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Restrictions on the Hypothetical Long-Range Interactions
from the Casimir-Type Null Experiment with Three Test Bodies

by

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Restrictions on the Hypothetical Long-Range Interactions from the Casimir-Type Null Experiment with Three Test Bodies*

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Abstract

A realistic null experiment is suggested in which the Casimir force between a plane plate and a spherical lens is compensated by the force of gravitational attraction. This configuration is shown to be very sensitive to the existence of additional hypothetical forces of Yukawa-type or power laws. From the suggested null experiment the restrictions on the Yukawa constant α can be strengthened by a factor up to 1000 in a wide range $10^{-8}\text{m} < \lambda < 10^{-4}\text{m}$ and by a factor of 10 for λ from several centimeters to several meters. For power law interactions the strengthening of restrictions by a factor of 20 is possible for the force decreasing as r^{-5} .

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I. Introduction

Recently great interest was in the search of new long-range interactions and restrictions on their parameters [1-7]. This interest is due to both the possible existence of corrections to the classical gravitational theory at small distances and hypothetical forces between macrobodies resulting from the exchange by light elementary particles between separate atoms. Massless or light elementary particles, such as arion, dilaton, scalar axion, spin-1 antigraviton etc [3,8] are predicted in almost any unified gauge theory, supersymmetry and supergravity. It seems impossible to eliminate such objects from the formalism of modern elementary particle theory. So, there were undertaken a number of attempts to observe additional forces in gravitational experiments [2], in elementary particle physics [8] and in astrophysical observations [3].

The strongest restrictions on the constants of the hypothetical forces are obtained in laboratory experiments of Eötvös-type, of Cavendish-type, in measuring Van der Waals and Casimir forces and the transition probabilities in exotic atoms [2,4,5,9,10]. In the paper [7] the optimal configuration of two test bodies was found which allowed to obtain the most rigid restrictions on hypothetical forces from the force measuring or measuring the deviations from the known force law. It was shown that the optimal configuration was very nearly to the configuration of two plane parallel plates.

One of the most interesting experiments on obtaining the restrictions on hypothetical forces is the experiment on Casimir force measurements. From this experiment the best restrictions on Yukawa-type interactions, described by the potential

$$V(r) = \frac{\alpha}{r} N^2 \exp\left(-\frac{r}{\lambda}\right), \quad (1)$$

were obtained [10] for the wide range $10^{-8}\text{m} < \lambda < 10^{-4}\text{m}$ (r is the distance between atoms, α is the interaction constant, $\hbar=c=1$, N is the number of nuclei in atomic nucleus (it is introduced in order to make α independent of the sort of atoms)).

Before 1990 the restrictions on the power law interactions, described by the potential

$$V_n(r) = \frac{\lambda_n}{r} N^2 \left(\frac{r_0}{r} \right)^{n-1}, \quad (2)$$

obtained from the Casimir force measurements, also were the best for $n = 2, 3$ [11] (here λ_n are the dimensionless interaction constants and $r_0 \equiv 10^{-15}\text{m}$ is introduced for the proper dimensionality of V_n). But in 1990 these restrictions were overcome [12] by the data from the new Cavendish-type experiment [13].

In the present paper a new Casimir-type compensation (null) experiment is suggested for obtaining the more rigid restrictions on hypothetical interactions. It uses the optimal configurations of Ref. [7] with three, instead of two, test bodies for which the Casimir force is compensated by the gravitational one. This compensation experiment is more sensitive to the presence of additional interactions and allows to strengthen all known up to now restrictions on Yukawa type interactions by the factors up to 10^3 in the range $10^{-4}\text{m} < \lambda < 10^{-8}\text{m}$ and up to 10 for the λ region from several centimeters to several meters. For power law interactions the possible strengthening for $n = 4$ is 20 times in comparison with the best known results [7]. So the suggested here compensation experiment promises the restrictions strengthening for Yukawa-type interactions and for power law interactions of the same order as the optimal experiments with two test bodies of the paper [7]. But this experiment is much more convenient for experimental technique realization and deals with only equipment and configurations used before in the experiments on measuring Van der Waals, Casimir and gravitational forces. The aim of this paper is to attract the attention of experimentalists to this new laboratory experiments on fundamental interactions.

II. The General Scheme of the Null Experiment

Let us consider a round plate A with area S , thickness H_p and density ρ_3 which is hanged up to a point P by a long thread (see Fig. 1). A spherical lens made, e.g., of quartz with curvature radius R , of height H_l and density ρ_2 is glued to the plate in its center. This lens plays the role of one of the test bodies of the Casimir-type optimal experiment in Ref. [7]. The role of the second test body plays a large round plate B of thickness D_1 and density ρ_4 , which is parallel to A and put on the distance $0.1\mu\text{m} < d_s < 1.5\mu\text{m}$ from the lens. The configuration of spherical lens over a plane plate was used for the Casimir force measurements in papers [14,15]. Due to the large value of R , the Casimir interaction between the lens and the plate B does not differ essentially from the case of two plane parallel plates investigated in [7]. The gravitational interaction between A and B can be neglected.

In order to compensate the attractive Casimir force, acting upon A , we use the gravitational interaction between the plate B and the plate C so that $d_b \gg d_s$, d_b is the distance between A and C (see Fig. 1). The diameter of the plate C is denoted by $2L$, its density by ρ_1 , and its thickness by $D \gg D_1$. The distance d_b is chosen to be so large that only the gravitational interaction between the plates A and C must be taken into account. The condition $S \ll L^2$ is suggested so that the plate A is concentrated near the center of C . The value of the gravitational force between the plates A and C can be changed by the variation of D (for example a special tank with a liquid can be used as C with a mobile back wall for changing the quantity of liquid and, as a consequence, of the gravitational force). For the appropriate range of hypothetical interaction it is more convenient to treat the gravitational force as a probe for hypothetical interactions and the Casimir force as the compensating one.

Let us now find the equilibrium conditions between the Casimir and gravitational forces acting on the plate A with the lens. The Casimir force between the plane

plate B and the spherical lens is given by the formula [14]

$$F_{Cas} = \frac{2\pi R B_c}{3 d_s^3}, \quad (3)$$

where $B_c \approx 3 \times 10^{-28} \text{Jm}$ for the metallic plate and quartz lens, B is calculated with the relative error of 10-20% (we can neglect the Casimir interaction between B and the underlying plate A due to the quick decreasing of Casimir force with distance).

For the calculation of the gravitational force between the plate C and the plate A with the lens let us calculate firstly the force between C and an individual atom of mass m_a on the distance h from the center of C . It reads

$$\begin{aligned} F_{g,a} &= 2\pi\rho_1 G \int_0^L x dx \int_{-D}^0 dz \frac{m_a}{\sqrt{x^2 + (z-h)^2}} \\ &= 2\pi\rho_1 G m \left[\frac{D}{L} + \sqrt{1 + (h/L)^2} - \sqrt{1 + ((D+h)/L)^2} \right], \end{aligned} \quad (4)$$

where G is Newtonian gravitational constant.

Integrating this equation over the volumes of the plate A and of the spherical lens, we obtain for the sought force in the zero order of the small parameters d_b/L , D/L , H_p/L , $\sqrt{S}/L$:

$$F_g = 2\pi\rho_1 G \left[SDH_p\rho_3 + \frac{\pi\rho_2}{3} \left(R - \frac{H_l}{3} \right) DH_l^2 \right]. \quad (5)$$

For numerical estimations it is convenient to rewrite the results (3), (5) in the form with characteristic values of all these parameters:

$$F_{Cas} = 4 \times 10^{-12} N \left(\frac{R}{0.7\text{cm}} \right) \left(\frac{1\mu\text{m}}{d_s} \right)^3 \left(\frac{B}{3 \times 10^{-28}\text{Jm}} \right), \quad (6)$$

$$F_g = 4 \times 10^{-12} N \left(\frac{\rho_1}{10^3\text{kg/m}^3} \right) \left(\frac{\rho_3}{2 \times 10^3\text{kg/m}^3} \right) \left(\frac{D}{4\text{cm}} \right) \left(\frac{S}{1\text{cm}^2} \right) \left(\frac{H_p}{1\text{mm}} \right), \quad (7)$$

where also it is taken into account that the second item in (5), which describes the contribution of the lens, is small in comparison with the first.

Now it is necessary to discuss the exactness with which the equality of F_{Cas} and F_g can be obtained. The value of gravitational constant G is known up to 1%

[16]. So it is desirable to know the value of B_c with the same accuracy. But the theoretical value of B_c presented in the beginning of this section is not so exact. For this purpose it is necessary to state experimentally the equilibrium of the system under consideration with certain values of D and d_s (gravitational forces (5) does not depend on d_b in our approximation) and then to calculate the value of B_c . After that one can use the obtained value of B_c with the relative error of 1% for the calculations of restrictions on hypothetical interactions for the other values of D and d_s .

The suggested scheme of null experiment may be said to be a composition of experimental devices previously used in the measuring of Casimir and gravitational forces. For example, all the experimental difficulties under measuring the Casimir forces (non-ideality of test body surfaces, measuring of small distances, different types of noises connected with measurement of small forces etc) can be overcome like that was done in the papers [14,15,17]. Then, extremely small gravitational forces (up to 2×10^{-15} N that is by 3 orders less than in (7)) were detected successfully in the paper [18]. At last, the compensation scheme of the experiment is generally used for obtaining the sensitivity limits of different physical quantities (see, e.g., [19]).

So the Casimir force F_{Ca} can be compensated by the gravitational force F_g with the relative error of 1%. If the additional hypothetical interaction exists between the bodies A, B and A, C , then the equilibrium state may be broken due to the difference of additional interactions between A, B and A, C . Let us discuss separately the cases of Yukawa and power law hypothetical interactions and analyze, for what parameters values the strongest restrictions on hypothetical interaction constants could be obtained if no breaking of equilibrium were observed.

III. The Restrictions on Yukawa-type Hypothetical Interactions

Because of the hypothetical interaction is very small it can be obtained by additive integration of the potential (1) over the volumes of the test bodies. Let us calculate firstly the force between the plate C and an atom in the distance h from the center of C due to the potential (1). By simple integration we obtain:

$$F_{H,a}(h) = 2\pi\alpha\lambda n_1 N^2 \left[e^{-h/\lambda} - e^{-(D+h)/\lambda} + e^{-\sqrt{L^2+(D+h)^2}/\lambda} - e^{-\sqrt{L^2+h^2}/\lambda} \right], \quad (8)$$

where n_1 is the number of atoms per unit volume of the material of the plate C .

Because from Casimir force measurements the best restrictions on α follow for the region $10^{-8}\text{m} < \lambda < 10^{-4}\text{m}$ we can neglect the third and fourth terms in (8). Integrating then the result (8) over the volumes of the plane plate A and the spherical lens we obtain the expression for the hypothetical force between them and the plate C :

$$\begin{aligned} F_{H,1} &= S n_3 \int_{d_b}^{d_b+H_p} F_{H,a}(h) dh \\ &\quad + \pi n_2 \int_{d_b+H_p}^{d_b+H_p+H_l} F_{H,a}(h) \left[R^2 - (R - d_b - H_p - H_l + h)^2 \right] dh \\ &= 2\pi\alpha n_1 \lambda^2 N^2 \left\{ e^{-d_b/\lambda} \left[1 - e^{-D/\lambda} - e^{-H_p/\lambda} + e^{-(D+H_p)/\lambda} \right] n_3 S \right. \\ &\quad \left. + \pi n_2 e^{-(D+H_l+H_p+d_b)/\lambda} \left(e^{D/\lambda} - 1 \right) \right. \\ &\quad \left. \times \left[e^{H_l/\lambda} \left(H_l^2 - 2H_l R - 2H_l \lambda + 2R\lambda + 2\lambda^2 \right) - 2R\lambda - 2\lambda^2 \right] \right\}, \end{aligned} \quad (9)$$

where n_3, n_2 are the numbers of atoms in the unit volume of the plate A and of the lens materials.

In a quite similar way the hypothetical force between the plate A with the spherical lens and the plate B may be found (taking into account that the characteristic size of the plate B is also of order of L):

$$\begin{aligned}
F_{H,2} &= S n_3 \int_{d_s+H_l}^{d_s+H_l+H_p} F_{H,a}(h) \Big|_{\substack{D=D_1 \\ n=n_4}} dh \\
&\quad + \pi n_2 \int_{d_s}^{d_s+H_l} F_{H,a}(h) \Big|_{\substack{D=D_1 \\ n=n_4}} [2R(h-d_s) - (h-d_s)^2] \\
&= 2\pi\alpha n_4 \lambda^2 N^2 \left\{ e^{-(H_l+d_s)/\lambda} \left[1 - e^{-D_1/\lambda} - e^{-H_p/\lambda} + e^{-(D_1+H_p)/\lambda} \right] n_3 S + \right. \\
&\quad \left. + \pi n_2 e^{-(D_1+H_l+d_s)/\lambda} (e^{D_1/\lambda} - 1) \right. \\
&\quad \left. \times [2H_l R - H_l^2 - 2H_l \lambda - 2\lambda^2 + 2R\lambda + 2e^{H_l/\lambda} \lambda(\lambda - R)] \right\}, \tag{10}
\end{aligned}$$

where n_4 is the number of atoms in the unit of volume of the plate B .

Now it is possible to obtain restrictions on α in dependence on λ from the evident inequality

$$|F_{H,1} - F_{H,2}| < \delta \Delta F = \frac{F_g}{100}, \tag{11}$$

which means that no deviations from equilibrium state are registered which may be caused by the hypothetical force with the value of $\geq 0.01 F_g$. As it is seen from (7) the right hand side of (11) is of the order of $> (10^{-13} \dots 10^{-12})N$. Here we must underline that it is not necessary to measure such forces and only the sensitivity of the used setup to forces shift relatively zero is needed. Recall that the nowadays experimental limit to such quantity is $2 \times 10^{-15}N$ [18].

The results of numerical calculations based on Eqs. (9)-(11) are presented in Fig. 2 by the curve 1. The permitted region of (α, λ) lies below the curve 1. For every λ the optimization was made on the values of parameters D, S, H_p, H_l, R, d_b to get the strongest restriction on α . For the same purpose the following values for the densities were chosen: $\rho_1 = 10^3 \text{kg/m}^3$, $\rho_2 = \rho_3 = 2 \times 10^3 \text{kg/m}^3$, $\rho_4 = 2 \times 10^4 \text{kg/m}^3$. As an example, for $\lambda = 10^{-5} \text{m}$ the optimal parameters values are: $D = 0.11 \text{m}$, $S = 10^{-3} \text{m}^2$, $H_p = 6.3 \times 10^{-4} \text{m}$, $H_l = 10^{-4} \text{m}$, $R = 6.6 \times 10^{-3} \text{m}$, the value of d_b practically does not influence the result in a wide region from 1 cm and more.

In the region of $\lambda > 10^{-6} \text{m}$ the optimal distance d_s for obtaining the strongest restrictions was found to be equal to $(1-1.5)\mu\text{m}$. Beginning from $\lambda \approx 10^{-6} \text{m}$ and

less, the optimal distance d_s decreases from $1\mu\text{m}$ till $0.1\mu\text{m}$. It should be noted that in the region $10^{-8}\text{m} < \lambda < 0.1\text{m}$ the role of probe force to hypothetical interactions plays the Casimir force and gravitational force is only the compensation. For the region $\lambda > 0.1\text{m}$ the situation changes *vice versa*: gravitational force is the probe and the Casimir force compensates it. In the same Fig., by the curve 2 the best restrictions on hypothetical interactions are shown which are obtained up to today from different laboratory experiments [7].

It is seen that in a wide region $10^{-4}\text{m} < \lambda < 10^{-8}\text{m}$ (for which the known results obtained from the Casimir experiments of the paper [15,17] are shown in the curve 2) the best restrictions on α can be strengthened in the suggested experiment up to 1000 times. In the region from several centimeters to several meters the known up to now restrictions on Yukawa-type interactions may be strengthened up to 10 times (the known results here, represented in curve 2, follow from Eötvös-type experiments of the paper [5]).

IV. The Restrictions on Power-Law Hypothetical Interactions

Now let the hypothetical force between the separate atoms of macrobodies is caused by the potential (2). In a manner, analogical to Sec.3, we can calculate the additional forces acting between the test bodies A, C and A, B .

The hypothetical force acting between the plate C and an atom at the distance h from the center of C is

$$F_{H,a}^n = 2\pi\lambda_n N^2 r_0^{n-1} n_1 \int_0^L x dx \left\{ \frac{1}{(x^2 + h^2)^{n/2}} - \frac{1}{(x^2 + (h+D)^2)^{n/2}} \right\}. \quad (12)$$

In the cases $n = 2, 3, 4$ – for which a strengthening of modern restrictions will be possible in the suggested here experiment – the results of integration (12) read:

$$F_{H,a}^{(2)} = 2\pi\lambda_2 N^2 r_0 n_1 \left[\ln \frac{D+h}{h} - \frac{1}{2} \ln \frac{(D+h)^2 + L^2}{h^2 + L^2} \right], \quad (13)$$

$$F_{H,a}^{(3)} = 2\pi\lambda_3 N^2 r_o^2 n_1 \left[\frac{D}{h(D+h)} - \frac{1}{\sqrt{h^2 + L^2}} + \frac{1}{\sqrt{(D+h)^2 + L^2}} \right], \quad (14)$$

$$F_{H,a}^{(4)} = \pi\lambda_4 N^2 r_o^3 n_1 L^2 \left[\frac{1}{h^2(L^2 + h^2)} - \frac{1}{(D+h)^2[(D+h)^2 + L^2]} \right]. \quad (15)$$

Now the additional hypothetical forces $F_{H,1}^{(n)}, F_{H,2}^{(n)}$ acting due to the potential (2) between the plate A with the lens and plates C, B correspondingly are expressed by the first lines of Eqs. (9), (10) in which the function $F_{H,a}(h)$ must be replaced by $F_{H,a}^{(n)}(h)$ (Eqs. (13)-(15)). All these integrals can be calculated in analitical form in the zero order with respect to the small parameters $d_b/L, D/L, H_l/L, \sqrt{S}/L, d_s/L, D_1/L$. For the sake of brevity we will write out here only the results for $n = 4$. As it will be seen below, in this case the suggested experiment leads to the most fruitful results for the power law interactions. So the expression for $F_{H,1}^{(4)}$ reads :

$$\begin{aligned} F_{H,1}^{(4)} = & \pi\lambda_4 N^2 r_o^3 n_1 \left\{ Sn_3 H_p \left[\frac{1}{d_b(H_p + d_b)} - \frac{1}{(d_b + D)(H_p + d_b + D)} \right] \right. \\ & + \pi n_2 \left[H_l \left(\frac{D + d_b + H_l + H_p - 2R}{D + d_b + H_p} - \frac{d_b + H_l + H_p - 2R}{d_b + H_p} \right) \right. \\ & + 2(d_b + H_l + H_p - R) \ln \frac{d_b + H_l + H_p}{d_b + H_p} \\ & \left. \left. - 2(D + d_b + H_l + H_p - R) \ln \frac{D + d_b + H_l + H_p}{D + d_b + H_p} \right] \right\}. \quad (16) \end{aligned}$$

The corresponding expression for $F_{H,2}^{(4)}$ is:

$$\begin{aligned} F_{H,2}^{(4)} = & \pi\lambda_4 N^2 r_o^3 n_1 \left\{ Sn_3 D \left[\frac{1}{(d_s + H_l)(H_l + d_s + D)} \right. \right. \\ & \left. \left. - \frac{1}{(d_s + H_l + H_p)(H_p + H_l + d_s + D)} \right] \right. \\ & + \pi n_2 \left[D_1 + \frac{(d_s + 2R)d_s}{d_s + H_l} - \frac{(D_1 + d_s)(D_1 + d_s + 2R)}{D + d_s + H_l} \right. \\ & \left. \left. + 2(d_s + R) \ln \frac{d_s + H_l}{d_s} - 2(D + d_s + R) \ln \frac{D + d_s + H_l}{D + d_s} \right] \right\}. \quad (17) \end{aligned}$$

Now the restrictions on λ_n may be obtained from the inequality (11) using the expressions (13)-(17) for the hypothetical forces. In all the cases the values of

the plates geometrical parameters were chosen to obtain the strongest restrictions. All these results together with the relevant sensitivity of the laboratory setup to the force value displacement are collected in the Table I. The optimal densities are the same as in Sec.3. From the Table it is seen that the most strengthening of restrictions on λ_n from the suggested experiment (by the factor of 20) takes place for $n = 4$ (now it is known from Cavendish-type experiments that $\lambda_4 \leq 1 \times 10^{-3}$, $\lambda_3 \leq 0.7 \times 10^{-16}$, $\lambda_2 \leq 0.7 \times 10^{-29}$ [12]). So the suggested experiment promises the large progress in obtaining the most rigid restrictions for Yukawa-type hypothetical interactions and power law ones for $n = 4$. For other power - law interactions it will give the results which are compared to those obtained in Cavendish-type experiments.

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References

- [1] E.G. Adelberger *et al.*, Annu.Rev.Nucl.Sci. **41**, 269 (1991).
- [2] C.W. Stubbs *et al.*, Phys.Rev.Lett. **62**, 609 (1989).
- [3] J. Kim, Phys.Rep. **150**, 1 (1987).
- [4] G. Feinberg, Commun.Mod.Phys.A **19**, 51 (1989).
- [5] B.R. Heckel *et al.*, Phys.Rev.Lett. **63**, 2705 (1989).
- [6] E. Fischbach *et al.*, Metrologia **29**, 215 (1992).
- [7] V.M. Mostepanenko and I.Yu.Sokolov, Phys.Rev. D **47**, 2882 (1993).
- [8] A.A. Anselm, N.G. Uraltzev and V.A. Hose, Usp.Fiz.Nauk **145**, 185 (1985)
[Sov.Phys.Usp. **28**, 113 (1985)].
- [9] C.W. Stubbs *et al.*, Phys.Rev.Lett. **62**, 609 (1989).
- [10] V.M. Mostepanenko and I.Yu. Sokolov, Phys.Lett. A **132**, 313 (1988).
- [11] V.M. Mostepanenko and I.Yu. Sokolov, Phys.Lett. A **125**, 405 (1987).
- [12] V.M. Mostepanenko and I.Yu. Sokolov, Phys.Lett. A **146**, 373 (1990).
- [13] J.K. Hoskins *et al.*, Phys. Rev. D **32**, 3084 (1985).
- [14] B.V. Derjaguin, I.I. Abrikosova and E.M. Lifshitz, Quart.Rev. **10**, 295 (1968).
- [15] Y.N. Israelachvili and D. Tabor, Proc.R.Soc.London **A331**, 19 (1972).
- [16] G. Müller *et al.*, Phys.Rev.Lett. **63**, 2621 (1989).
- [17] S. Hunklinger, H.Beisselman and W.Arnold, Rev.Sci.Instrum. **43**, 584 (1972).

- [18] V.I. Panov and V.N. Frontov, Zh.Eksp.Teor.Fiz. **77**, 1701 (1979)
[Sov.Phys.JETP **50**, 852 (1979)].
- [19] Y.T. Chen, A.H. Cook and A.J.F. Metherell, Proc.R.Soc.London **A394**, 47
(1984).

n	$\lambda_{n\ max}$	$D(cm)$	$S(m^2)$	$H_p(m)$	$H_l(m)$	$R(m)$	$d_s(\mu m)$	$\delta\Delta F = \frac{F_g}{100}(N)$
2	1.6×10^{-29}	12	10^{-4}	10^{-4}	10^{-2}	10^{-2}	1.5	2×10^{-13}
3	1.4×10^{-16}	3.6	10^{-2}	2×10^{-3}	10^{-4}	3.2	1.5	6×10^{-12}
3	1.4×10^{-16}	3.6	10^{-4}	2×10^{-3}	10^{-4}	3×10^{-2}	1.5	6×10^{-14}
4	5×10^{-5}	10	10^{-4}	10^{-4}	10^{-4}	9×10^{-2}	1.45	2×10^{-13}

TABLE I. The limits on the constants of power law long-range interactions from the suggested experiment and the values of experimental device parameters.

FIG.1. The general scheme of the null experiment. The plate A of the area S and of thickness H_p has the density ρ_3 and the density of nucleons n_3 . The spherical lens of the height H_l and the curvature radius R has the density ρ_2 and the nucleon density n_2 . The distance of it from the plate B is d_s . The thickness of B is D_1 and the densities are ρ_4 and n_4 . The plate C has the diameter $2L$, other parameters D, ρ_1, n_1 and the distance of it from A is d_b .

FIG.2. The restrictions on the parameters of Yukawa interaction (α, λ) from: 1 - the suggested here Casimir-type null experiment; 2 - all experiments made up today.