About cold fusion possibilities in frame of the waveguide-resonance propagation of radiation fluxes

V K Egorov¹ and E V Egorov¹,²

¹ Institute of Microelectronics Technology Russian Academy of Science (IMT RAS), Russia, 142432 Chernogolovka, Moscow district, street Osyp’yana, 6
² Financial University under the government of the Russian Federation, Russia, 125993 Moscow, Leningradsky prospect, 49

egorov@iptm.ru

Abstract. The work proposes the original possible approach for the nuclear synthesis execution on base of radiation fluxes waveguide-resonance propagation phenomenon consequences. The experimental data set obtained in frame of quasimonochromatical X-ray radiation fluxes early and the corpuscle-wave dualism conception allowed for us to suggest the principle solution of cold fusion problem going round the Coulomb barrier impeding to nuclear interaction. Short characteristics of radiation fluxes waveguide-resonance propagation phenomenon and its consequence connected with independent radiation fluxes interaction through mutual influence of radiation standing waves uniform interference fields excited by these fluxes are presented.

1. Introduction
The phenomenon of cold fusion reaction process is the experimental proved fact [1], today. But the phenomenon effect is very small. The effect was registered in different conditions but the cold fusion mechanism is not enough clear. We assume that results of our investigations connected with the consequences phenomenon of radiation fluxes waveguide-resonance propagation can form the background of the cold fusion process possible mechanism elaboration [2].

The waveguide-resonance mechanism was discovered in result of explanation search of X-ray flux propagation through planar air extended slit clearances with nanosize width [3]. It is known, that the quasimonochromatic X-ray flux undergoes the external total reflection of the planar material interface with appearing of X-ray standing wave local interference area [4]. Similar areas appearing are featured for reflection of any nature radiation fluxes [5]. Size of the interference area is defined by the radiation coherence length, which conforms to the photon longitudinal size [6]. The transverse size of the interference area is defined by experimental conditions [7], and in conditions of X-ray fluxes external total reflection it is equal to half of radiation coherence length [8]. On the conception foundation of X-ray standing wave interference field appearing at the flux total reflection the idea of radiation waveguide-resonance propagation was born.

2. Radiation waveguide-resonance propagation phenomenon
The phenomenon of X-ray flux waveguide-resonance propagation is consequence of the radiation total external reflection effect on the material interface [9]. The effect is accompanied by X-ray standing wave interference field appearing in the air space under the interface. If we built the planar extended slit clearance by two planar dielectric plates (reflectors) use we can create two different situations for
X-ray flux propagation. In case of the wide slit clearance one can receive a device which will transport X-ray flux by the multiple total external reflection mechanism. This mechanism is accompanied by local interference fields set appearing of X-ray standing wave in the clearance space. At the same time, when the distance between reflectors forming the planar extended slit will be smaller than the half coherence length of X-ray quasimonochromatic flux transported by the clearance the interference field configuration will change to appearing of the X-ray standing wave uniform interference field (Figure 1). The films intensity in the slit will have the intensity maximum and will diminish in the reflectors volumes exponentially. The radiation flux transportation by such manner was called as the X-ray waveguide-resonance propagation or the radiation superfluidity and devices functioned in frame of the mechanism – the planar X-ray waveguide-resonator (PXWR) [10]. PXWR devices are unique instruments for X-ray nanosize beams formation. The uniform interference field appearing leads to abrupt change of the slit clearance radiation transportation efficiency owing to reflectors volumes overexcitation necessity absence. Period of the radiation standing wave uniform interference field is defined by the expression:

\[
D = \frac{\lambda_0}{2 \sin \theta} \approx \frac{\lambda_0}{2 \theta} \tag{1}
\]

where \( \theta \) is the radiation flux incidence angle. It is very important to notice that the waveguide-resonance effect is possible in case of the quasimonochromatic radiation fluxes propagation, which characterized by the radiation coherence length parameter defined by the expression [5]:

\[
L = \frac{\lambda_0^2}{\Delta \lambda} \tag{2}
\]

where \( \Delta \lambda \) is the radiation monochromatism degree. The phenomenon of radiation is characterized by very low attenuation of the fluxes intensity. It is connected with the necessity absence of the reflectors volumes over excitation. In the result, the intensity flux attenuation is defined by the standing wave interference field absorption in the reflections material and its penetration into the material depth is amenable to an exponential low. It is very important that the reflectors volumes must be characterized by monocrystal or amorphous structures. The volumes polycristallinity leads to uniform interference field distraction.

3. Radiation fluxes interaction through the interference fields mutual influence

Planar X-ray waveguide-resonator with simplest design showed on Figure 2a captures radiation flux in the angular interval nonexceeding of double value of the radiation total external reflection critical angle for the reflectors material, transports it almost without attenuation and forms the emergent beam characterized by filament form, nanosize width, enhance radiation density and angular divergence been equal to the capture angle. Last feature is the weak parameter of simplest PXWR. Because of this, PXWR specific constrctions for this shortage overcoming were elaborated [11]. The composite
planar X-ray waveguide-resonator (CPXWR) is the best solution for the parameter improving. It is completed by two simplest PXWR installed one by one with mutual aligning (Figure 2b).

This device is characterized by the emergent beam angular divergence decreasing in comparison with the input capture angle at the beam integral intensity conservation. Figure 3 illustrates the angular divergence decreasing effect. This effect is the result of X-ray standing wave interference fields interaction initiated in first and second PXWRs [12]. Function principle of CPXWR is the next. If the distance between subsequently mounted PXWRs exceeds $\Delta \lambda \left(8\Delta \lambda^2\right)^{-1}$ (Figure 4a), this structure forms a low-divergence X-ray beam with small intensity. At the distance between PXWRs becomes less than the abovementioned value, the situation at the output of the second waveguide-resonator will change cardinally (Figure 4b). The occurring change is related to the fact that the uniform interference field of the standing X-ray wave appearing in the slit clearance of the first PXWR is characterized by a certain protrusion which can penetrate into the second PXWR slit clearance. Due to the fact the interference fields begin to interact and reach a certain new state. The achieved stationary regime is characterized by preservation of the integral intensity of the quasi-monochromatic X-ray flux and decrease in the angular divergence of this flux as compared to the angle of radiation capture by the first waveguide-resonator.

Angular divergence decreasing is accompanied by growth of $\Delta \lambda$ radiation [12] defined by the expression:

$$\Delta \lambda = \phi \Delta \phi$$ (3)
Figure 4. Scheme of formation of a quasi-monochromatic X-ray flux by a pair of subsequently mounted and mutually adjusted PXWRs with slit clearance width $s=40$ nm with a distance $\Delta w$ between PXWRs: (a) $\Delta w > \lambda (8\Delta x^2)^{-1}$, which does not admit the partial angular tunnelling of the quasi-monochromatic X-ray flux and (b) $\Delta w < \lambda (8\Delta x^2)^{-1}$, which implements the radiation angular tunnelling.

So, the interaction between radiation standing waves uniform interference fields leads to some modification of the uniform interference field in the second PXWR. More wonderful result was obtained in attempts to find conditions of X-ray and light independent fluxes interaction by use the interference fields mutual influence of its radiation standing waves [13]. The PXWR specific design was served as the basis for the experimental conditions search of the possible interaction. Figure 5a shows scheme for study of the radiation standing waves interference fields expected interaction. The experimental setup of the scheme allowed to work with X-ray and optical standing waves interference fields. The optical radiation introduced into the experimental cell from a solid state laser by the quartz fiber across the filament collimator ($s=0.1$ mm) to semicylinder prism which was fastened on the external surface of one quart reflector forming X-ray waveguide structure. The laser had power 300 mW and generated radiation flux with wavelength 532 nm and was characterized by the coherence length value near 10 meters. Because of the PXWR reflector thickness is 2.5 mm and more smaller than the optical radiation flux coherence length parameter we received the uniform interference field of optical standing wave in the reflector volume. (It is interesting notice that in despite of generally accepted point of view all optical fibers function in frame of the waveguide-resonance propagation phenomenon owing to very great value of laser radiation coherence length parameter.) The critical angle of internal total reflection for this radiation on quartz/air interface is equal 42.5 degrees. Variation of the optical flux total reflection angle allowed to change period magnitude of the optical standing wave uniform interference field in the range 360-1027 nm.

Figure 5. Experimental setup used for interaction study between X-ray and light beams through mutual influence of standing wave interference fields excited by these fluxes (a).

Experimental pattern demonstrating the mutual interaction between standing waves interference fields provoked by CuK$\alpha$ radiation flux and green light flux in the unit built on base of PXWR simplest design [13] (b).

The X-ray standing wave uniform interference field was excited in the waveguide-resonator slit clearance by CuK$\alpha$ flux formed by Si monochromator from radiation generated by BSW-24 (Cu)
power source. The period of this uniform interference field can be varied in the range 21-180 nm by change of the initial flux incidence angle. We registered the interaction effect between interference fields when the period of X-ray interference field was equal to 180 nm and one of optical interference field was equal to 360 nm. This result is shown on Figure 5b. We had registered that the effect demonstrates resonance character with very narrow interaction range. In the investigations result we revealed the effect of radiation interference fields interaction but study of its features are in sight.

4. Waveguide-resonance propagation consequences for non zero rest mass particles

Investigations of elementary particles and atoms fluxes properties showed that it can display waves features described by the average wavelength $\lambda_0$, the monochromatism degree $\Delta \lambda$ and the coherence length parameter $L$, which can be defined by expression (1) [14].

$$\lambda_0 = \frac{h}{mv}$$

(4)

where $m$ and $v$ are particle mass and movement velocity.

$$\Delta \lambda = \frac{h \Delta v}{mv^2}$$

(5)

where $\Delta v$ is the particle velocity spreading.

$$L = \frac{h}{m \Delta v}$$

(6)

Moreover, it is well known, that atomic fluxes can diffract [15] and neutron fluxes can form the radiation standing wave areas [16]. So, in light of the radiation waveguide-resonance propagation phenomenon reality, the experimental proof of uniform interference fields interaction possibility and principle of the wave-corpuscle dualism one can assume that the consequences phenomenon of radiation fluxes waveguide-resonance propagation can be key for elaboration of the cold fusion fusion process allowing to go round the Coulomb barrier. It is clear that the conditions creation for the uniform interference field excitation by molecular or atomic beams is not simplest task. Experimental experience showed that similar conditions can be prepared for low energy atomic and molecular fluxes by the same pattern as X-ray ones [17]. The required conditions search is difficult but very perspective direction because of the energy yield of nuclear reactions is not comparable with the chemical reaction one. Scheme of the possible setup is presented on Figure 6.

\begin{figure}
\centering
\includegraphics[width=\textwidth]{figure6.png}
\caption{Scheme of the principle setup for low energy cold fusion fusion realization $(d+d \rightarrow ^4He + 24 MeV)$.}
\end{figure}

At the same time, specific demands must be imposed upon to the reaction chamber. Its construction must allow to decrease the wavelength featured to deuterium particle flux on half. The cold fusion problem solution is connected with preparation of atomic or molecular quasimonoenergetical fluxes with very much initial energy ($E_0 =$0.01 eV) and very small energy spreading ($\Delta E =$0.0001 eV), and the reaction chamber must be characterized by very high vacuum. But these problems solution is simpler and cheap in comparison with thermonuclear synthesis.

5. Conclusion
The work presents some arguments allowed to assume that the phenomenon of radiation fluxes waveguide-resonance propagation can be the key to execution of low energy nuclear reaction process being free from Coulomb limitation.

6. Appendix A

Table A1. A table with energy and wavelength another particle

| Particle | E, eV; $\lambda$, nm | E, eV; $\lambda$, nm | E, eV; $\lambda$, nm | E, eV; $\lambda$, nm | E, eV; $\lambda$, nm | Mass, g$\cdot$10$^{-24}$ |
|----------|----------------------|----------------------|----------------------|----------------------|----------------------|-------------------------|
| Electron | 0.01 1160 | 0.025 730 | 0.1 506 | 1 116 | 10 39 | 100 12 | 9.1$\cdot$10$^4$ |
| Proton | 0.01 0.27 | 0.025 0.17 | 0.1 0.085 | 0.1 0.027 | 10 0.009 | 100 0.0028 | 1.7 |
| Neutron | 0.01 0.27 | 0.025 0.17 | 0.1 0.085 | 0.1 0.027 | 10 0.009 | 100 0.0028 | 1.7 |
| Deuton | 0.01 0.194 | 0.025 0.122 | 0.1 0.061 | 0.1 0.019 | 10 0.0065 | 100 0.0002 | 3.3 |
| $^3$He atom | 0.01 0.157 | 0.025 0.099 | 0.1 0.05 | 0.1 0.016 | 10 0.0052 | 100 0.0019 | 5 |
| $^4$He atom | 0.01 0.137 | 0.025 0.86 | 0.1 0.042 | 0.1 0.014 | 10 0.0046 | 100 0.0018 | 6.6 |

7. References

[1] Storm E 2007 The science of low energy nuclear reaction (New Jersey: World Scientific).
[2] Egorov V and Egorov E 2017 Planar X-ray waveguide-resonators. Realization and perspectives (Saarbrucken: Lambert Acad. Publ.). (On Russian).
[3] Egorov V and Egorov E 2003 J. Advances in X-ray analysis 46 307.
[4] Bedzyk M, Bommarito G and Schildkraut J 1989 J. Phys. Rev. Letters 69 1376.
[5] Brehovskiy L 1980 Waves in layered media (New York: Academic Press).
[6] Born M and Wolf E 1993 Principles of optics electromagnetic theory of propagation of interference and diffraction of light (Oxford: Pergamon Press).
[7] Mondel L and Wolf E 1995 Optical coherence and quantum optics (Cambridge: Cambridge Univ. Press).
[8] Egorov V and Egorov E 2007 J. X-ray spectrometry 36(2) 381.
[9] Compton A 1923 J. Phil. Mag. 45(270) 1121.
[10] Egorov V and Egorov E 2004 J. X-ray spectrometry 33 360.
[11] Egorov V and Egorov E 2002 Mat. Res. Soc. Symp. Proc. 716 189.
[12] Egorov V and Egorov E 2018 J. Optics and spectroscopy 124(6) 838.
[13] Egorov V, Egorov E and Rogozhnikov G 2016 Proc. of 24 International symp. “Nanostructures: Physics and technology” (Saint Petersburg: Acad. Univ. Press) pp 281-282.
[14] Broglie L 1970 J. Foundation of physics 1(1) 5.
[15] Carnal O and Mlynek J 1991 J. Phys. Rev. Let. 66(21) 2689.
[16] Aksenov V, Ignatov V and Nikitenko Yu 2006 J. Crystallography reports 51(5) 734.
[17] Esterman I, Frisch R and Stern O 1931 J. Zs. F. Phys. 73 348. (On German).

Acknowledgments

We are grateful to prof. B.A. Kalin and Dr. A.A. Galitsyn for the attention and interest to our investigations. This work produced by State task #075-00475-19-00 and has been partially financial supported by RFFI (grant #19-07-00271).