New findings related to high Tc super-conductivity

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Abstract

I learned simultaneously about two findings related to high Tc super-conductivity. The first finding [D5] provides further evidence for high Tc superconductivity at room temperature and pressure. Second finding provides evidence for positive feedback in the transition to high Tc superconductivity. This inspires a proposal of a general TGD based mechanism of bio-control in which small signal can serve as a control knob inducing phase transition producing macroscopically quantum coherent large h_{eff} phases in living matter. I have added to the text the discovery of BCS type super-conductivity in lantanium hydroxide at temperature of 250 K towards the end of 2018 together with TGD based explanation in terms of $h_{eff} = n \times h_0$ hypothesis.

Contents

1 Introduction

I learned simultaneously about two findings related to high Tc super-conductivity. The first finding [D5] provides further evidence for high Tc superconductivity at room temperature and pressure. Skinner has made a strange observation about magnetic susceptibility as a function of temperature for two values of external magnetic field [D1] (see `http://tinyurl.com/yaxtjjp5`). What looks like noise is essentially same for the curves at the level of detail. Unless only pseudonoise is in question, the finding forces to ask whether the data are manipulated. TGD inspired explanation involving so called de Haas-van Alphen effect allows to understand how pseudo noise for certain pairs of value of external magnetic field could have same shape.

Second finding provides evidence for positive feedback in the transition to high Tc superconductivity. This inspires a proposal of a general TGD based mechanism of bio-control in which small signal can serve as a control knob inducing phase transition producing macroscopically quantum coherent large h_{eff} phases in living matter.

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2 High Tc superconductivity at room temperature and pressure

Indian physicists Kumar Thapa and Anshu Pandey have found evidence for superconductivity at ambient (room) temperature and pressure in nanostructures [D5] (see `http://tinyurl.com/ybqybvap`). There are also earlier claims about room temperature superconductivity that I have discussed in my writings [K1, K3, K4].

2.1 The effect and its TGD explanation

Here is part of the abstract of the article of Kumar Thapa and Anshu Pandey.

We report the observation of superconductivity at ambient temperature and pressure conditions in films and pellets of a nanostructured material that is composed of silver particles embedded into a gold matrix. Specifically, we observe that upon cooling below 236 K at ambient pressures, the resistance of sample films drops below 10^{-4} Ohm, being limited by instrument sensitivity. Further, below the transition temperature, samples BCSome strongly diamagnetic, with volume susceptibilities as low as -0.056. We further describe methods to tune the transition to temperatures higher than room temperature.

During years I have developed a TGD based model of high Tc superconductivity and of bio-superconductivity [K1, K3, K4] (see `http://tinyurl.com/yazy5kwt` and `http://tinyurl.com/y7dd4f9m`).

Dark matter is identified as phases of ordinary matter with non-standard value $h_{eff}/h = n$ of Planck constant [K5, K6] ($h = 6h_0$ is the most plausible option [L4, L8]). Charge carriers are $h_{eff}/h_0 = n$ dark macroscopically quantum coherent phases of ordinary charge carriers at magnetic flux tubes along which the supra current can flow. The only source of dissipation relates to the transfer of ordinary particles to flux tubes involving also phase transition changing the value of h_{eff}.

This superconductivity is essential also for microtubules exhibit signatures for the generation of this kind of phase at critical frequencies of AC voltages serving as a metabolic energy feed providing for charged particles the needed energy that they have in $h_{eff}/h_0 = n$ phase [L1].

Large h_{eff} phases with same parameters than ordinary phase have typically energies large than ordinary phase. For instance. Atomic binding energies scale like $1/h_{eff}^2$ and cyclotron energies and harmonic oscillator energies quite generally like h_{eff}. Free particle in box is however quantum critical in the sense that the energy scale $E = \hbar_{eff}^2/2mL^2$ does not depend on the h_{eff} if one has $L \propto h_{eff}$. At space-time level this is true quite generally for external (free) particles identified as minimal 4-surfaces. Quantum criticality means independence on various coupling parameters.

What is interesting is that Ag and Au have single valence electron. The obvious guess would be that valence electrons BCSome dark and form Cooper pairs in the transition to superconductivity. What is interesting that the basic claim of a layman researcher David Hudson is that ORMEs or mono-atomic elements as he calls them include also Gold [H1]. These claims are not of course taken seriously by academic researchers. In the language of quantum physics the claim is that ORMEs behave like macroscopic quantum systems. I decided to play with the thought that the claims are correct and this hypothesis served later one of the motivations for the hypothesis about dark matter as large h_{eff} phases [K1, K2]: this hypothesis follows from adelic physics [L6, L7] (see `http://tinyurl.com/ycbhse5c`, which is a number theoretical generalization of ordinary real number based physics.

TGD explanation of high Tc superconductivity and its biological applications strongly suggest that a feed of "metabolic" energy is a prerequisite of high Tc superconductivity quite generally. The natural question is whether experimenters might have found something suggesting that the external energy feed - usually seen as a prerequisite for self-organization - is involved with high T_c superconductivity. During same day I got FB link to another interesting finding related to high Tc superconductivity in cuprates and suggesting positive answer to this question!

2.2 The strange observation of Brian Skinner about the effect

After writing the above comments I learned from a popular article (see `http://tinyurl.com/ybm8perx`) about and objection (see `http://tinyurl.com/yaxtjjp5`) by Brian Skinner [D1] challenging the claimed discovery [D5] (see `http://tinyurl.com/ybqybvap`). The claimed finding received a lot of attention and physicist Brian Skinner in MIT decided to test the claims. At first the findings look quite convincing to him. He however decided to look for the noise in the measured value of volume susceptibility χ_V. χ_V relates the magnetic field B in superconductor to the external magnetic field B_{ext} via the formulate $B = (1+\chi_V)B_{ext}$ (in units with $\mu_0 = 1$ one has $B_{ext} = H$, where H is used usually).

For diamagnetic materials χ_V is negative since they tend to repel external magnetic fields. For superconductors one has $\chi_V = -1$ in the ideal situation. The situation is not however ideal and stepwise change of χ_V from $\chi_V = 0$ to χ_V to some negative value but satisfying $|\mu_V| < 1$ serves as a signature of high Tc superconductivity. Both superconducting and ordinary phase would be present in the sample.

Figure 3a of the article of authors gives χ_V as function of temperature for some values of B_{ext} with the color of the curve indicating the value of B_{ext}. Note that μ_V depends on B_{ext}, whereas in strictly linear situtation it would not do so. There is indeed transition at critical temperature $T_c = 225$ K reducing $\chi_V = 0$ to negative value in the range $\chi_V \in [-0.05, -.06]$ having no visible temperature dependence but decreasing somewhat with B_{ext}.

The problem is that the fluctuations of χ_V for green curve ($B_{ext} = 1$ Tesla) and blue curve ($B_{ext} = 0.1$ Tesla) have the same shape. With blue curve only only shifted downward relative to the green one (shifting corresponds to somewhat larger dia-magnetism for lower value of B_{ext}). If I have understood correctly, the finding applies only to these two curves and for one sample corresponding to $Tc = 256$ K. The article reports superconductivity with Tc varying in the range [145,400] K.

The pessimistic interpretation is that this part of data is fabricated. Second possibility is that human error is involved. The third interpretation would be that the random looking variation with temperature is not a fluctuation but represents genuine temperature dependence: this possibility looks infeasible but can be tested by repeating the measurements or simply looking whether it is present for the other measurements.

2.3 TGD explanation of the effect found by Skinner

One should understand why the effect occurs only for certain pairs of magnetic fields strengths B_{ext} and why the shape of pseudo fluctuations is the same in these situations.

Suppose that B_{ext} is realized as flux tubes of fixed radius. The magnetization is due to the penetration of magnetic field to the ordinary fraction of the sample as flux tubes. Suppose that the superconducting flux tubes assignable 2-D surfaces as in high Tc superconductivity. Could the fraction of super-conducting flux tubes with non-standard value of h_{eff} - depends on magnetic field and temperature in predictable manner?

The pseudo fluctuation should have same shape as a function temperature for the two values of magnetic fields involved but not for other pairs of magnetic field strengths.

1. Concerning the selection of only preferred pairs of magnetic fields Haas-van Alphen effect gives a clue. As the intensity of magnetic field is varied, one observes so called de Haas-van Alphen effect (`http://tinyurl.com/hoywcnq`) used to deduce the shape of the Fermi sphere: magnetization and some other observables vary periodically as function of $1/B$ (for a model for the quantum critical variant of the effect see [D4]). In particular, this is true for χ_V.

   The value of P is

$$P_{H-A} \equiv \frac{1}{B_{H-A}} = \frac{2\pi e}{\hbar S_e} \ , \tag{2.1}$$

   where S_e is the extremum Fermi surface cross-sectional area in the plane perpendicular to the magnetic field and can be interpreted as area of electron orbit in momentum space (for illustration see `http://tinyurl.com/y9zxhu9o`).

   Haas-van Alphen effect can be understood in the following manner. As B increases, cyclotron orbits contract. For certain increments of $1/B$ $n+1$:th orbit is contracted to n:th orbit so that the sets of the orbits are identical for the values of $1/B$, which appear periodically. This causes the periodic oscillation of say magnetization. From this one learns that the electrons rotating at magnetic flux tubes of B_{ext} are responsible for magnetization.

2. One can get a more detailed theoretical view about de Haas-van Alphen effect from the article of Lifschitz and Mosevich (see `http://tinyurl.com/yay3pg9b`). In a reasonable approximation one can write

$$\begin{array}{ll} P = \frac{e\hbar}{m_e E_F} = \frac{4\alpha}{3^{2/3}\pi^{1/3}} \times \frac{1}{B_e} \ , & B_e \equiv \frac{e}{a_e}^2 = \frac{1}{x^2} \times 16 \text{ Tesla} \ , \\ a_e = (\frac{V}{N})^{1/3} = xa \ , & a = 10^{-10} \text{ m} \ . \end{array} \tag{2.2}$$

Here N/V corresponds to valence electron density assumed to form free Fermi gas with Fermi energy $E_F = \hbar^2(3pi^2N/V)^{2/3}/2m_e$. $a = 10^{-10}$ m corresponds to atomic length scale. $\alpha \simeq 1/137$ is fine structure constant. For P one obtains the approximate expression

$$P \simeq .15x^2 \text{ Tesla}^{-1} \ .$$

If the difference of $\Delta(1/B_{ext})$ for $B_{ext} = 1$ Tesla and $B_{ext} = .1$ Tesla correspond to a k-multiple of P, one obtains the condition

$$kx^2 \simeq 60 \ .$$

3. Suppose that $B_{ext,1} = 1$ Tesla and $B_{ext,1} = .1$ Tesla differ by a period P of Haas-van Alphen effect. This would predict same value of χ_V for the two field strengths, which is not true. The formula used for χ_V however holds true only inside given flux tube: call this value $\chi_{V,H-A}$.

   The fraction f of flux tubes penetrating into the superconductor can depend on the value of B_{ext} and this could explain the deviation. f can depend also on temperature. The simplest guess is that that two effects separate:

$$\chi_V = \chi_{V,H-A}(\frac{B_{H-A}}{B_{ext}}) \times f(B_{ext}, T) \ . \tag{2.3}$$

   Here $\chi_{V,H-A}$ has period P_{H-A} as function of $1/B_{ext}$ and f characterizes the fraction of penetrated flux tubes.

4. What could one say about the function $f(B_{ext}, T)$? $B_{H-A} = 1/P_{H-A}$ has dimensions of magnetic field and depends on $1/B_{ext}$ periodically. The dimensionless ratio $E_{c,H-A}/T$ of cyclotron energy $E_{c,H-A} = \hbar e B_{H-A}/m_e$ and thermal energy T and B_{ext} could serve as arguments of $f(B_{ext}, T)$ so that one would have

$$f(B_{ext}, T) = f_1(B_{ext}) f_2(x) \quad , \ x = \frac{T}{E_{H-A}(B_{ext}))} \ . \tag{2.4}$$

   One can consider also the possibility that $E_{c,H-A}$ is cyclotron energy with $\hbar_{eff} = nh_0$ and larger than otherwise. For $h_{eff} = h$ and $B_{ext} = 1$ Tesla one would have $E_c = .8$ K, which is same order of magnitude as variation length for the pseudo fluctuation. For instance, periodicity as a function of x might be considered.

   If $B_{ext,1} = 1$ Tesla and $B_{ext,1} = .1$ Tesla differ by a period P one would have

$$\frac{\chi_V(B_{ext,1}, T)}{\chi_V(B_{ext,2}, T)} = \frac{f_1(B_{ext,1})}{f_1(B_{ext,2})} \tag{2.5}$$

   independently of T. For arbitrary pairs of magnetic fields this does not hold true. This property and also the predicted periodicity are testable.

3 Transition to high Tc superconductivity involves positive feedback

The discovery of positive feedback in the transition to hight Tc superconductivity is described in the popular article "*Physicists find clues to the origins of high-temperature superconductivity*" (see `http://tinyurl.com/ybo89asd`). Haoxian Li et al at the University of Colorado at Boulder and the Ecole Polytechnique Federale de Lausanne have published a paper [D3] on their experimental results obtained by using ARPES (Angle Resolved Photoemission Spectroscopy) in Nature Communications (see `http://tinyurl.com/y7z2lbh7`).

The article reports the discovery of a positive feedback loop that greatly enhances the superconductivity of cupra superconductors. The abstract of the article is here.

> *Strong diffusive or incoherent electronic correlations are the signature of the strange-metal normal state of the cuprate superconductors, with these correlations considered to be undressed or removed in the superconducting state. A critical question is if these correlations are responsible for the high-temperature superconductivity. Here, utilizing a development in the analysis of angle-resolved photoemission data, we show that the strange-metal correlations dont simply disappear in the superconducting state, but are instead converted into a strongly renormalized coherent state, with stronger normal state correlations leading to stronger superconducting state renormalization. This conversion begins well above Tc at the onset of superconducting fluctuations and it greatly increases the number of states that can pair. Therefore, there is positive feedbackthe superconductive pairing creates the conversion that in turn strengthens the pairing. Although such positive feedback should enhance a conventional pairing mechanism, it could potentially also sustain an electronic pairing mechanism.*

The explanation of the positive feedback in TGD TGD framework could be following. The formation of dark electrons requires "metabolic" energy. The combination of dark electrons to Cooper pairs however liberates energy. If the liberated energy is larger than the energy needed to transform electron to its dark variant it can transform more electrons to dark state so that one obtains a spontaneous transition to high Tc superconductivity. The condition for positive feedback could serve as a criterion in the search for materials allowing high Tc superconductivity.

The mechanism could be fundamental in TGD inspired quantum biology. The spontaneous occurrence of the transition would make possible to induce large scale phase transitions by using a very small signal acting therefore as a kind of control knob. For instance, it could apply to bio-superconductivity in TGD sense, and also in the transition of protons to dark proton sequences giving rise to dark analogs of nuclei with a scaled down nuclear binding energy at magnetic flux tubes explaining Pollack effect [L2] [L2]. This transition could be also essential in TGD based model of "cold fusion" [L5] based also on the analog of Pollack effect. It could be also involved with the TGD based model for the finding of macroscopic quantum phase of microtubules induced by AC voltage at critical frequencies [L1] (see `http://tinyurl.com/y6vxplt3`).

4 BCS super conductivity at almost room temperature

Towards the end of year 2018 I learned about the discovery of BCS type (ordinary) superconductivity at temperature warmer than that at North Pole (see `http://tinyurl.com/ybgphjmd`). The compound in question was Lantanium hydride LaH_{10}. Mihail Eremets and his colleagues found that it BCSame superconducting at temperature -23 C and high pressure 170 GPa about 1.6 million times the atmospheric pressure [D2].

The popular article proposed an intuitive explanation of BCS superconductivity, which was new to me and deserves to be summarized here. Cooper pairs would surf on sound waves. The position would correspond to a constant phase for the wave and the velocity of motion would be the phase velocity of the sound wave. The intensity of sound wave would be either maximum or minimum corresponding to a vanishing force on Cooper pair. One would have equilibrium position changing adiabatically, which would conform with the absence of dissipation.

This picture would conform with the general TGD based vision inspired by Sheldrakes's findings and claims related to morphic resonance [L3] , and by the conjectured general properties of preferred extremals of the variational principle implied by twistor lift of TGD [L9]. The experimental discovery is of course in flagrant conflict with the predictions of the BCS theory. As the popular article tells, before the work of Eremets et al the maximum critical temperature was thought to be something like 40 K corresponding to -233 °C.

The TGD based view is that Cooper pairs have members (electrons) at parallel flux tubes with opposite directions of magnetic flux and spin and have non-standard value of Planck constant $h_{eff} = n \times h_0 = n \times h/6$ [L4, L8], which is higher than the ordinary value, so that Cooper pairs can be stable at higher temperatures. The flux tubes would have contacts with the atoms of the lattice so that they would experience the lattice oscillations and electrons could surf at the flux tubes.

The mechanism binding electrons to a Cooper pair should be a variant of that in BCS model. The exchange of phonons generates an attractive interaction between electrons leading to the formation of the Cooper pair. The intuitive picture is that the electrons of the Cooper pair can be thought of lying on a mattress and creating a dip towards which the other electron tends to move. The interaction of the flux tubes with the lattice oscillations inducing magnetic oscillations should generate this kind of interaction between electrons at flux tubes and induce a formation of a Cooper pair.

Isotope effect is the crucial test: the gap energy and therefore critical temperature are proportional the oscillation frequency ω_D of the lattice (Debye frequency) proportional to $1/\sqrt{M}$ of the mass M of the molecule in question and decreases with the mass of the molecule. One has lantanium-hydroxide, and can use an isotope of hydrogen to reduce the Debye frequency. The gap energy was found to change in the expected manner.

Can TGD inspired model explain the isotope effect and the anomalously high value of the gap energy? The naive order of magnitude estimate for the gap energy is of form $E_{gap} = x\hbar_{eff}\omega_D$, x a numerical factor. The larger the value of $h_{eff} = n \times h_0 = n \times h/6$, the larger the gap energy. Unless the high pressure increases ω_D dramatically, the critical temperature 253 K would require $n/6 \sim T_{cr}/T_{max}(BCS) \sim 250/40 \sim 6$. Note that for this value the cyclotron energy $E_c = h_{eff}f_c$ is much below thermal energy for magnetic fields even in Tesla range so that the binding energy must be due to the interaction with phonons.

The high pressure is needed to keep lattice rigid enough at high temperatures so that indeed oscillates rather than "flowing". I do not see how this could prevent flux tube mechanism from working. Neither do I know, whether high pressure could somehow increase the value of Debye frequency to get the large value of critical temperature. Unfortunately, the high pressure (170 GPa) makes this kind of high Tc superconductors unpractical.

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