PRODUCTION OF SCALAR BOSON AND NEUTRINO PAIR IN LONGITUDINALLY POLARIZED ELECTRON-POSITRON COLLIDING BEAMS

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Within the framework of the Minimal Supersymmetric Standard Model, the processes of the production of a scalar boson in longitudinally polarized electron-positron collisions are investigated: $e^-e^+ \to H\nu\bar{\nu}$, $e^-e^+ \to h\nu\bar{\nu}$, where $\nu\bar{\nu}$ is the neutrino-antineutrino pair. It is shown that each process is described by two spiral amplitudes F_{LR} and F_{RL} that describe the processes $e_L^- e_R^+ \to H(h)\nu\bar{\nu}$ and $e_R^- e_L^+ \to H(h)\nu\bar{\nu}$ accordingly. Two mechanisms for the creation of a scalar boson have been studied in detail: the radiation of a scalar boson by a vector Z^0-boson and the production of a scalar boson as a result of the fusion of W^+W^--bosons. An analytic expression of the effective cross sections is obtained, which describe the angular and energy distributions of the scalar boson.

Keywords: Scalar boson, Minimal Supersymmetric Standard Model, left and right coupling constants, helicity, Weinberg parameter.
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1. INTRODUCTION

The Standard Model (SM), based on the local gauge symmetry group $SU_C(3)\times SU_L(2)\times U_4(1)$, has achieved great success in describing the strong, electromagnetic, and weak interactions between elementary particles [1-3]. With the recent discovery of the scalar Higgs boson at the Large Hadron Collider (LHC) by the ATLAS and CMS laboratories [4-5] (see also the reviews [6-8]) the CM of fundamental interactions has got a logical conclusion. We note that the SM contains one scalar doublet that provides a mass to $W^{\pm}$, Z^0-bosons, quarks, and leptons simultaneously. In this case, there is only one CP-even Higgs boson H_{CM}. The SM extension is the Minimal Supersymmetric Standard Model (MSSM), where, unlike SM, two doublets of scalar complex fields with hypercharges -1 and 1 are introduced [8-11]:

$$H_1 = \begin{pmatrix} H_1^0 \\ H_1^- \end{pmatrix}, \qquad H_2 = \begin{pmatrix} H_2^+ \\ H_2^0 \end{pmatrix}.$$

Scalar fields are written as:

$$H_1 = \frac{1}{\sqrt{2}}\begin{pmatrix} \vec{\upsilon}_1 + H_1^0 + iP_1^0 \\ H_1^- \end{pmatrix}, \; H_2 = \frac{1}{\sqrt{2}}\begin{pmatrix} H_2^+ \\ \vec{\upsilon}_2 + H_2^0 + iP_2^0 \end{pmatrix},$$

where H_1^0, P_1^0, H_2^0 and P_2^0 are real scalar fields, υ_1 and υ_2 are the vacuum values of the fields $< H_1 >= \frac{1}{\sqrt{2}}\upsilon_1$ and $< H_2 >= \frac{1}{\sqrt{2}}\upsilon_2$.

CP-even *H* and *h*-bosons are obtained by mixing the fields H_1^0 и H_2^0 (α the mixing angle):

$$\begin{pmatrix} H \\ h \end{pmatrix} = \begin{pmatrix} \cos\alpha & \sin\alpha \\ -\sin\alpha & \cos\alpha \end{pmatrix}\begin{pmatrix} H_1^0 \\ H_2^0 \end{pmatrix}.$$

Similarly, we get Goldstone's $G^0, G^{\pm}, CP$ odd *A* and charged $H^{\pm}$-bosons (β mixing angle):

$$\begin{pmatrix} G^0 \\ A \end{pmatrix} = \begin{pmatrix} \cos\beta & \sin\beta \\ -\sin\beta & \cos\beta \end{pmatrix}\begin{pmatrix} P_1^0 \\ P_2^0 \end{pmatrix}, \quad \begin{pmatrix} G^{\pm} \\ H^{\pm} \end{pmatrix} = \begin{pmatrix} \cos\beta & \sin\beta \\ -\sin\beta & \cos\beta \end{pmatrix}\begin{pmatrix} H_1^{\pm} \\ H_2^{\pm} \end{pmatrix}.$$

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Thus, there are five Higgs bosons in the MSSM: two CP-even bosons $h, H,$, one CP-odd *A*-boson and two charged $H^{\pm}$ bosons. Here the Higgs boson sector is characterized by six parameters: M_H, M_h, M_A, $M_{H^\pm}$, α and β. Of these, only two parameters are free: M_A and $tg\beta$. The masses of the CP-even *h*- and *H*-bosons are expressed in terms of the masses M_A and M_Z:

$$M^2_{h(H)} = \frac{1}{2}\left[M_A^2 + M_Z^2 \mp \sqrt{\left(M_A^2 + M_Z^2\right)^2 - 4M_A^2 M_Z^2 \cos^2 2\beta}\right],$$

and the value $\cos^2(\beta-\alpha)$ is given by the relation:

$$\cos^2(\beta-\alpha) = \frac{M_h^2(M_Z^2 - M_h^2)}{M_A^2(M_H^2 - M_h^2)} .$$

The parameter $tg\beta$ is equal to the ratio of the vacuum values of the fields H_2^0 and H_1^0 $(tg\beta = \upsilon_2/\upsilon_1)$ varies within the limits $1 \le tg\beta \le m_t/m_b$, where m_t and m_b is the mass of t - and b -quarks.

In the present paper we have studied the processes of the production of a scalar *H* (or *h*) boson and a neutrino pair on longitudinally polarized electron-positron colliding beams:

$$e^- + e^+ \to H + \nu + \bar{\nu}, \tag{1}$$

$$e^- + e^+ \to h + \nu + \bar{\nu} \tag{2}$$

where $\nu\bar{\nu}$ is a pair of muon, tau-lepton or electron neutrinos ($\nu\bar{\nu} \Rightarrow \nu_\mu\bar{\nu}_\mu,\ \nu_\tau\bar{\nu}_\tau, \nu_e\bar{\nu}_e$).

2. THE MECHANISM OF EMISSION OF A SCALAR BOSON

The Feynman diagrams of the reaction (1) are shown in Fig. 1. In brackets are written 4-particle momentum, electron and positron helicity. We note that diagram a) corresponds to the emission of a scalar boson by a vector Z^0-boson.

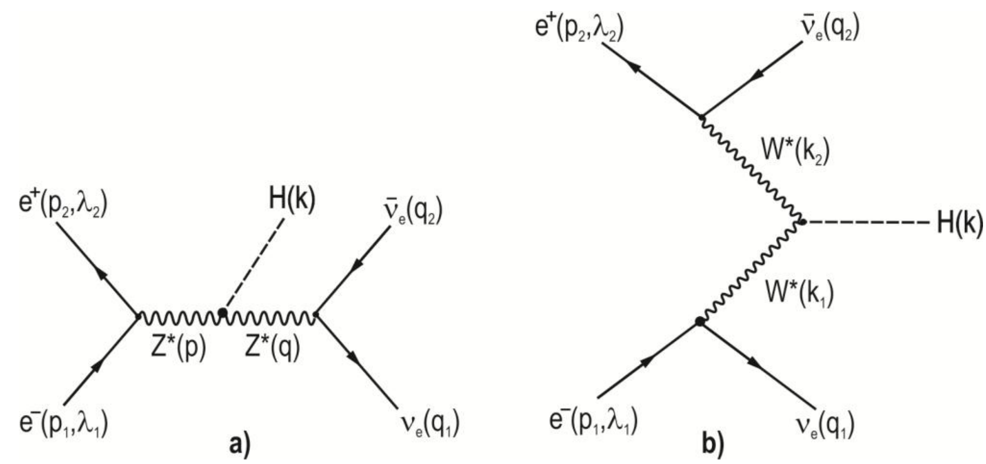

Fig. 1. Feynman diagrams of the reaction $e^-e^+ \to H\nu_e\bar{\nu}_e$.

Diagram a) corresponds to the following matrix element (here, the conservation of electron and neutrino currents is taken into account, and also $p^2 = (p_1 + p_2)^2 > M_Z^2$):

$$M_a(e^-e^+ \to H\nu\bar{\nu}) = i\left(\frac{e}{2\sin\theta_W \cdot \cos\theta_W}\right)^3 \cdot M_Z \cos(\beta-\alpha)\ D_Z(s)\, D_Z(xs) \times$$
$$\times \bar{\upsilon}(p_2,\lambda_2)\gamma_\mu[g_L(1+\gamma_5) + g_R(1-\gamma_5)]u(p_1,\lambda_1)\cdot \bar{u}(q_1)\gamma_\mu(1+\gamma_5)\upsilon(q_2), \tag{3}$$

where θ_W is the Weinberg angle,

$$D_Z(s) = (s - M_Z^2)^{-1}, \quad D_Z(xs) = (xs - M_Z^2 + iM_Z\Gamma_Z)^{-1},$$

M_Z and Γ_Z the mass and total width of the Z^0-boson, $s = p^2$ the square of the total energy of the $e^- e^+$-pair in the center-of-mass system, g_L and g_R the left and right coupling constants of the electron with the Z^0-boson

$$g_L = -\frac{1}{2} + x_W, \quad g_R = x_W, \tag{4}$$

$x_W = \sin^2\theta_W$ – the Weinberg parameter, x – the invariant mass of the neutrino pair in units s:

$$x = \frac{q^2}{s} = \frac{(q_1 + q_2)^2}{s} = 1 - \frac{2E_H}{\sqrt{s}} + \frac{M_H^2}{s}, \tag{5}$$

E_H and M_H is the energy and mass of the scalar boson *H*.

At high energies in weak interactions the helicity of the particles is conserved. Preservation of helicity requires that the colliding electron and positron have opposite helicities: $e_L^- e_R^+$ or $e_R^- e_L^+$. Here e_L^- – the left-polarized electron ($\lambda_1 = -1$), and e_R^+ – the right-handed positron ($\lambda_2 = +1$). Thus, the process (1) has two spiral amplitudes: F_{LR} and F_{RL} (the first and second indices correspond to the helicities of the electron and the positron, respectively). These spiral amplitudes describe the processes $e_L^- + e_R^+ \to H + \nu + \bar{\nu}$ and $e_R^- + e_L^+ \to H + \nu + \bar{\nu}$ are given by the expressions: $F_{LR} = D_Z(s) D_Z(xs) g_L, \quad F_{RL} = D_Z(s) D_Z(xs) g_R$.

First we consider the matrix element of the process $e_L^- + e_R^+ \to H + \nu + \bar{\nu}$:

$$M_a(e_L^- e_R^+ \to H\nu\bar{\nu}) = i\left(\frac{e}{2\sin\theta_w \cdot \cos\theta_w}\right)^3 \cdot M_Z \cos(\beta - \alpha) \cdot F_{LR} \times$$

$$\times [\bar{\upsilon}(p_2, \lambda_2 = 1)\gamma_\mu (1 + \gamma_5) u(p_1, \lambda = -1_1)] \cdot [\bar{u}(q_1)\gamma_\mu (1 + \gamma_5)\upsilon(q_2)] \tag{7}$$

and draw it square:

$$\left|M_a(e_L^- e_R^+ \to H\nu\bar{\nu})\right|^2 = \left(\frac{e^2}{4x_w(1 - x_w)}\right)^3 M_Z^2 \cos^2(\beta - \alpha) \left|F_{LR}\right|^2 T_{\mu\nu}^{(1)} T_{\mu\nu}^{(2)}. \tag{8}$$

Here

$$\begin{aligned} T_{\mu\nu}^{(1)} &= 8[p_{1\mu} p_{2\nu} + p_{2\mu} p_{1\nu} - (p_1 \cdot p_2) g_{\mu\nu} - i\varepsilon_{\mu\nu\rho\sigma} p_{1\rho} p_{2\sigma}], \\ T_{\mu\nu}^{(2)} &= 8[q_{1\mu} q_{2\nu} + q_{2\mu} q_{1\nu} - (q_1 \cdot q_2) g_{\mu\nu} + i\varepsilon_{\mu\nu\alpha\beta} q_{1\alpha} q_{2\beta}] \end{aligned} \tag{9}$$

– tensors of electron-positron and neutrino pairs. The product of these tensors gives a simple expression:

$$T_{\mu\nu}^{(1)} \cdot T_{\mu\nu}^{(2)} = 2^8 (p_1 \cdot q_2)(p_2 \cdot q_1) = 2^8 p_{1\alpha} p_{2\beta}\, q_{2\alpha} q_{1\beta}. \tag{10}$$

We integrate over momentum of neutrino and antineutrino pair by the invariant methods [12-15]:

$$I_{\alpha\beta} = \int q_{2\alpha} q_{1\beta} \cdot \frac{d\vec{q}_1}{\omega_1} \cdot \frac{d\vec{q}_2}{\omega_2}\, \delta(q_1 + q_2 - q) = A \cdot q^2 g_{\alpha\beta} + B q_\alpha q_\beta, \tag{11}$$

where *A* and *B* are scalar functions, and a $q = p - k$ is the total 4-momentum of the neutrino pair. To find the scalar functions A and B, we first multiply the integral $I_{\alpha\beta}$ by the tensor $g_{\alpha\beta}$, and then by $q_\alpha q_\beta$. The result is a system of equations

$$g_{\alpha\beta} I_{\alpha\beta} = \frac{1}{2} q^2 I = 4Aq^2 + Bq^2,$$
$$q_\alpha q_\beta I_{\alpha\beta} = \frac{1}{4} q^4 I = 4Aq^4 + Bq^4, \quad (12)$$

where the integral

$$I = \int \frac{d\vec{q}_1}{\omega_1} \cdot \frac{d\vec{q}_2}{\omega_2} \, \delta(q_1 + q_2 - q)$$

it is easily calculated in the center of mass system of neutrinos and antineutrinos, and is equal to 2 π. From the system of equations (12) we obtain:

$$A = \frac{\pi}{6}, \qquad B = \frac{\pi}{3}.$$

Thus, for the integral $I_{\alpha\beta}$ we have the expression:

$$I_{\alpha\beta} = \frac{\pi}{6}(q^2 g_{\alpha\beta} + 2q_\alpha q_\beta)\,. \quad (13)$$

As a result of integrating the neutrinos and antineutrinos momentum for the differential cross section of the process $e_L^- + e_R^+ \Rightarrow H + \nu + \bar{\nu}$ in the center-of-mass system we obtain:

$$\frac{d\sigma_a(e_L^- e_R^+ \Rightarrow H\nu\bar{\nu})}{dE_H d(\cos\theta)} = \frac{1}{12}\left(\frac{\alpha_{КЭД}}{x_w(1-x_w)}\right)^3 M_Z^2 s k_H \cos^2(\beta-\alpha)|F_{LR}|^2\left(2x + \frac{1}{s}k_H^2 \sin^2\theta\right). \quad (14)$$

Here $k_H = \sqrt{E_H^2 - M_H^2}$ is the momentum modulus of the scalar boson *H*, θ is the angle of emission of the *H* boson with respect to the momentum of the electron.

Similarly, we obtain the expression for the cross section of the reaction $e_R^- + e_L^+ \Rightarrow H + \nu + \bar{\nu}$:

$$\frac{d\sigma_a(e_R^- e_L^+ \to H\nu\bar{\nu})}{dE_H d(\cos\theta)} = \frac{1}{12}\left(\frac{\alpha_{KED}}{x_W(1-x_W)}\right)^3 M_Z^2 s k_H \cos^2(\beta-\alpha)|F_{RL}|^2\left(2x + \frac{1}{s}k_H^2 \sin^2\theta\right). \quad (15)$$

In the case of annihilation of a longitudinally polarized $e^- e^+$-pair, the contribution of diagram a) to the differential cross section of the reaction $e^- + e^+ \to H + \nu + \bar{\nu}$ is given by:

$$\frac{d\sigma_a(\lambda_1, \lambda_2)}{dE_H d(\cos\theta)} = \frac{1}{96}\left(\frac{\alpha_{KED}}{x_W(1-x_W)}\right)^3 M_Z^2 s k_H \cos^2(\beta-\alpha) \times$$
$$\times [|F_{RL}|^2(1-\lambda_1)(1+\lambda_2) + |F_{RL}|^2(1+\lambda_1)(1-\lambda_2)]\left(2x + \frac{1}{s}k_H^2 \sin^2\theta\right).$$

3. MECHANISM OF FUSION OF W^+W^--BOSONS

Now consider the diagram b) corresponding to the fusion mechanism of charged vector bosons. The matrix element corresponding to this diagram is written as follows:

$$M_b(e^-e^+ \to H\nu_e\bar{\nu}_e) = i\frac{e^3 M_W}{8\sin^3\theta_W}\cdot\cos(\beta-\alpha)D_1\cdot D_2\times$$

$$[\bar{u}(q_1)\gamma_\mu(1+\gamma_5)u(p_1,\lambda_1)]\cdot[\bar{\upsilon}(p_2,\lambda_2)\gamma_\mu(1+\gamma_5)\upsilon(q_2)].$$
(18)

Here

$$D_1=(k_1^2-M_W^2)^{-1},\quad D_2=(k_2^2-M_W^2)^{-1},$$
$$k_1=p_1-q_1,\quad k_2=p_2-q_2, \tag{19}$$

$M_W -$ mass of a charged *W*-boson.

The square of the matrix element (18) is equal to:

$$\left|M_b(e^-e^+\to H\nu_e\bar{\nu}_e)\right|^2=\left(\frac{e^3M_W}{\sin^3\theta_W}\right)^2\cos^2(\beta-\alpha)(D_1\cdot D_2)^2(1-\lambda_1)(1+\lambda_2)(p_2\cdot q_1)(p_1\cdot q_2). \tag{20}$$

The integration over momentum of neutrinos and antineutrinos is carried out in the center of mass system of this pair $\vec{q}_1+\vec{q}_2=0$ (see Fig. 2). In this system we have [14, 15]:

$$\int\left|M_b\right|^2\cdot\frac{d\vec{q}_1}{\omega_1}\cdot\frac{d\vec{q}_2}{\omega_2}\delta(p_1+p_2-k-q_1-q_2)=\int\left|M_b\right|^2 d\omega_1 d(\cos\theta_1)d\varphi_1\,\delta(E_1+E_2-E_H-2\omega_1)=$$

$$=\frac{1}{2}\int_{-1}^{1}d(\cos\theta_1)\int_0^{2\pi}\left|M_b\right|^2 d\varphi_1 \tag{21}$$

The square of the amplitude $\left|M_b\right|^2$ can be represented in the form (here it is taken into account that $q_2=p_1+p_2-k-q_1$):

$$\left|M_b\right|^2=\frac{1}{2}\left(\frac{e^3M_W}{\sin^3\theta_W}\right)\cdot\cos^2(\beta-\alpha)\frac{(1-\lambda_1)(1-\lambda_2)\cdot[s-2(k\cdot p_1)-2(p_1\cdot q_1)]\;(p_2\cdot q_1)}{[2(p_1\cdot q_1)+M_W^2]^2\,[s+M_W^2-2(k\cdot p_2)-2(p_2\cdot q_1)]^2}. \tag{22}$$

We note that in the expression $\left|M_b\right|^2$ the dependence on the azimuth angle φ_1 appears only in the scalar product $(p_2\cdot q_1)$. In the coordinate system under consideration, we have:

$$(p_1\cdot q_1)=\frac{1}{4}[s-2(k\cdot p_1)](1-\cos\theta_1),$$

$$(p_2\cdot q_1)=\frac{1}{4}[s-2(k\cdot p_2)](1-\cos\theta_1\cos\chi-\sin\theta_1\sin\chi\cos\varphi_1),$$

but $\cos\chi$ is expressed by invariant variables:

$$\cos\chi=1-\frac{2s[s+M_H^2-2(k\cdot p_1)-2(k\cdot p_2)]}{[s-2(k\cdot p_1)][s-2(k\cdot p_2)]}. \tag{23}$$

The integration over the azimuth angle φ_1 is easily carried out:

$$\int_0^{2\pi}\left|M_b\right|^2 d\varphi_1\sim\frac{1}{s_1s_2(h_1-\cos\theta_1)^2}\Big[2(h_2+\cos\theta_1\cos\chi)\cdot(1+\cos\theta_1)\times$$

$$\times\left[\left(1+\frac{M_W^2}{s_2}\right)\cdot\frac{1}{R\sqrt{R}}-(1+\cos\theta_1)\cdot\frac{1}{R}\right], \tag{24}$$

the notations are given by

$$\begin{aligned} &s_1 = s-2(k\cdot p_1), && s_2 = s-2(k\cdot p_2),\\ &h_1 = 1+\frac{2M_W^2}{s_1}, && h_2 = 1+\frac{2M_W^2}{s_2},\\ &R=\cos^2\theta_1+2h_2\cos\theta_1\cos\chi+h_2^2-\sin^2\chi. \end{aligned} \tag{25}$$

The integrals over the polar angle θ_1 are easily calculated.

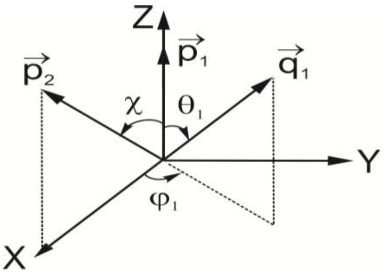

Fig. 2. The center of mass $\nu\bar{\nu}$ -pair system.

After integrating over the angles θ_1 and φ_1, for the differential cross section the following expression was obtained:

$$\frac{d\sigma_b(e^-e^+\Rightarrow H\nu_e\bar{\nu}_e)}{dE_H d(\cos\theta)}=\frac{M_Z^2}{4}\left(\frac{\alpha_{KED}}{x_W(1-x_W)}\right)^3\cdot\frac{k_H}{s}\cos^2(\beta-\alpha)(1-\lambda_1)(1+\lambda_2)\cdot F_W. \tag{26}$$

Here

$$F_W=\frac{(1-x_W)^4}{s_1 s_2 r}\left\{(1+h_1)(1+h_2)\left[\frac{2}{h_1^2-1}+\frac{2}{h_2^2-1}-\frac{6\sin^2\chi}{r}+\left(\frac{3t_1t_2}{r}-\cos\chi\right)\frac{L}{\sqrt{r}}\right]-\right.$$

$$\left.-\left[\frac{2t_1}{h_2-1}+\frac{2t_2}{h_1-1}+(t_1+t_2+\sin^2\chi)\frac{L}{\sqrt{r}}\right]\right\} \tag{27}$$

$$s_1=\sqrt{s}(\sqrt{s}-E_H+k_H\cos\theta),\quad s_2=\sqrt{s}(\sqrt{s}-E_H-k_H\cos\theta),$$

$$\cos\chi=1-\frac{2xs}{xs+k_H^2\sin^2\theta},\quad \sin^2\chi=1-\cos^2\chi\ ,$$

$$t_1=h_1+h_2\cos\chi,\quad t_2=h_2+h_1\cos\chi,\ r=h_1^2+h_2^2+2h_1h_2\cos\chi-\sin^2\chi,$$

$$L=\ln\frac{h_1h_2+\cos\chi+\sqrt{r}}{h_1h_2+\cos\chi-\sqrt{r}}$$

In the process of production of a neutrino pair $\nu_e\bar{\nu}_e$ between diagrams a) and b), there is an interference. The interference contribution to the cross section is given by:

$$\frac{d\sigma(e^- e^+ \Rightarrow H\nu_e \bar{\nu}_e)}{dE_H d(\cos\theta)} = \frac{M_Z^2}{4}\left(\frac{\alpha_{КЭД}}{x_W(1-x_W)}\right)^3 \cdot \frac{k_H}{s}\cos^2(\beta-\alpha)(1-\lambda_1)(1+\lambda_2)g_L F_I , \quad (28)$$

where

$$F_I = \frac{1}{2}(1-x_W)^2 \frac{xs - M_Z^2}{(s-M_Z^2)[(xs-M_Z^2)+M_Z^2\Gamma_Z^2]} \times$$

$$\times\left[2-(h_1+1)\ln\frac{h_1+1}{h_1-1} - (h_2+1)\ln\frac{h_2+1}{h_2-1} + (h_1+1)(h_2+1)\frac{L}{\sqrt{r}}\right]. \quad (29)$$

4. DISCUSSION OF THE RESULTS

The differential cross section of the reaction $e^- + e^+ \to H + \nu_e + \bar{\nu}_e$ measured in the experiments consists of three parts: the contribution of diagram a), the contribution of diagram b), and the interference contribution. At the energies of a $e^- e^+$-pair $\sqrt{s} > M_Z$, the differential cross section has the form:

$$\frac{d\sigma(e^- e^+ \Rightarrow H\nu_e \bar{\nu}_e)}{dx d(\cos\theta)} = \frac{M_Z^2}{8}\left(\frac{\alpha_{KED}}{x_w(1-x_w)}\right)^3 \frac{k_H}{\sqrt{s}}\cos^2(\beta-\alpha)\times$$

$$\times\{3[g_L^2(1-\lambda_1)(1+\lambda_2)+g_R^2(1+\lambda_1)(1-\lambda_2)]F_s + (1-\lambda_1)(1+\lambda_2)(g_L F_I + F_W)\}. \quad (30)$$

Here the function F_s corresponds to the contribution of diagram a) (the scalar boson *H* is emitted by the vector boson Z^0):

$$F_s = \frac{1}{12}\cdot\frac{s(2xs + k_H^2\sin^2\theta)}{(s-M_Z^2)^2[(xs-M_Z^2)^2+M_Z^2\Gamma_Z^2]}. \quad (31)$$

The factor 3 in the first term (30) is associated with the possibility of decay of the Z^0-boson into three types of neutrino pair $(\nu_e\bar{\nu}_e,\ \nu_\mu\bar{\nu}_\mu,\ \nu_\tau\bar{\nu}_\tau)$. In the annihilation of a left-handed polarized electron and a right-polarized positron, we have a cross section:

$$\frac{d\sigma(e_L^- e_R^+ \Rightarrow H\nu_e \bar{\nu}_e)}{dx d(\cos\theta)} = \left(\frac{\alpha_{KED}}{x_W(1-x_W)}\right)^3 \cdot \frac{M_Z^2}{2}\cdot\frac{k_H}{\sqrt{s}}\cos^2(\beta-\alpha)[3g_L^2 F_s + g_L F_I + F_W]. \quad (32)$$

If the electron (positron) is polarized right (left), then the contribution of diagram b) vanishes and the differential cross section takes the form:

$$\frac{d\sigma(e_R^- e_L^+ \to H\nu_e \bar{\nu}_e)}{dx d(\cos\theta)} = \left(\frac{\alpha_{KED}}{x_W(1-x_W)}\right)^3 \frac{M_Z^2}{2}\cdot\frac{k_H}{\sqrt{s}}\cos^2(\beta-\alpha)\cdot 3g_L^2 F_s. \quad (33)$$

In the case of unpolarized colliding electron-positron beams, the differential cross section of the reaction $e^- + e^+ \to H + \nu + \bar{\nu}$ is expressed by the formula:

$$\frac{d\sigma(e^- e^+ \to H\nu_e \bar{\nu}_e)}{dx d(\cos\theta)} = \frac{M_Z^2}{8}\left(\frac{\alpha_{KED}}{x_W(1-x_W)}\right)^3 \cdot \frac{k_H}{\sqrt{s}}\cdot\cos^2(\beta-\alpha)\cdot[3(g_L^2+g_R^2)F_s + g_L F_I + F_W]. \quad (34)$$

On the fig. 3 shown the angular dependence of the h-boson in the reaction, at an energy of $\sqrt{s}$ =1000 GeV, a mass of $M_h = 67.533$ GeV, energy $E_h = 2M_h$ and the Weinberg parameter $x_W = 0.232$. As can be seen from the figure, with increasing boson emission angle, the contribution of the diagram *a*) increases and reaches a maximum at an angle of $\theta = 90°$, and a further increase in the angle leads to a decrease in the cross section. But the contribution of diagram *b*) decreases with increasing angle θ and reaches a minimum at θ=90°. The contribution to the cross section from the interference of diagrams a) and b) is negative. The dependence of the total cross section of the process $e^- + e^+ \to h + \nu_e + \bar{\nu}_e$ on the angle θ in the fig. 3 is shown by the dotted line

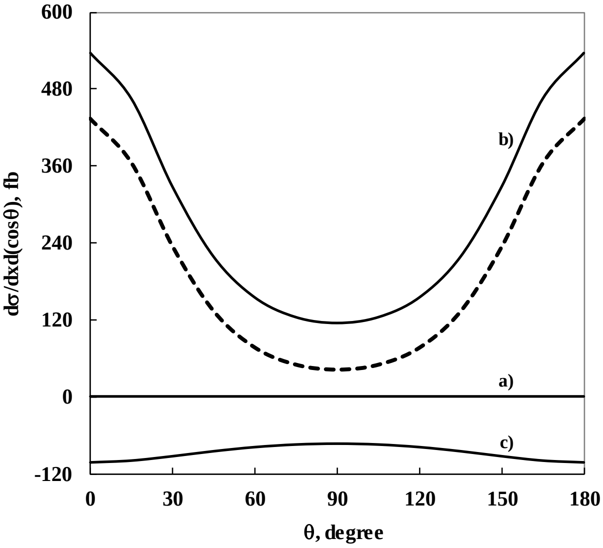

Fig. 3. Angular dependence of the effective cross section of the process $e^- + e^+ \to h + \nu_e + \bar{\nu}_e$.

Similar results were obtained for the reaction $e^- + e^+ \to H + \nu_e + \bar{\nu}_e$.

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