ISSN: 0975-833X

Available online at http://www.journalcra.com

International Journal of Current Research
Vol. 9, Issue, 06, pp.53361-53365, June, 2017

INTERNATIONAL JOURNAL OF CURRENT RESEARCH

RESEARCH ARTICLE

QUANTUM NON-IDEAL PLASMA AS A SOURCE OF HEAT ENERGY. PLASMA FUEL COMBUSTION

***Kulakov, A.V.**

Expert- analytical Center of the Ministry of Education and Science of the Russian Federation, Moscow, Russia

ARTICLE INFO

Article History:
Received 23rd March, 2017
Received in revised form
12th April, 2017
Accepted 10th May, 2017
Published online 30th June, 2017

Key words:

Quantum non-ideal plasma, Modern power industry, energy release mechanism, New state of matter, Quantum plasma condensate, Physical and chemical methods of power generation, energy transformation, alternative, Efficient, renewable, Sustainable and stable revolutionary source of energy, Plasma fuel combustion, Purification of the ecosphere of our planet.

ABSTRACT

For the first time in history the existence of a new state of matter - quantum plasma condensate combining the properties of a normal liquid and ionized plasma was theoretically predicted and confirmed. This paper analyzes the modern power industry paying special attention to its ecological condition, physical and chemical methods of power generation, discusses the quantum non-ideality of non-degenerate plasma and electron exchange in it leading to efficient energy release in the plasma under consideration. This paper defines the directions for using this energy, which are as follows: heating, lighting, transformation by means of photo elements or MHD-movements to electric power, producing energy in the ultraviolet and X-ray range, generating and accelerating charged particles. This paper pays special attention to one of the most fast-growing applications of quantum non-ideal plasma, namely, heating during which plasma combustion occurs. The discovery of this kind of phase state of collisional non-degenerate plasma and its application in science and technology will lead to creating a revolutionary efficient power industry globally. This source of energy is the only environmentally safe source that does not destroy and pollute our planet, and using it helps make our ecosphere cleaner.

Citation: Kulakov, A.V., 2017. "Quantum non-ideal plasma as a source of heat energy. Plasma fuel combustion", *International Journal of Current Research*, 9, (06), 53361-53365.

INTRODUCTION

Modern power industry and its ecological state

Today many developed countries are experiencing energy-related problems that have been increasingly coming to the fore. Further development of industry, engineering and technology is directly determined by achievements in the resolution of this pressing issue. Natural sources of energy such as minerals are depleted to a considerable degree. It is noteworthy that the most precious organic raw materials are burnt which cannot practically be restored. Moreover, burning these materials produces great amounts of harmful waste gas and ballast materials that are not readily amenable to processing and generate a tremendous amount of hazardous emissions in the three main natural spheres. These hazardous emissions are poisoning the environment irrespective of whether they are visible or invisible with unaided eye. The functioning of the modern energy "machine" as a comprehensive scheme of energy reproduction can be described by three efficiency factors: conventional thermodynamic efficiency, proportional to the energy capacity of materials being burnt, chemical coefficient that determines the reproduction level of precious chemical composites and, finally, ecological coefficient which a ratio of the cleanness level, for instance, of the atmosphere or water sources taken in a certain conventional scale and estimated based on this scale before and after completion of the reproduction cycle. The set pattern of engineering thinking estimates the degree of sophistication of power generation technology mainly based on the criterion of the first of the above coefficients - the higher it is, the better. It leads to the situation where the two remaining coefficients are great in modulus, but have a negative sign. A posteriori attempts to eliminate the negative sides of production turn out to be labor-intensive, inefficient and involve huge energy losses. That creates a vicious circle in the power industry: a certain amount of energy is produced in a certain cycle, a large portion of this energy must be wasted on removing what, at a first glance, seems to be negative side effects. However, we can assert that the development of modern physics and chemistry has reached such a high level that it is justified to call for the creation of such energy sources which would be fairly efficient in a thermodynamic sense without producing negative impact on the environment at the same time.

Corresponding autour: **Kulakov, A.V.,**
Expert- analytical Center of the Ministry of Education and Science of the Russian Federation, Moscow, Russia.

Power industry: physical or chemical?

Chemical sources of energy act at the expense of burning one or another type of fuel. Hydraulic resources create a mechanical source. It goes without saying that the operating principle of such a source is pretty straight-forward, however, the capabilities of this type of sources are limited; most importantly, before such sources can be used, the problem related to power transmission over extremely long distances should be properly addressed. Power transmission lines must be superconductive, the approach to using such lines is a fundamental problem which lies in the field of science rather than being purely an application or engineering task.

The nuclear power industry is undoubtedly efficient in a quantitative sense, i.e. in terms of specific power output. Here, as it is known, there are two ways - thermonuclear fusion or fission. Anyway, the first way is usually considered as a temporary transient solution. The stage of uranium nuclear combustion must act until artificial (industrial) suns are lit up. Unfortunately, there has been any noticeable progress over a historically significant period. Natural sources of nuclear fusion can function at the action of powerful gravity forces, an equivalent of which we have failed so far to create in the laboratory. Besides, there is a growing amount of observation data witnessing that there are energy sources other than nuclear ones even in stellar interiors. For this reason, we should increasingly focus on alternative, so to say, principles of power generation. In this regard, it is important to point out, first of all, physical and chemical methods of power generation and transformation. These methods are by no means exhausted, considering that the advancement of modern non-linear physics, the many-body theory, and statistical physics serves as a basis for discovering and using these methods. It is sufficient to point to the natural realization of powerful energy processes in atmospheric phenomena, volcanic eruptions, and space eruptive phenomena.

Conventional chemical methods for energy extraction are based on paired molecular interactions which ultimately lead to the formation of more energetically beneficial molecular compounds with low energy of state. Surplus energy is subject to variations in the level of energy coupling between interacting molecules. Can atoms of a matter be combined in a certain unified super molecule in macroscopic scales with efficient energy release? It can be affirmed that such compounds, which are not strongly dependent on the initial chemical composition of the original material, are possible. To some extent, even usual phase transitions in a matter, for instance, transition of vapour to liquid, clearly demonstrate the reality of this kind of transformations. However, their energy capacity is not so significant as in the case with strong exothermic chemical reactions. Nevertheless, qualitative interatomic processes are possible, and their energy release level may exceed the corresponding output in reactions with specifically selected chemical reagents. We meanplasma modifications accompanied with energy release. The physical essence of this phenomenon consists in the following: In plasma electrons disconnected from atoms move practically as free particles. Coulomb forces are known to be long-ranging. These forces are screen inside the so-called Debye sphere enveloping each of the charged particles. Outside of the above sphere the field created by this particle decreases exponentially as the distance grows, at the same time the particles trapped inside the sphere experience dissipation, each instance of such dissipation is called the Coulomb collision. As a whole, the plasma behaves almost as a perfect gas of charged particles, while the interaction between particles is determined only by Coulomb's collisions. However, quantum forces start to play an increasingly important role as plasma density increases. It has nothing to do with the customary perception of the degeneration of electrons. The author of this article has discovered that before the degeneration stage occurs, the overlap of electronic wave clouds becomes significant. The overlap effects create the first-order effect by the ratio of de Broglie wave-length to the interionic distance. If the overlap also exists in substances in normal phase state, but it drops exponentially as interatomic distance increase, then in the plasma - since the spectrum of quantum energy states of electrons in it is continuous - the drop effect of the envelope overlaps slows down as interparticle distances increase and is described by the power-law dependence (Kulakov and Rumyantsev, 1988).

As a result, already in a plasma of moderate density with an iron concentration of$n\sim10^{20}\,\mathrm{cm}^{-3}$arise the state of a mutual be coupled up of particles which corresponds to the chain of sequentially overlapping electron clouds, with each string of the chain spreading over a distance in the order of the screening radius. The whole chain encompasses the entire plasma as a whole - plasma ions trapped by this chain are attracted to each other which causes plasma phase transformation to occur. Transition to a new state is accompanied by the release of an amount of energy equal to transformation heat. The below qualitative analysis suggests that energy release can turn out to be very significant and even exceed the corresponding specific energy release during the combustion of conventional fuel (Kulakov and Rumyantsev, 1991; Kulakovv and Teutyunnik, 2016 & 2017; Kulakov and Rantsev-Kartinov, 2015).

Quantum plasma non-ideality and physical mechanism of energy release

As it was mentioned before, in a relatively dense and "cold" plasma with an iron concentration of $n\sim10^{20}\,\mathrm{cm}^{-3}$and particle temperature T in the order of several thousands of degrees, in addition to conventional natural forces, specific quantum forces come into action. These forces are determined by the sequential overlapping of electron envelopes belonging to the adjacent atoms or ions. With the above concentrations quantum forces ensure a strong cohesion of particles of a matter, i.e. create attraction between them. The nature of overlapping exchange forces is particularly evident with increasing electron concentrations when the number of electrons per one ion is number z is considerably higher than unity. The fact that the overlapping of electron envelopes leads to their efficient cohesion is well known from the valence bond theory. It is sufficient, for instance, to mention the Heitler-London molecular forces theory where such forces are found in calculating primary molecules based on the variation method. At present this method is most commonly used to explain and calculate the structure of molecules and forces acting between their atoms. Variation methods in physics belong to the category of intuitive a posteriori methods. The only theory that can qualify as a consistent heuristic theory is the one that is based on a direct solution of the fundamental equation of the quantum theory - the Schrodinger equation. The perturbation theory considering exchange forces (or Pauli principle) is exactly such a theory (Kulakov and Rumyantsev, 1988 & 1990). This theory applies the class of continuous spectrum states, which are realized in relation to states of electrons in the plasma, and allows explaining the observed peculiarities of plasma phase and predicting and using those phase properties which can and must be used by modern engineering and technology. This refers to manifestations of plasma non-ideality, especially the one of quantum origin. Some aspects of such non-ideality manifest themselves already in gases (Bashkin, 1986) and electric discharges (Ayrapetyan *et al.,* 1988; Trubnikov, 1990), however, their true physical essence and applied significance in that period of time had not be revealed to the required extent. Numerical calculations conducted, for example, in (Kulakov and Rumyantsev, 1988 & 1990) showed that the quantum effects were significant in the case of the so-called non-degenerate plasma, with the following equation

$$\lambda\!\!\!^{-} = \frac{h}{p} \geq (\frac{1}{5} \div \frac{1}{10})(zn)^{-1/3}, \qquad \ldots \ldots (1)$$

where $\lambda\!\!\!^{-}$- is the de Broglie wave-length of heat electrons, $(zn)^{-1/3}$ – r-average distance between electrons. Exchange interaction between electrons under such conditions leads to electrons being attracted to each other, the bond energy of the latter becomes negative. Consequently, quantum transition for one ion releases an amount of energy equal to

$$\mathcal{E} = z^3 e^2 r^{-1} \cdot \Delta\,, \qquad \ldots \ldots (2)$$

where $\Delta \sim 20$ – a value similarto the Coulomb logarithm, e – electron charge taken in cgs (just as in all subsequent theoretical formula).

In connection with the above estimate of the energy released in the plasma during phase transition, the following two circumstances should be pointed out. Firstly, a direct analytical calculation shows that the exchange cohesion of particles of the considered type turns out to be independent on the spin state of electrons in plasma (Kulakov and Rumyantsev, 1988 & 1990) i.e. it is realized and gives a positive energy output according to the Young's arbitrary scheme describing these states. Secondly, exchange cohesion is proportional to the third degree of ion charge, therefore, this cohesion and its associated heat release are realized provided that plasma is formed by multicharge ions. In practice, the greatest effect can be produced by ions of carbon, oxygen, silica and other easily ionizable elements, but in definite proportion. Thus, phase transition of 1 type in common substances must occur in plasma (Kulakov and Rantsev-Kartinov, 2015), which is accompanied by efficient energy release. Let us estimate the latter for a unit of plasma mass, we have

$$\mathcal{E}_1 = \frac{\mathcal{E}}{Am_H} \approx \frac{(3z)^2 e^2 n^{1/3}}{m_H} \frac{\text{erg}}{\text{g}}, \qquad \ldots \ldots (3)$$

where $A \approx 2z$ – atomic number, m_H – hydrogen atom weight (in grams). We suppose that $e = 4{,}8 \cdot 10^{-10}; n = 10^{20}; z = 4$; $m_H = 1{,}7 \cdot 10^{-24}$g, we obtain$\mathcal{E}_1 \sim 10^{13}\ ^{\text{erg}}/_{\text{g}}$. This value is higher than specific energy output by order of magnitude during, for example petrol combustion. Plasma fuel, however, must not necessarily be a complex or special organic compound - it can be formed considering an arbitrary non-organic mixture that can be ionized with sufficient ease. Losses on ionizing the substance are set off by phase energy release. Apparently, to achieve this, the factor $^{\mathcal{E}}/_{zI}$, where I-ionization energy, is significantly higher than unity. This is comparatively easy to achieve: for instance, with a concentration of$n \sim 10^{20}\text{cm}^{-3}andz = 3$the above factor is around 10. Energy release can be either gradual (continuous) or impulse depending on phase transformation forces. The energy released in the plasma process under consideration can be used in a variety of applications: heating, lighting, transformation by means of photo elements or MHD-movements to electric power, producing energy in the ultraviolet and X-ray range, generating and accelerating charged particles (Kulakov and Rumyantsev, 1991 & 1979; Kulakovv and Teutyunnik, 2016 & 2017; Kulakov and Rantsev-Kartinov, 2015). It is this type if transformations that ultimately determine the efficiency factor of a particular plant. When this energy is used for lighting, the density of the body of a plasma lamp may be lower than that of the gas environment, this lamp will be floating in the atmosphere. Various waste materials containing carbon, sulfur, boron, calcium and other elements that are relatively easy to ionize can be used as a fuel. Removing such waste in a quantum plasma generator can, on the one hand, provide a source of energy, and, on the other hand, serve the purposes of cleaning biosphere and production sphere.

Plasma fuel combustion

Let us consider one of the most generic applications of quantum collisional plasma, namely, heating during which plasma combustion occurs. The process flow diagram for using plasma combustion is fairly simple (refer to Fig.1). Condensed gaseous fuel is fed to tank 1 at p$\geq$ 1,0 atm. The gas is a mixture of vapors of water, carbon oxide, nitrogen and sulphur compounds, i.e., those materials which constitute typical production waste. The mixture is heated up to a temperature of about two thousand degrees. On entering tank 2 the mixture is compressed to a pressure of around 10 atm. In the meantime, vapours of easily ionizable elements of alkaline and alkaline earth metals compounds are added to the mixture. The proportion is chosen experimentally. An intensive ionization from valent electron envelopes must take place in the mixture heated up to several thousand degrees. As the plasma enters tank 3, it is liquified. The energy re-leased through the surface of the tanks during this process is spent on heating water (vapour) coming over piping. Further use of the vapour water system is the same as in conventional electric power plants. As far as cooling plasma condensate is concerned, it can be used in two ways. Either liquefied plasma is used as some kind of feedstock material for chemical synthesis which, in the plasma state under consideration, must occur over special chemical channels that are not available to conventional chemical technology. Or cooled condensed plasma jet is compressed in tank 3 which results in its implosion.

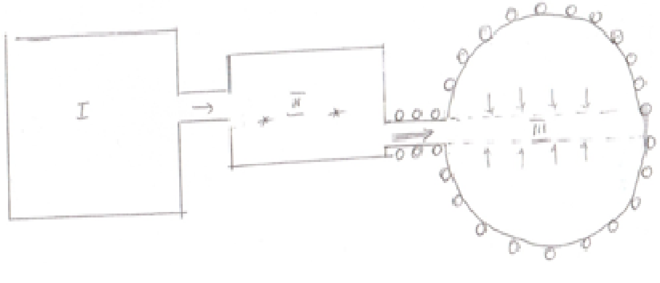

Fig.1 Plasma Fuel Plant Diagram

The causes and mechanisms of implosion in the condensed plasma are as follows. In the process of the phase transformation discussed above the plasma transitions to lower energy state ε_1, so that the bond energy of plasma particles is determined (by modulus) by the following formula (3). When cooled the bond forces of particles increase, while plasma pressure drops. The gas surrounding the plasma is dissipated under the action of gas dynamic forces in the direction of the plasma (showed by arrows in Fig.1). Gas energy is spent on exciting plasma particles and overcoming bond forces. The plasma transitions to a new energy state 2, during which transition a chemical relaxation occurs, i.e., chemical transformations take place so that the energy of the system as a whole is lower than the level 0 corresponding to the continuous spectrum. The power developed by the plant can be calculated by the formula

$$W = k \cdot \mathcal{E} \cdot m_A \cdot n \cdot L^3 \cdot \tau^{-1}, \quad \text{..............................} (4)$$

where $m_A = Am_H$ – ion mass, n–their concentration, L – linear dimension of the first tank, τ – energy exchange time between plasma and the vapour water system, k – exchange efficiency, Ɛ-specific energy release ($^{\text{erg}}/_{\text{g}}$), n – ion concentration (cm^{-3}). Time $\tau \sim {R^2}/{\chi}$,

where R – radius of vapour conducting tubes, χ – vapour temperature conductivity.

Let us provide the simplest energy power estimates as applied to the simplest type of a demo plasma generator which corresponds to the diagram depicted in Fig.1.

Let us assume for estimation that

$k = 0{,}8; R = 1\text{cm}; \chi = 1\ {\text{cm}^2}/{\text{sec}}; m_A = 3 \cdot 10^{-23}\text{g}; n \sim 3 \cdot 10^{19}\text{cm}^{-3};$

$L = 30$ cm, then by the formula (4) and (5) we obtain $W \sim 2 \cdot 10^{14}\ {\text{erg}}/{\text{sec}} = 20$ MW.

Specific energy consumptions on compression, ionization, heating amount to the following values in order

$$\mathcal{E}_3 = \frac{kT}{m_A} + \frac{I}{2m_H} \sim \frac{1}{3}\mathcal{E}, \quad \text{..................................} (6)$$

here $I \approx 10^{-11}$ergis ionization energy of a single-charge ion. The energy losses are a relative value of around 30% from the effective energy, which appears to be satisfactory. To enable the generator to operate, it requires fuel in the amount of 30 kg/hr. But this fuel is a relatively cheap mixture, in other words, direct wastes of other production plants that are seeking a way to dispose of them. There is such a way, and it is beneficial in terms of energy!

We highlight that the phase transformation effect considered herein takes places only in the event of multiple ionization of atoms. The gain in energy with such a transformation (see the diagram in Fig.1) is proportional to the third degree of the ion charge. In case of single-charge ionization, for instance, alkali atoms, the gain in energy may be lower than the energy decrease reached in chemical reactions or in the formation of associates of ions and atoms. That is the reason why the phenomenon considered in this paper has not been discovered up to the present day: experiments were conducted predominantly on alkaline compounds. The main focus of this paper is on the energy output in the process of quantum transformation in plasma. It was demonstrated that plasma condensate can and must be considered as a source of energy. However, other important consequences of the physical effect of quantum transformation were out of the scope of this paper. In particular, one of such phenomena is spontaneous magnetic field generation (Kulakov and Rumyantsev, 1988). The structure of exchange interactions in plasma is such that the state that is beneficial in terms of energy is the one where orbital magnetic elements of electrons in plasma are oriented in one and the same direction which is a peculiar effect of ferromagnetism in plasma. The experimental discovery of such an effect in plasma would be of a principle significance both to its use in electronics and to explain many mysterious phenomena in space plasma. The author's discovery of such a kind of phase state and its usage in engineering and technology will really help create a high-energy power industry on a global scale. Therefore, the author of this article was the first to predict and confirm the existence of a revolutionary efficient, alternative, renewable and sustainable source of energy on planet Earth - plasma quantum condensate. This source of energy is the only environmentally safe source that does not destroy and pollute our planet, and using it helps make the three natural spheres of our plant cleaner. The usage of this new state of matter - quantum plasma condensate of quantum collisional plasma as a source of heat energy is a revolutionary technology for creating a global highly efficient power industry in this century.

REFERENCES

Ayrapetyan, V.S., V.V. Vikhrev, V.V. Ivanov, 1988. "Pinch mechanism of energy release of stellar flares". Technical Physics Journal, Volume 58, No.4, pages 662-668.

Bashkin, E. P. 1986. "Spin waves and quantum collective phenomena in Boltzmann gases", Advances in Physical Sciences, Volume 148, 3trd edition, pages 433-477.

Kulakov, A. V., A.A. Rumyantsev, 1979. "Generation of high energy particles by MHD impact turbulence". *Technical Physics Journal,* Volume 49, 10th edition, p/ 2127-2132.

Kulakov, A. V., V. M. Teutyunnik, "Operating principle of a plasma ultraviolet laser", Global Scientific Potential, 2016, No. 9 (66), pages 115-116.

Kulakov, A. V., V. M. Tyunyunnik, 2017. Solid phase plasma ultraviolet laser, *International Journal of Advanced Research,* Vol. 5(4), pp.271-273.

Kulakov, A. V., V.M. Teutyunnik, 2016. "Plasma quantum condensate - a new state of matter, source of alternative renewable and sustainable energy", Science and business: ways of development, No.7 (61), C. 13-21.

Kulakov, A.V. and Teutyunnik, V. M. 2017. "New approach to the plasma quantum condensate as a new state of matter", *International Journal of Current Research,* Vol.9, Issue 03, pp.47699-47703.

Kulakov, A.V., A. A. Rumyantsev, 1991. "Globe lightning as quantum condensate". The USSR Academy of Sciences Reports, Physics, Volume 320, No.5 pages 1103-1106.

Kulakov, A.V., A.A. Rumyantsev, 1988. "Spontaneous magnetism of quantum plasma". *Technical Physics Journal,* Volume 58, issue 4, pages 657-660.

Kulakov, A.V., E.V. Orlenko, A.A. Rumyantsev, 1990. "Quantum exchange forces in condensed media". Moscow, Science Publishing House.

Kulakov, A.V., V. A. Rantsev-Kartinov, 2015. "Experimental confirmation of the fact of the existence of plasma quantum condensate". *The Russian Academy of Sciences News Energy,* No.1. pages 46-61.

Trubnikov, B.A. 1990. "On possible generation of space beams in plasma pinches" Advances in Physical Sciences, Volume 160, 12th edition, p.167-18662.

****