is the London penetration dept. This equation, which is known as the London equation, predicts that the magnetic field in a superconductor decays exponentially from whatever value it possesses at the surface.

2-2 Different Types of Superconductors

We have two type of superconductors, superconductors type I and type II. In superconductor type: I if magnetic field increases from the base (H_C) , superconductor suddenly disappears. (H-C) is a limit of the magnetic field. Most of the superconductors type 1 are simple elements except (Tc. V. carbon Nano layers) (Fig 1). Depending on the geometry of the sample, one may obtain an intermediate state consisting of a baroque pattern of regions of normal material carrying a magnetic field mixed with regions of superconducting material containing no field [2].

In Type II superconductors, raising the applied field past a critical value Hc1 leads to a mixed state (also known as the vortex state) in which an increasing amount of magnetic flux penetrates the material, but there remains no resistance to the flow of electric current as long as the current is not too large. At second critical field strength Hc2, superconductivity is destroyed. The mixed state is actually caused by vortices in the electronic superfluid, sometimes called fluxion (Fig. 2).

Most pure elemental superconductors, except niobium and carbon nano-tubes, are Type I, while almost all impure and compound superconductors are Type II.

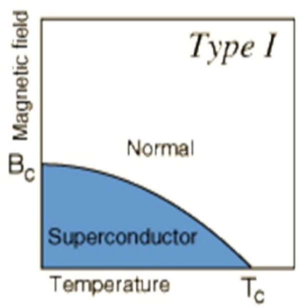

Fig.1: Superconductivity, Type I

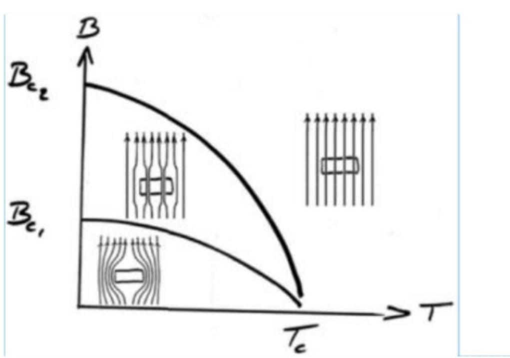

Fig.2: Superconductivity, Type II

Elements that they are superconductor type: I , with their Tc in kelvin are as written in table (1) and compounds with their superconductivity in table (2).

Table 1: superconductor Type I, elements

element	Tc	element	Tc	element	Tc	element	Tc	element	Tc
Al	1.175	Hg^{β}	3.949	Nb	9.25	Ru	0.49	V	5.40
Be	0.026	In	3.408	Os	0.66	Sn	3.722	w	0.0154
Cd	0.517	Ir	0.1125	Pa	1.4	Ta	4.47	Zn	0.850
Ga	1.083	Laα	4.88	Pb	7.196	Tc	7.8	Zr	0.61
Hf	0.128	La^{β}	6.0	Re	1.697	Th	1.38	Tl	2.38
Hgα	4.154	Lu	0.1	Mo	0.915	Ti	0.40	-	

Table 2: Compounds are superconductor type: II and Tc in kelvin

Compounds	T_c
Nb_3Sn(Niobium- tin)	18
Nb_3Ge (Niobium-germanium)	23.2
V_3Si	17.1
$La_{1.8}Sr_{0.2}CuO_4$	35
$YBa_2Cu_3O_7$	95
$Tl_2Ba_2Ca_2Cu_2O_{10}$	125
$Y_{0.6}Ba_{0.4}CuO_4$	90
Bi_1-xKxBiO_3-Y	27

3 Experiment

On the planet Arodnap, the average atmospheric temperature is about 60 K and it doesn't fluctuate much during day and night (Fig. 3). To design some levitating islands, and explain the science behind it to come up with a plausible mechanism of the formation of such islands, we have used the properties of superconductivity.

To find the mechanism in order to solve this problem; some properties such as the type of superconductor disk, mass, ingredient, maximum resistance to magnetic field and the intensity of the magnetic field in terms of Tesla or Gauss should be considered. The suspension of the disk occurs by putting superconductor disk on the magnetic field .By using a texture disk, we can reverse the magnetic field without the disk falling. This happens because the magnetic field is locked into the superconductor disk.

Fig. 3: Floating Island [3]

We used superconductor type II and it should be texture to lock into magnetic field and also we used neodymium magnetic field because it is strong.

For suspending the superconductor disk ($YBa_2Cu_3O_7$) at first we have to have liquid nitrogen to cool down the superconductor disk then we need a strong magnetic field. At first we cooled down the superconductor disk then put it in the magnetic field, instantly . Then the superconductor disk started to be suspended with a liquid nitrogen vapor around it (Fig.4).

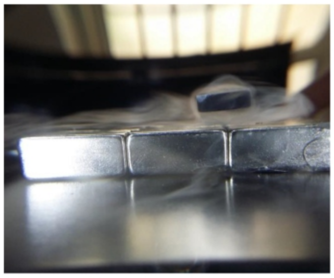

Fig.4: Experiment procedure and suspension of superconductor disk

4 Conclusions

According to this experience we understood to find and build some levitating islands, like the ones from the Avatar movie , in a planet which is fictional. The mechanism of the formation of such islands which could lead to the formation of specific minerals, that are in charge of these effects, is similar to floating of a superconductors in a magnetic field. We tried to suspend a superconductor disk with some important parameters such as the mass of superconductor disk, type of the material and power of the magnetic field are considered.

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