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JOSEPHSON'S EFFECT – EFFECT OF EXPERIMENT OR DEFECT OF THE THEORY?

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ABSTRACT

The problem of search and creation of the self-coordinated and not inconsistent system of fundamental constants of physics is discussed. The statement expresses, that the usual system of constants with value of Fine Structure Constant (FSC) $\alpha^{-1} = 137.036$ is not self-coordinated. It does not take into account effectively the substantial cluster of experimental data of atomic physics.

The statement expresses, that the mismatch of experimental data is connected with incorrect theoretical interpretation of Josephson's Effect and with representation that the charge of the carrier of a current carrier of superconductivity q^{SC} is equal accuracy 2e (Je, at J=2).

Alternative representation that the fairly theoretically proved value FSC $\alpha^{-1} = 2^{39/4}/2\pi = 137.0448088$ and, apparently, $J = 2\,(1+\varepsilon)$, $\varepsilon \neq 0$, [i.e. the charge q^{SC} is not equal precisely 2e and, it is possible exist *anomalous electric charge* (of superconductivity) $\Delta q^{SC} = \varepsilon \cdot 2e$] opens an opportunity of construction of the self-coordinated system of fundamental constants of physics.

Josephson's Effect. Quantization of a Tunnel Current.

As is known [Josephson, 1962, 1965], between two weakly connected superconductors which are taking place under a voltage V (of a difference of potentials), there is a alternating tunnel current with frequency ν. The standard theoretical relation describing Josephson's effect, looks like

$$\nu = (2e/h)V,$$

where e – charge of electron, h – Planck's Constant.

In further with the purposes of consecutive analysis shall use also this relation as

$$\nu = B_{\nu/V} V,$$

where $B_{\nu/V} = Je/h$, J=2 – (we shall speak) the *Number of Josephson-Cooper*. By introduction of a designation $B_{\nu/V}$ we emphasize, that in experiment it is actually measured the coefficient $B_{\nu/V}$, having dimension frequency (Hz) /voltage (Volts). At detecting of external radiation of frequency ν as a result of effect of quantization of a tunnel current there are steps of a voltage $V_n = n\nu(h/2e)$, $V_n = n\nu/B_{\nu/V}$, where n - integer.

The problem of transition from dimension describing coefficient $B_{\nu/V}$ in experiment, to dimension (e/h), characteristic for fundamental constants of physics (for example, CGSE), represents not an absolutely trivial problem in metrology.

Universality of Quantum Process of Tunneling.

Is experimentally established, that the course of Josephson's effect and its description by a theoretical relation $\nu = B_{\nu/V}V$, $B_{\nu/V}$ = const is *universal* - does not depend on a kind of a superconductor, way of achievement of weak connection etc.

In a very wide range of variations of physical parameters (conditions) of experiment coefficient $B_{\nu/V}$ = const is fundamental invariant with accuracy about 10^{-4} %.

Physical Challenge.

The central statement, on which it would be desirable to pay the special attention, can be submitted as follows

Proposition

[J $\neq$ 2; Anomalous electric charge (of superconductivity)].

Standard relation describing Josephson's effect as

$$\nu = (2e/h)V$$

is *not (absolute) exact*.

Actually, in a physical relation correctly describing Josephson's effect

$$\nu = B_{\nu/V} V,\ B_{\nu/V} = Je/h = const,$$

coefficient $J = 2(1+\varepsilon)$ is not equal precisely 2 (two), i.e., generally speaking, small number ε is not equal to zero ($\varepsilon \neq 0$).

Another words, it is possible, exist *anomalous electric charge (of superconductivity)* $\Delta q^{SC} = \varepsilon \cdot 2e$.

The *integer value*, accepted by standard representations, of coefficient J (J=2) (Number of Josephson-Cooper) is, generally speaking, *postulate* which has been not proved strictly theoretically or experimentally.

At the given stage - with the purposes of maximum objectivity - it is meaningful to consider this statement, faster, as *Proposition* for the experimenters in the greater degree, than potentially existing or really available argument of the theory.

Mirage of Integernity.

Aspiration to attribute *integer values* of a various sort to dimensionless physical coefficients - quite known tradition. It is so ancient, as natural aspiration to simplicity and harmony.

The similar motives are interesting and are attractive, but hardly only they can be convincing in such basic problem, as an establishment of fundamental constants of physics.

The Concept Pairing of Electrons Pairing.

However, there is a vast, very colourful (almost poetic) narration about "marriaging" – pairing electrons [details see in numerous works - Cooper, 1956; Bardeen, Cooper, Schriffer, 1960, 1957; Buckel, 1972].

Business of taste to accept such verbose explanation of integer character J = 2 as physical true. But the unbiassed objective analysis shows, that such interpretation hardly maintains the requirements of theoretical severity and physical unambiguity. But, in fact the condition J = 2 [i.e. $B_{\nu/V} = 2e/h$] in the theory, in essence, "is brought in by hands" and, thus, - *conventionally*, and experimental metrology during many years indefatigably, diligently and none-critically selects such e, h (and other fundamental constants), that this relation, becoming canonical, was carried out "strictly".

As worthy exercise for the independently conceiving theorists it is possible to suggest connected with the previous statement

Proposition [Outside of - Cooper].

The explanation of absolute value of coefficient J in Josephson's effect lays outside of the concept (of Cooper) of electrons pairing.

Quantization of a Magnetic Flux. London Effect.

In close connection with quantization of a tunnel current in superconductivity lays and, we shall speak, London effect.

The effect of quantization of a magnetic flux was theoretically predicted by London [London, 1935, 1950] already for a long time.

It was expected, that the magnetic flux quantizates as follows

$$\Phi_n{}^{L} = n\Phi_{n=1}{}^{L}, \quad \Phi_{n=1}{}^{L} = hc/e^{\#} = hc/e, \quad n = 1,2,3,...$$

according to that the elementary charge of the carrier of a supercurrent $e^{\#}$ Is equal to a charge of electron e (i.e. $e^{\#} = e$). But the experiment has shown [Deaber, Fairbank, 1961; Doll, Nabauer, 1961], that the magnetic flux quantizates with a condition [we shall to speak, close to]

$$e^{\#}=2e$$

$$\Phi_n=n\Phi_{n=1}\ , \ \Phi_{n=1} = hc/e^{\#} = hc/2e\ , \ n=1,2,3,...$$

By virtue of it till now it is considered, that "... The results of experiences on study of quantization of a magnetic flux were by the direct proof that the supercurrent is transferred by actually is measured pairs of electrons" [see, for example, Shmidt, 1982, p.38].

Cooper Pairs and Theory BCS.

Namely here, on this place, obviously, the most simple of possible assumptions arose, assumption that lays on a surface, that in conditions of superconductivity the electrical current is transferred by pairs of electrons (by *Cooper's pairs*), for (everyone can "see" from experiments, that) $e^{\#} = 2e$.

Such generalization of representations has not forced itself to wait (Theory BCS – of Bardeen, Cooper, Schrieffer, 1957).

Occurrence of "aspiration" to form pairs – of *mechanism of an attraction* between *two negative* charges of electrons – is a special picturesque chapter in such representations. And all this - to explain J=2.

Other Representations.

More modest statement, on our sight, consists in the following. Effect of quantization of a magnetic flux (London effect) and

Josephson's effect - the phenomena connected to superconductivity, - demonstrate display of the same *unified* (and *never former dismembered* - "binary") charge $q^{SC} = e^{\#}$ (of a current carriers of superconductivity (SC)), its value (so has appeared!) is equal $q^{SC} = e^{\#} = Je$, $J = (1+\varepsilon)2$, ε - small number (i.e. is only *close to 2e*). Such representation refuses a postulate (faster, the dogmas) J=2 and opened an opportunity of search of (true) real value of electrical charge $q^{SC} = Je$ of superconductivity carriers.

Uncertainty of Experiment.

The situation in experiment is not so unequivocal and certain, as it seems in the theory. As illustration we shall result only one example [Gough et al, 1987]: " Using these results and the earlier calibration we obtain a value for the flux quantum of 0.97 ± 0.04 (h/2e) thus demonstrating that superconductivity in this high - T_c material involves the pairing of electrons as in conventional BCS (Bardeen - Cooper - Schrieffer) superconductivity."

The result can be represented and in the following form for quantum of a magnetic flux h/Je, where J is in a range J = 2 (0.99 ? 1.075) with average value $J = 2(1/0.97) = 2 \cdot 1.0309$, obviously, *not equal strictly* J=2.

Will not be unexpected, if on the part of the theorists the statement nowadays will follow, that the progress of experiment removes this contradiction.

Impasses of Metrology: Sources of (Invisible) Crisis.

On not indignant, safe background of modern physics the preconditions of deep crisis ripen. It is connected to a self-coordinated choice of "true", "correct" absolute numerical values of fundamental constants (α, e, h, m_e, c, etc). On our sight, one of aspects of a developing today situation can be briefly described as follows.

Confrontation of Experiments.

There are, at least, two clusters of experiments connected to definition of fundamental constants.

 # (J=2) Josephson's cluster (of experiments). These experiments significally use Josephson's effect with a condition (postulate) J=2. Result of such experiments is, in particular, value of Fine Structure Constant (FSC), close to $\alpha^{-1} = 137.036$

 # Not - (J=2) Josephson's cluster (of experiments). Its - experiments using others (not Josephson's effect) methods of measurement of fundamental constants.

Let's result some data, concerning only definitions of Fine Structure Constant (FSC) α^{-1} [details see in Teylor, Parker, Langenberg, 1972].

[a_e^-] Wilkinson, Crane (Corrected by Rich) α^{-1} = 137,0467 (36)
[ΔE_D-S_D; D (αa)] Dayhoff, Triebwasser, Lamb α^{-1} = 137,04034 (51)
[S_{He+}, n=4] Jacobs, Lea, Lamb α^{-1} = 137,05 (14)
[ΔE_{He+} - S_{He+}] Jacobs, Lea, Lamb α^{-1} = 137,0398 (42)
[ΔE_D, n=3] Wilcox, Lamb α^{-1} = 137,042 (21)
[ΔE_{He+}, n=4] Jacobs, Lea, Lamb α^{-1} = 137,040 (16)

In the report of fundamental constants of physics [Du Mond and Cohen, 1951] specify the following value FSC α^{-1} = 137.0429. It is visible, that the data on (FSC) α^{-1} for both clusters of experiments are in the irreconcilable contradiction with each other (though are self-coordinated inside - within the limits of itself cluster of experiments).

It is possible to act simply and by "obvious" way - *to ignore* the data of Not (J=2) Josephson's cluster (of experiments). So, actually, acts modern metrology. But it is indefinitely long such depressing blindness proceed can not. The progress of the theory and of experimental engineering inevitably will blow up the self-calming of standard physics.

Atom and Superconductivity: a Mismatch of Experiments.

It is interesting to note and following not trivial aspect of the above mentioned data on FSC.

Division them on two clusters, apparently, not casually one of them is connected to experiments significally using effects of superconductivity (Josephson's effect). Another - uses the data of (over) fine structure of atoms. The correct coordination of results (data), unfortunately, has not taken place. Simply - "has won" superconductivity (cluster J=2).

Constants of Bohr's Atom and Superconductivity: Problem of the Concordance.

And, really, on what basis in standard representations it is considered, that fundamental constants of Bohr's atom and fundamental constants of superconductivity is same?

But in fact, from history of modern physics it is known, that hasty attempt to consider a charge of a current carriers of superconductivity $q^{SC} = e^{\#}$ equal to a charge $e^{B} = e$ of Bohr's atom successfully has failed. Nowadays it is admited other convention (postulate or dogma): q^{SC} – *precisely* is equal 2e. The bases, on our sight, - are *so hasty and are unreasonable*. We believe, that the problem of the correct concordance of fundamental constants (of all) physics (in particular, of atom and of superconductivity) is so important and is so fundamental, that it is better to proceed from more cautious position.

Proposition.

Relation $B_{\nu/V} = Je/h$, $J=2\ (1+\varepsilon)$ for Josephson's Effect

$$\nu = B_{\nu/V}V = (Je/h)V$$

opens an opportunity of the correct concordance of fundamental constants of physics (of atom and of superconductivity) with use of (small) adjusting parameter ε, which should be justified by experiment.

Last but not Least: FSC - as Argument of the Theory.

Let's result the information following from the general analysis of *wave dynamic systems (WDS)* in frameworks of *WU Concept* [Chechelnitsky, 1980 - 2001].

MYSTERY OF THE FINE STRUCTURE CONSTANT (FSC).

Microworld:
Quantum Wave Mechanics and Fine Structure Constant.

From all modern theories of Microworld - quantum electrodynamics (QED) describes the dynamic structure and the interaction of elementary particles (photons, electrons, muons) most exactly.

There is the fundamental parameter (coupling constant, interaction parameter), that lies in the basis of that advanced and consistent theory - the Fine Structure Constant (FSC), [Born, 1963].

The theoretical representation of this constant is unknown up till now. " The Mysterious Number 137 " - so titled Max Born the famous paper of 1936 [Born, 1936].

The Fine Structure Constant (FSC) $\alpha = 2\pi e^2/hc$ or nondimensional number $\alpha^{-1} \approx 137$ (where e - electron charge, h - Planck constant, c – velocity of the light) was introduced in the theoretical physics by

Arnold Sommerfeld in 1915 [Sommerfeld, 1973]. That is the fundamental parameter of the all atomic spectroscopy. At present, only its experimental value is known ($\alpha^{-1} = 137.036$).

Answer of the WU Concept:
Theoretical Representation of the Fine Structure Constant.

In the framework of *Wave Universe concept* may be naturally obtained the following surpriselly simple analytical and numerical (closed) representation for the Fine Structure Constnt that is proved to be correct by the logics of the consistent theory [Chechelnitsky (1986) 1996]

$$\alpha^{-1} = 2^{39/4}/2\pi = 137.0448088$$

FSC - As Micro and Mega Parameter of the Universe.
FSC, Orbits, Heliopause.

Fine Structure Constant is fundamental constant *not only of Microworld (atoms)*, but also - of *Megaworld (astronomical systems)* - one of the *general nondimensional parameter of Universe*.

Megaworld:
Megaquantum Wave Astrodynamics and Astrophysics;
Earth Orbit and Heliopause.

We shall cite only one fragment of the new knowledge [Chechelnitsky, 1996], that is spontaneously connected with discussed theme - with wave structure, geometry and dynamics of Solar system.

Proposition.

∗ There is regular connection between planetary orbits arrangement and special critical surface of Solar system - *Heliopause* location.

∗ This connection may be presented by using the Fine - Structure Constant, that is considered as *megaparameter* of astronomical systems.

∗ In particular, when using the Earth orbit, the following most simple relation between the Keplerian periods of Earth orbit $T_E = 1^a$ and of Heliopause T_* is valid:

$$T_* \approx S_\alpha T_E \approx 861^a, \quad S_\alpha = 2\pi/\alpha \approx 2\pi \cdot 137 \approx 861.$$

The appearing from the above relation between semi-major axis of Earth orbit $a_E = 1$ AU and of Heliopause a_* is like this:

$$a_* \approx S_\alpha^{2/3} \cdot a_E = 90.5 \text{ AU}$$

These relations reflect the presence of spontaneous and close connection between Wave astrodynamics (celestial mechanics) - geometry and dynamics of regular set of elite (dominante) Solar system planetary orbits - and geometry and dynamics of Heliopause (of Solar system magnetosphere, or of standing shock wave of Heliosphere), that is traditionally regarded as an object of astrophysics.

Value FSC and Not - (J=2) Josephson's Cluster (of Data on FSC).

The comparison of data on Fine Structure Constant (FSC) shows, that the theory (WU Concept) coordinates, faster, to the data of Not - (J=2) cluster. It in the greater degree has to conclusion - not critical use of data of Josephson's effect in the present form (at J=2) does not promote the correct concordance of fundamental constants of physics. The offerd modification of the basic relation of Josephson's effect, on the contrary, opens a way to such concordance.

DISCUSSION.

By revelation will not note, that as the most important incentive motive for the present statement it has served the disturbing mismatch between the theoretically seriously argued value of Fine Structure Constant, received in frameworks of WU Concept $\alpha^{-1} = 2^{39/4}/2\pi = 137.0448088$, and accepted today by physical community of experimental value FSC

$$N_\alpha = \alpha^{-1} = 137.036.$$

For all that it is found out, that this experimental value of FSC *wholly stands* on measurements with use of *Josephson's effect (at J = 2)*.

The further analysis shows, that the postulate (Number) of Josephson - Cooper J = 2 is in the greater degree "a Symbol of Belief", than experimentally proved fact.

The alternative suggestion - to consider J as only adjusting coefficient that must be subjected to experimental definition, - opens a road for serious procedure of the concordance of fundamental constants of physics.

Even if would appear, that, at the end, J nevertheless is equal precisely to two, it would be achieved not as a result of autohyonosis, and as a *result of the intense search and indisputable proofs*.

Otherwise doubts will exist always, while nevertheless will not be shown enough strictly, that the absolute value J in Josephson's Effect is based not on belief to numberlogy (integernity), but stands on carefully controllable precision observations and experiments.

And then, probably, will find out, that the extremely sharp transition of absolute value of FSC from α^{-1}=137.05 to α^{-1} = 137.036 is obliged not to growth of accuracy of experiments, but to growth of fallacy.

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To describe the Josephson effect and show some consequences of it. To understand the workings of a SQUID (Superconducting QUantum Interference Device) and to demonstrate its features. Below is given a quite detailed discussion on various effects. Do not get lost in the derivations, but try to pick out the main results. Introduction.Â Equations (5) and (6) represent the main results of the general theory of the Josephson junction. The current I is called a Josephson current or a supercurrent. This strongly non-linear current-voltage behaviour is the origin for many different physical phenomena. We will study some simple cases below. The DC Josephson effect. The Josephson effects describe the transfer of Cooper pairs and the coupling of the macroscopic wave functions between two superconductors via a weak link. Some of the dependencies of such junctions are strongly related to the fundamental flux quantum. This gives excellent possibilities for application in measurement science and electronics. Within this chapter the general properties of Josephson junctions are summarized with respect to the nature of the high-Tc superconductors. Preparation technologies and performance of different types of thin film Josephson are discussed in detail and selec The Josephsonâ€“Anderson theories indicated that a stronger effect could be obtained with a synchronizing mechanism to monochromatize the frequency emitted, and this was realized in the â€œspontaneous stepâ€ phenomenon in which internal electromagnetic resonances of the junctions become locked to the a.c. Josephson currents. This chapter also discusses the generalization from the pure Josephson effect to the general idea of â€œcoupled superconductors.â€Â Investigation of the magnetic field dependence of the maximum zero-voltage current of wide, high-current Josephson junctions has revealed behavior drastically different from the usual Fraunhofer pattern for narrow junctions.