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INTERACTION OF SCALAR PARTICLES VIA A TACHYON FIELD: SCATTERING PROBLEM

The interaction of scalar particles via a tachyon field is considered in the scope of partially reduced field theory. The differential and total cross-sections of elastic scattering of two different particles interacting via a mediating field of imaginary mass are calculated.

Keywords: partially reduced field theory, Yukawa model, scattering problem, tachyons.

1. Introduction

The concept of tachyons – particles that move faster than light – is known for more than half a century [1, 2]. Several possible descriptions for tachyons are available in Quantum Field Theory [3–5]. Each description has some defect, such as an uncertain number of tachyons, noninvariance and/or vacuum nonstability, scattering matrix nonunitarity, *etc.* All these facts give rise to a doubt whether it is possible to generate or detect free quanta of the tachyon field and to the reason to have doubt in their existence in the Nature (it must be in agreement with experiments).

However there exists a possibility of the existence of "hidden" tachyons as virtual particles. The virtual tachyons can be detected in interactions between tardons – slower-than-light particles. In particular in work [6], the peaks in the differential cross section of a meson-nucleon scattering are interpreted in terms of tachyonic resonances. Owing to the peculiarities of the superluminal particle kinematics, quantum [7] or classical [8] tachyons can participate in exchanges. In both cases, the fundamental essence of these particles is the tachyon field. But the problems of its quantization are still unsolved.

We reject the idea of tachyons as particles, consider only a classical (nonquantized) tachyon field, and limit its role to be the interaction mediator between usual (quantized) fields. Gravity had a similar role in theoretical physics, by acquiring a more profound quantum interpretation only recently owing to the development of string theory. On the other hand, the existence and the necessity of the effective description of the states with negative mass square in string theory [9] led to the appearance of nonlinear classical models of the scalar tachyon field [10] and their applications to cosmology [11,12]. Such fields do not have a stable vacuum and cannot be secondarily quantized. Near the unstable vacuum, such fields linearize to the standard Klein–Gordon field with imaginary mass.

For the sake of simplicity, we consider two complex scalar matter fields interacting via a real scalar tachyon field – the field with imaginary mass $m' = i\mu$. This model can be conveniently described in the terms of partially reduced field theory (PRFT) [13–15]. Namely, the degrees of freedom of the tachyon interaction field are excluded from the Lagrangian on the classical level, and the interaction is described in terms of the symmetric Green function of this field. This function appears in the nonlocal term of the reduced Lagrangian. Such Green function is relativistically invariant, and the causality is not violated. Thus, the Poincaré-invariance is naturally provided in the partially reduced Yukawa model, and the quantization problems for the tachyon field do not arise. The time nonlocality in the Lagrangian complicates the hamiltonization and quantization of the model; it could be done perturbatively according to [14].

The main part of the paper is concerned with the elastic scattering of two particles in terms of the considered model, in which the tachyon exchange takes place. In Section 4, the amplitudes of such processes are found, and the differential and total cross sections are calculated in Section 5. These results are compared with the ones obtained in the case of the interaction via the Yukawa real mass field m'. For this goal, Section 3 presents some results that were obtained in previous works and are necessary for the solution of the scattering problem. Section 2 gives a short review of the history of tachyon theory.

2. Historical Review of the Problem of Tachyon Existence

The nonexistence of superluminal particles was widely accepted till 1960 when Ya.P. Terletskii in [16] has shown that the existence of such particles does not contradict the fundamental principles of physics.

He was the first who noticed that the causality principle is macroscopic (and thus statistical) and can be violated in the microworld. The existence of superluminal particles according to Terletskii has the fluctuation nature and, therefore, can be possible. But the systematic process of tachyon emission is forbidden. In addition, the tachyon mass should be imaginary. Almost simultaneously, six days after Terletskii's paper was accepted for publication, S. Tanaka in published work [17] where it was investigated in terms of canonical quantization how the existence of superluminal particles is consistent with the conventional theory of elementary particles.

Another notable work is the paper by O.-M. Bilaniuk, V.K. Deshpande, and E.C.G. Sudarshan [1]. There, the superluminal particles were considered in terms of classical relativistic mechanics, and a "reinterpretation principle" was put forward in order to overcome some problems arising in the tachyon theory.

In 1966, Ya.P. Terletskii published the book about paradoxes in relativity theory [18] and, in one of the chapters, interpreted the tachyons as a violation of the second thermodynamic law caused by fluctuations.

The term "tachyon" was introduced by G. Feinberg in [3]. He considered the quantization of such fields.

Since then, more researches were performed in the field. Those works were dedicated to the problems that occur in the process of construction of tachyon theory and its quantization. More details about the development of this theory can be found in [19].

In the last decades, the tachyon theory develops within the cosmology field [11], in particular in the works related to string theory [9, 10] and dark energy [12].

No experiment has yet confirmed the existence of tachyons. So, the scientific world is split in two camps having different views on the probability of the existence of tachyons.

3. Model Description. Hamiltonian and Scattering Matrix

The considered model is derived from the scalar Yukawa model [13, 14] describing the dynamics of complex scalar fields $\phi_a(x)$ with masses m_a (in our case – two fields: $a = 1, 2$) and a real scalar field $\chi(x)$ with mass m', being an interaction mediator.

The reduction of the field $\chi(x)$ in the initial Lagrangian of the Yukawa model leads to the nonlocal effective Lagrangian:

$$\mathcal{L} = \sum_{a=1}^{2} \mathcal{L}_a + \mathcal{L}_{\text{int}} = \\ = \sum_{a=1}^{2} \{(\partial_\nu \phi_a^*)(\partial^\nu \phi_a) - m_a^2 \phi_a^* \phi_a\} + \\ + \frac{1}{2} \int \mathrm{d}^4 x' \, \rho(x) G(x - x') \rho(x') \tag{1}$$

with a nonlocal term describing the interaction of currents $\rho = -\sum_a g_a \phi_a^* \phi_a$ of fields ϕ_a (with "charges" g_a) through the symmetric Green function $G(x - x')$ of a mediating field.

Time-nonlocality in Lagrangian (1) complicates the hamiltonization and quantization of the model. In [14] for such Lagrangian, the Hamiltonian in the quadratic approximation by a coupling constant ("charge") was constructed: $H = H_{\text{free}} + H_{\text{int}}$, where

$$H_{\text{free}} = \sum_{a=1}^{2} \int \mathrm{d}^3 k \; k_{a0} \{ b_{a\mathbf{k}}^\dagger b_{a\mathbf{k}} + d_{a\mathbf{k}}^\dagger d_{a\mathbf{k}} \} \tag{2}$$

is the free field Hamiltonian, and

$$H_{\text{int}} = -\sum_{ab} \frac{g_a g_b}{(4\pi)^3} \int \frac{\mathrm{d}^3 k \, \mathrm{d}^3 q \, \mathrm{d}^3 u \, \mathrm{d}^3 v}{\sqrt{k_{a0} q_{a0} u_{b0} v_{b0}}} : \Big\{ \tilde{G}(u_b - v_b) \times$$

$$
\begin{aligned}
&\times \left[\delta(\mathbf{k}{+}\mathbf{q}{+}\mathbf{u}{-}\mathbf{v}) d_{a\mathbf{k}} b_{a\mathbf{q}} d_{b\mathbf{u}} d^\dagger_{b\mathbf{v}} + \right.\\
&+ \delta(\mathbf{k}{+}\mathbf{q}{-}\mathbf{u}{+}\mathbf{v}) d_{a\mathbf{k}} b_{a\mathbf{q}} d^\dagger_{b\mathbf{u}} d_{b\mathbf{v}} +\\
&+ \delta(\mathbf{k}{-}\mathbf{q}{+}\mathbf{u}{-}\mathbf{v}) d_{a\mathbf{k}} d^\dagger_{a\mathbf{q}} d_{b\mathbf{u}} d^\dagger_{b\mathbf{v}} +\\
&+ \delta(\mathbf{k}{-}\mathbf{q}{-}\mathbf{u}{+}\mathbf{v}) d_{a\mathbf{k}} d^\dagger_{a\mathbf{q}} b^\dagger_{b\mathbf{u}} b_{b\mathbf{v}} +\\
&+ \delta(\mathbf{k}{-}\mathbf{q}{-}\mathbf{u}{+}\mathbf{v}) b^\dagger_{a\mathbf{k}} b_{a\mathbf{q}} d_{b\mathbf{u}} d^\dagger_{b\mathbf{v}} +\\
&+ \delta(\mathbf{k}{-}\mathbf{q}{+}\mathbf{u}{-}\mathbf{v}) b^\dagger_{a\mathbf{k}} b_{a\mathbf{q}} b^\dagger_{b\mathbf{u}} b_{b\mathbf{v}} +\\
&+ \delta(\mathbf{k}{+}\mathbf{q}{-}\mathbf{u}{+}\mathbf{v}) b^\dagger_{a\mathbf{k}} d^\dagger_{a\mathbf{q}} d_{b\mathbf{u}} d^\dagger_{b\mathbf{v}} +\\
&+ \left.\delta(\mathbf{k}{+}\mathbf{q}{+}\mathbf{u}{-}\mathbf{v}) b^\dagger_{a\mathbf{k}} d^\dagger_{a\mathbf{q}} b^\dagger_{b\mathbf{u}} b_{b\mathbf{v}}\right] +\\
&+ \tilde{G}(u_b + v_b) \left[\delta(\mathbf{k}{+}\mathbf{q}{+}\mathbf{u}{+}\mathbf{v}) d_{a\mathbf{k}} b_{a\mathbf{q}} d_{b\mathbf{u}} b_{b\mathbf{v}} + \right.\\
&+ \delta(\mathbf{k}{+}\mathbf{q}{-}\mathbf{u}{-}\mathbf{v}) d_{a\mathbf{k}} b_{a\mathbf{q}} b^\dagger_{b\mathbf{u}} d^\dagger_{b\mathbf{v}} +\\
&+ \delta(\mathbf{k}{-}\mathbf{q}{+}\mathbf{u}{+}\mathbf{v}) d_{a\mathbf{k}} d^\dagger_{a\mathbf{q}} d_{b\mathbf{u}} b_{b\mathbf{v}} +\\
&+ \delta(\mathbf{k}{-}\mathbf{q}{-}\mathbf{u}{-}\mathbf{v}) d_{a\mathbf{k}} d^\dagger_{a\mathbf{q}} b^\dagger_{b\mathbf{u}} b^\dagger_{b\mathbf{v}} +\\
&+ \delta(\mathbf{k}{-}\mathbf{q}{-}\mathbf{u}{-}\mathbf{v}) b^\dagger_{a\mathbf{k}} b_{a\mathbf{q}} d_{b\mathbf{u}} b_{b\mathbf{v}} +\\
&+ \delta(\mathbf{k}{-}\mathbf{q}{+}\mathbf{u}{+}\mathbf{v}) b^\dagger_{a\mathbf{k}} b_{a\mathbf{q}} b^\dagger_{b\mathbf{u}} b^\dagger_{b\mathbf{v}} +\\
&+ \delta(\mathbf{k}{+}\mathbf{q}{-}\mathbf{u}{-}\mathbf{v}) b^\dagger_{a\mathbf{k}} d^\dagger_{a\mathbf{q}} d_{b\mathbf{u}} b_{b\mathbf{v}} +\\
&+ \left.\left.\delta(\mathbf{k}{+}\mathbf{q}{+}\mathbf{u}{+}\mathbf{v}) b^\dagger_{a\mathbf{k}} d^\dagger_{a\mathbf{q}} b^\dagger_{b\mathbf{u}} d^\dagger_{b\mathbf{v}}\right]\right\} : \qquad (3)
\end{aligned}
$$

describes an interaction. Here, $b^\dagger_{a\mathbf{k}}$, $b_{a\mathbf{k}}$ are the creation and annihilation operators of a-sort particles, and $d^\dagger_{a\mathbf{k}}$, $d_{a\mathbf{k}}$ – accordingly, antiparticles; $k_a = \{k_{a0}, \mathbf{k}\}$ – 4-momentum on the mass surface with 0-component $k_{a0} = \sqrt{\mathbf{k}^2 + m_a^2}$; colon $: \cdots :$ denotes the normal ordering;

$$
\widetilde{G}(k) \equiv \widetilde{G}[k^2] = \int d^4x\, e^{-ikx} G(x) = \frac{\mathcal{P}}{m'^2 - k^2} \qquad (4)
$$

is the Fourier component of the symmetric Green function of a mediating field; and $\mathcal{P}$ means "in a sense of the principal value".

For such approximation, the unitary scattering matrix S was constructed in [15]. The expression for $S - 1$ can be obtained by the formal substitution $\delta(\mathbf{k}{+}\mathbf{q}{+}\mathbf{u}{+}\mathbf{v}) \mapsto -2\pi\,\mathrm{i}\,\delta^{(4)}(k_a{+}q_a{+}u_b{+}v_b)$, *etc.* (preserving the corresponding signs for momenta) in expression (3). Then the scattering amplitude $M(\mathbf{p}'_1 \ldots \mathbf{p}'_m; \mathbf{p}_1 \ldots \mathbf{p}_n)$ for the process of scattering of the n-particle state into an m-particle state can be determined from the equality

$$
\begin{aligned}
&\langle \mathbf{p}'_1 \ldots \mathbf{p}'_m | S - 1 | \mathbf{p}_1 \ldots \mathbf{p}_n \rangle =\\
&= \frac{\delta^{(4)}(p'_1 + \ldots + p'_m - p_1 - \ldots - p_n)}{\sqrt{2p'_{10} \ldots 2p'_{m0} 2p_{10} \ldots 2p_{n0}}} \times\\
&\times \mathrm{i}\,(2\pi)^4 M(\mathbf{p}'_1 \ldots \mathbf{p}'_m; \mathbf{p}_1 \ldots \mathbf{p}_n) \qquad (5)
\end{aligned}
$$

as in conventional field theory [20].

4. Two-Particle Elastic Scattering Processes

It is sufficient to consider three types of two-particle scattering states: different sorts of particles, e.g. $1{+}2$, the same sort of particles, e.g. $1+1$, and the particle-antiparticle state $1 + \bar{1}$:

$$
|1{+}2\rangle = b^\dagger_{1\mathbf{p}_1} b^\dagger_{2\mathbf{p}_2} |0\rangle, \qquad (6)
$$

$$
|1{+}1\rangle = 2^{-1/2}\, b^\dagger_{1\mathbf{p}_1} b^\dagger_{1\mathbf{p}_2} |0\rangle, \qquad (7)
$$

$$
|1{+}\bar{1}\rangle = b^\dagger_{1\mathbf{p}_1} d^\dagger_{1\mathbf{p}_2} |0\rangle, \qquad (8)
$$

where $|0\rangle$ is a vacuum. Other states, e.g. $1 + \bar{2}$ or $\bar{1} + \bar{1}$, can be reduced by physical properties to the preceding ones according to the charge symmetry of the system. The corresponding scattering amplitudes of states (6)–(8) are calculated by (5) and have the form

$$
M_{1+2} = \frac{g_1 g_2}{(2\pi)^6}\, \tilde{G}[t], \qquad (9)
$$

$$
M_{1+1} = \frac{g_1^2}{2(2\pi)^6} \{\tilde{G}[t] + \tilde{G}[u]\}, \qquad (10)
$$

$$
M_{1+\bar{1}} = \frac{g_1^2}{(2\pi)^6} \{\tilde{G}[t] + \tilde{G}[s]\}, \qquad (11)
$$

where

$$
\begin{aligned}
s &= (p_1 + p_2)^2 = (p'_1 + p'_2)^2,\\
t &= (p_1 - p'_1)^2 = (p_2 - p'_2)^2,\\
u &= (p_1 - p'_2)^2 = (p_2 - p'_1)^2
\end{aligned}
$$

are the invariant Mandelstam variables [20].

The structure of expressions (9)–(11) is analogous to two-particle scattering amplitudes in the conventional QFT that can be described by Feynman diagrams in Fig. 1: diagram 1, a corresponds to the contribution of $\tilde{G}[t]$, diagram 1, b – to the contribution of $\tilde{G}[u]$ and diagram 1, c – to the contribution of $\tilde{G}[s]$. The only difference is that, in conventional QFT, the causal Green function of this field corresponds to mediating field lines. In our case of a partially reduced FT, it is replaced by the symmetric Green function.

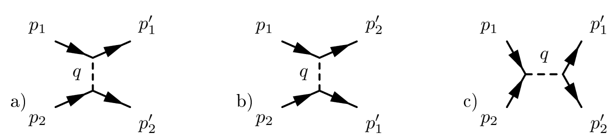

Fig. 1. Feynman diagrams for elastic scattering processes of a two-particle system

5. Differential and Total Cross Sections

In the center-of-mass system, where

$$\mathbf{p}_1 = -\mathbf{p}_2 \equiv \mathbf{p}, \quad \mathbf{p}'_1 = -\mathbf{p}'_2 \equiv \mathbf{p}', \quad |\mathbf{p}| = |\mathbf{p}'|,$$

for the same mass particles $m_1 = m_2 \equiv m$, the Mandelstam variables become

$$s = (p_{01} + p_{02})^2 = E^2 = 4p_0^2 \geq 4m^2, \tag{12}$$

$$t = -2\mathbf{p}^2(1 - \cos\theta) \leq 0, \tag{13}$$

$$u = -2\mathbf{p}^2(1 + \cos\theta) \leq 0, \tag{14}$$

where θ is the scattering angle, and E is the energy of the system. Then, according to the axial symmetry, the expression for differential cross section can be conveniently written as

$$\mathrm{d}\sigma = \frac{1}{64\pi^2}|M|^2\frac{\mathrm{d}o'}{E^2} = \frac{-1}{32\pi}|M|^2\frac{\mathrm{d}\cos\theta}{E^2} = $$
$$= \frac{-1}{64\pi}|M|^2\frac{\mathrm{d}t}{\mathbf{p}^2E^2}, \tag{15}$$

where $\mathrm{d}o' = 2\pi\sin\theta\mathrm{d}\theta = -2\pi\mathrm{d}\cos\theta = -\frac{\pi}{\mathbf{p}^2}\mathrm{d}t$ – element of the spatial angle of outgoing momenta, and $t \in [-4\mathbf{p}^2, 0]$ when $\theta \in [0, \pi]$.

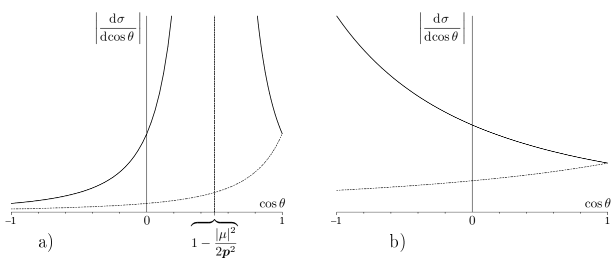

Fig. 2. Differential cross section for 1 + 2 reaction for massive (dashes) and tachyonic (continuous line) interaction mediators with the same (meta)mass value $|\mu|$: *a*) $2|\mathbf{p}| > |m'|$; *b*) $2|\mathbf{p}| < |m'|$

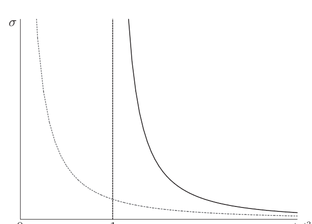

Fig. 3. Total cross section for 1 + 2 reaction for Yukawa-like (dashes) and tachyonic (continuous line) interactions as a function of the (meta)mass $|\mu|$

We consider the case where the interaction mediator is the tachyon field, i.e. the Klein–Gordon field with imaginary mass $m' = \mathrm{i}\,\mu$. The quantity $\mu \equiv |m'|$ according to [2] is called *metamass*.

The scattering matrix contains a symmetric Green function as opposed to the casual one in conventional QFT [20]. This fact is beneficial in the case of a tachyon mediating field, because the causal Green function for this field is not Poincaré-invariant, while the symmetric function is given in [4]. From the Fourier component of this function

$$\widetilde{G}(k) \equiv \widetilde{G}[k^2] = \frac{-\mathcal{P}}{\mu^2 + k^2} \tag{16}$$

and from inequalities (13)–(14), it can be noted that amplitudes (9)–(11) and the corresponding cross sections (15) have the poles:

$$t + \mu^2 = 0 \implies \cos\theta = 1 - \frac{\mu^2}{2\mathbf{p}^2}, \tag{17}$$

$$u + \mu^2 = 0 \implies \cos\theta = \frac{\mu^2}{2\mathbf{p}^2} - 1. \tag{18}$$

They exist when

$$2|\mathbf{p}| \geq \mu \tag{19}$$

and are symmetrically located in relation to the plane of the equator of the scattering sphere (i.e. θ and $\pi - \theta$). It corresponds to lateral surfaces of the cones, along which the flow density of particles is infinite (*shining*). For the reactions 1 + 2 and 1 + $\bar{1}$, there exists only one shining cone (17), and the reaction 1 + 1 gives two cones because of the interference of incoming and outgoing particles.

The following heuristic interpretation can be proposed for the existence of shining cones. Consider Feynman diagram 1, *a* and suppose that the free particles with corresponding 4-momenta p_1, ..., p'_2, q (on their mass surfaces) correspond to all lines, and the interaction occurs only in vertices. In each vertex, the 4-momentum conservation law is satisfied. Then, in center-of-mass system, we have $\mathbf{q} = \mathbf{p} - \mathbf{p}'$, $q_0 = 0$. The last equality is impossible for the massive interaction mediator. Hence, the vertices in diagram 1, *a* can only be connected by virtual particles. But tachyons are particles without threshold, and this means that the condition

$$q_0 \equiv \sqrt{\mathbf{q}^2 - \mu^2} = 0 \implies \mathbf{q}^2 = \mu^2 \tag{20}$$

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is possible and corresponds to the existence of the *transcendental* tachyon moving with infinite velocity [1, 8]. Thus, there is no fundamental difference between virtual and real tachyons. The latter are a subset of the former. In view of the fact that condition (20) is identical to (17), the shining cone (17) can be interpreted as the contribution of the free tachyons (or, in our case, the free field) to the scattering process.

The differential cross sections of $1+2$ reaction for ordinary and tachyonic interaction mediators with the same mass $|m'|$ by condition (19) are shown in Fig. 2, *a*. It is natural to suppose that the existence of a shining pole in the differential cross section is caused by the stability of tachyonic states as a consequence of the over-simplified model. More complicated theories which involve the tachyon interaction with electromagnetic or gravitational fields [21] or are based on the string theory [10] yield the tachyon instability. In that case, the finite peaks should appear in the cross sections instead of the poles. The tachyon interpretation of peaks in meson-nucleon sections was proposed in [6].

The pole disappears when $2|\mathbf{p}|<\mu$. In this case, the differential cross section is finite, and the backward scattering predominates in $1+2$ and $1+\bar{1}$ reactions over forward scattering, in contrast to the case of the ordinary mediator Fig. 2, *b*.

The total cross section

$$\sigma=\int\limits_{\Omega}\mathrm{d}\sigma=\frac{1}{64\pi\mathbf{p}^2E^2}\int\limits_{-4\mathbf{p}^2}^{0}|M|^2\mathrm{d}t \qquad (21)$$

is infinite by condition (19) because of the pole and converges in the opposite case. For instance, for reaction $1+2$

$$\sigma=\frac{g_1^2g_2^2}{2^{20}\pi^{13}\mathbf{p}^2E^2}\times\begin{cases}(\mu^2-4\mathbf{p}^2)^{-1}-\mu^{-2}, & 2|\mathbf{p}|<\mu,\\ \infty, & 2|\mathbf{p}|\geq\mu;\end{cases} \qquad (22)$$

see Fig. 3.

It should be noted that, in the case of the Rutherford scattering, the total cross section is theoretically infinite. But in practice, it is cut off by the screening of distant charges. If the tachyon interaction exists, as described here, then there should exist the cutoff mechanism for it. The possible mechanism that would provide the finite total cross section, by simultaneously avoiding the pole in the differential cross section, can be supported by the assumption about the large metamass of the tachyon field, such that $2|\mathbf{p}|<\mu$.

6. Conclusions

We have presented the scattering problem for the interaction via a tachyon field in Partially Reduced FT.

By the interaction via the field with imaginary mass $m'=\mathrm{i}\,\mu$, the differential cross section for different-sort particles (or particle-antiparticle) has a singularity (a pole), if the momenta of particles (in C.M. system) are large enough: $2|\mathbf{p}|\geq\mu$. This pole corresponds to the cone surface with corresponding scattering angle. Along this surface, the density of particle current is infinite (the so-called *shining*). Hereby, the total cross section is divergent. Two symmetric conjugate shining cones arise because of the scattering of one-sort particles caused by the interference of the incoming and outgoing currents.

By the condition $2|\mathbf{p}|<\mu$, the pole in the different cross section is absent, and the total cross section is finite. In this case, the backward scattering predominates over the forward scattering in contrast to the case of a usual massive interaction mediator.

To the author's knowledge, the scattering processes with such nontrivial properties are not observed in experiments. By assumption of the existence of tachyonic interactions, the lack of reconciliation between theory and experiment should be explained. For the present we can propose two different explanations.

One of the possible explanations: the intermediate state corresponding to tachyon lines in Feynman diagrams (Fig. 1) can be considered as unstable. Then the denominators of the tachyonic propagator (16) in amplitudes (9)–(11) (i.e. the expressions $t+\mu^2$, $s+\mu^2$, and so on) transform into the Breit–Wigner expressions $t+\mu^2-\mathrm{i}\,\mu\Gamma$, and so on. The corresponding poles transform into finite peaks with width Γ. The similar tachyon interpretation of the peaks in the meson-nucleon cross sections was proposed in [6]. Unfortunately, the cited work obtained no further development or confirmation.

The other way to interpret the shining nonobservability by the sideward scattering is the assumption that the metamass of the tachyonic field is near several TeV or more. Then condition (19) for a pole to exist is not provided for the modern accelerators, but it can be reached in the future.

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ВЗАЄМОДІЯ СКАЛЯРНИХ ЧАСТИНОК
ЧЕРЕЗ ТАХІОННЕ ПОЛЕ: ЗАДАЧА РОЗСІЯННЯ

Р е з ю м е

Розглянуто взаємодію скалярних частинок через тахіонне поле в рамках частково редукованої теорії поля. Обчислено диференціальний та повний перетини пружного розсіяння двох різних частинок, що взаємодіють через поле-посередник з уявною масою.

И. Загладько

ВЗАИМОДЕЙСТВИЕ СКАЛЯРНЫХ ЧАСТИЦ
ЧЕРЕЗ ТАХИОННОЕ ПОЛЕ: ЗАДАЧА РАССЕЯНИЯ

Р е з ю м е

Рассмотрено взаимодействие скалярных частиц через тахионное поле в рамках частично редуцированной теории поля. Получены дифференциальное и полное сечения упругого рассеяния двух разных частиц, которые взаимодействуют через поле-посредник с мнимой массой.