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AUTOMODELITY, LORENTZ INVARIANCE AND INTERACTION TIME OF THE PARTICLE SCATTERING PROCESSES ESTIMATIONS

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1 Introduction

Scale invariance phenomena observed in the first experiments on large machines of 70ies (CERN, FNAL, Serpukhov) are still important for the present particle theory and phenomenology [1].

The usage of Lobachevsky velocity space (LVS) [2] to analyze deep inelastic scattering processes (DIS) has allowed to introduce a new scale parameter α ($0 \leq \alpha \leq 1$) – a part of the 4-momentum transfer q_α:

$$-q_\alpha^2 = \alpha Q^2 \, , \nu_\alpha = \alpha \nu \, , x = -q_\alpha^2/(2m_b \nu_\alpha) = Q^2/(2m_b \nu) \, , \tag{1}$$

where Q^2 is the 4-momentum transfer squared, ν – energy transfer, x – the Bjorken scale variable [3], m_b – the target mass. For the given x this approach [4] allows one to get the final state of a system of two interacting particles from the initial one as an evolution of one parameter α (as seen above, x does not depend on α). One can introduce rapidities $\rho_{q\alpha}$ and $\rho_{\nu\alpha}$, corresponding to ν_α and to q_α ([4]):

$$\nu_\alpha = m(ch\rho_o - ch\rho_{\nu\alpha}) = \alpha\nu \, , \;\; ch\rho_{\nu\alpha} = ch\rho_o - \alpha\nu/m \, , \tag{2}$$

$$-q_\alpha^2 = 2m^2(ch\rho_{q\alpha} - 1) = \alpha Q^2 \, , \;\; ch\rho_{q\alpha} = \alpha Q^2/(2m^2) + 1 \, , \tag{3}$$

here: m – the mass of the beam particle (lepton for DIS); ρ_o and ρ_c – the lepton initial rapidity for *lab*– and *c*– systems, correspondingly (see fig.1). Then, using Bjorken's x definition, one can find a particle rapidity $\rho(\theta)$ (for the lepton, for example) as a function on the current scattering angle θ. For the c-system this function is:

$$th\rho(\theta) = \frac{AB\cos\theta + C\sqrt{B^2\cos^2\theta + C^2 - A^2}}{B^2\cos^2\theta + C^2} \, , \tag{4}$$

where

$$A = ch\rho_c + a\; ch(\rho_o - \rho_c) \, , \quad B = sh\rho_c - a\; sh(\rho_o - \rho_c) \, , \tag{5}$$

$$C = a\; ch\rho_o + 1 \, , \quad a = xm_b/m \, . \tag{6}$$

At $\theta = 0$ and $\theta = \theta_f$ (θ_f is the final scattering angle) formula (4) defines initial and final lepton velocities (for given x). All dynamical values for the lepton as well as for the hadronic shower can be expressed in the same way as functions on θ. So, for the fixed x the angle θ can be considered as the evolution parameter of the system of two interacting particles.

It is known from mechanics [5], that evolution parameters – time and angle – are equivalent: $dt \sim d\theta$, at least, in the case of central forces. So, one can assume that some observed final scattering angle θ_f corresponds to some time interval Δt – the time needed for the interacting particle to transfer from the initial state up to the final one.

A method to establish time - angle relation $dt \sim d\theta$ for particle scattering processes and some results of its integration for elastic pp, μp and inclusive inelastic μp reactions are presented in this paper. The method is based on the geometrical interpretation of the time-like interval invariance in the euclidean, as well as in noneuclidean (LVS) spaces.

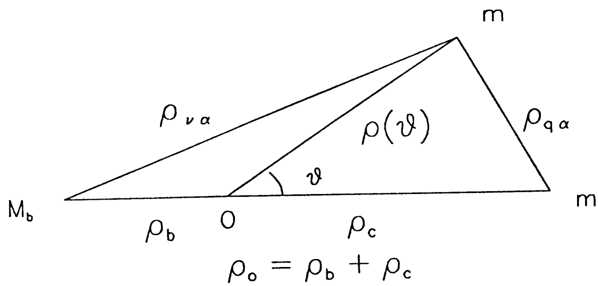

Fig.1 Geometrical view of the scale invariance in Lobachevsky velocity space.

2 Geometrical views of time-like interval invariance

The rapidity definition can be done equivalently by energy-momentum variables of a particle and through its space-time characteristics. The last one indicates some kind of relation between the interval and LVS. The invariance of the time-like interval:

$$(cdt)^2 - (vdt)^2 = (cd\tau)^2, \qquad v = dx/dt\,, \tag{7}$$

$$dt\sqrt{1-\beta^2} = d\tau, \qquad \beta = v/c\,, \tag{8}$$

$$\int\limits_{t_1}^{t_2} dt\sqrt{1-\beta^2} = \Delta\tau, \qquad \Delta t = t_2 - t_1 \tag{9}$$

expresses the particle proper time $d\tau$ ($\Delta\tau$) via the time dt (Δt) of a system where it moves with the velocity v (c is the light velocity) [6]. The moving system is often the system where particle is in the rest ($dx' = 0$, x' - coordinate in the moving system). It is seen from (8) that $cd\tau > 0$ (interval is time-like), if $\beta < 1$. Note also that (7-9) are valid for the particle arbitrary motion [6].

Let us divide the integration region in (9) into n of arbitrary parts $\Delta t_i = t_{2i} - t_{1i}$. Then one can get for each i-th interval:

$$\int\limits_{t_{1i}}^{t_{2i}} dt\sqrt{1-\beta^2} = \Delta\tau_i \tag{10}$$

or, using the mean value theorem, and taking into account that $\sqrt{1-\beta^2} = 1/ch\rho$:

$$\Delta t_i/ch\bar{\rho}_i = \Delta t_i\sqrt{1-\bar{\beta}_i^{\,2}} = \Delta\tau_i \tag{11}$$

or, just multiplying on c and raising to the second power:

$$(c\Delta t_i)^2 - (\bar{v}_i\Delta t_i)^2 = (c\Delta\tau_i)^2 \quad \bar{v}_i = \Delta l_i/\Delta t_i\,, \tag{12}$$

where $\bar{\rho}_i$, $\bar{v}_i$ – rapidity and velocity mean values, Δl_i – particle displacement (shift) over the time Δt_i. Thus, the integral (9) can be written in the form

$$\sum_{i=1}^{n} \Delta t_i \sqrt{1-\bar{\beta}_i^{\,2}} = \sum_{i=1}^{n} \Delta\tau_i\,. \tag{13}$$

These evident transformations of the integral (9) reveal some important characteristics.

1. The invariance of the infinitesimal (7) and average (12) intervals expresses the geometrical relation of the Pithagor theorem for the right-angled triangle with hypotenuse cdt and cathetuses vdt and $cd\tau$ for (7) (see fig.2a, for (12) it is also obvious).

2. Each term in (13) can be transformed to the form (12). It means, that an arbitrary (curviliner) motion over full time Δt can be represented by the sum of simple shifts Δl_i (rectilinear and uniform) with mean velocity $\bar{\beta}_i$ during the time Δt_i and proper time $\Delta\tau_i$ (fig.2d, 2e).

The relation (13) has the same sense as (7) and (9), but the real particle motion (for instance, over some curve) in (13) is expressed by the sum of the simplest motions (shifts and rotations) – by the motion over the broken line inscribed into some curve. Each segment of the broken line is the cathetus of the right-angled triangle with light beams $c\Delta t_i$ and $c\Delta\tau_i$ as other sides (fig.2e). So, the splitting time integration region on arbitrary parts in the integral (9) is equivalent to the decomposition of the particle resulting motion into the simplest ones.

Let us come back to triangles. The acute angle θ_L between vdt and cdt is just the Lobachevsky parallel angle:

$$\cos\theta_L = vdt/cdt = \beta = th\rho\,, \tag{14}$$

where ρ is the rapidity, corresponding to particle velocity β. From (14) one can get immediately the main formula of the Lobachevsky geometry [2,7]:

$$\theta_L = 2arctg\; e^{-\rho}\,. \tag{15}$$

Formula (15) is called Lobachevsky's function. It establishes the definite relation between the angular and linear values. For the interval with mean values (12) the parallel angle is expressed via the mean value of velocity (or rapidity): $\cos\theta_L = \bar{\beta} = th\bar{\rho}$.

So, the geometrical form of the interval invariance reveals Lobachevsky's function in its definition. One can conclude, that in the foundation of the special relativity theory there is the theory of parallel lines (with all its scientific contents).

It is important to note that (as it follows from (7) and (14)) for any β there exists a light beam cdt emitted under definite angle θ_L from the reference point of the rest system. Sience the plane for the light beam is not fixed, then all triangles with the hypotenuse on the light cone (formed by rotation of the light beam around particle motion direction) are equivalent.

In the LVS the intervals (7) and (12) are also represented by right-angled triangles with the same parallel angles and with sides formed by rapidities instead of the corresponding velocities (fig.2b). As the rapidity for the c is infinite, then the corresponding sides (light beams) of the noneuclidean triangles are infinite and parallel – that is why the angle between them is equal to zero. Just this kind of the triangle was introduced by Lobachevsky (fig.2c), and at present time is used to define parallel lines on Lobachevsky [2,7].

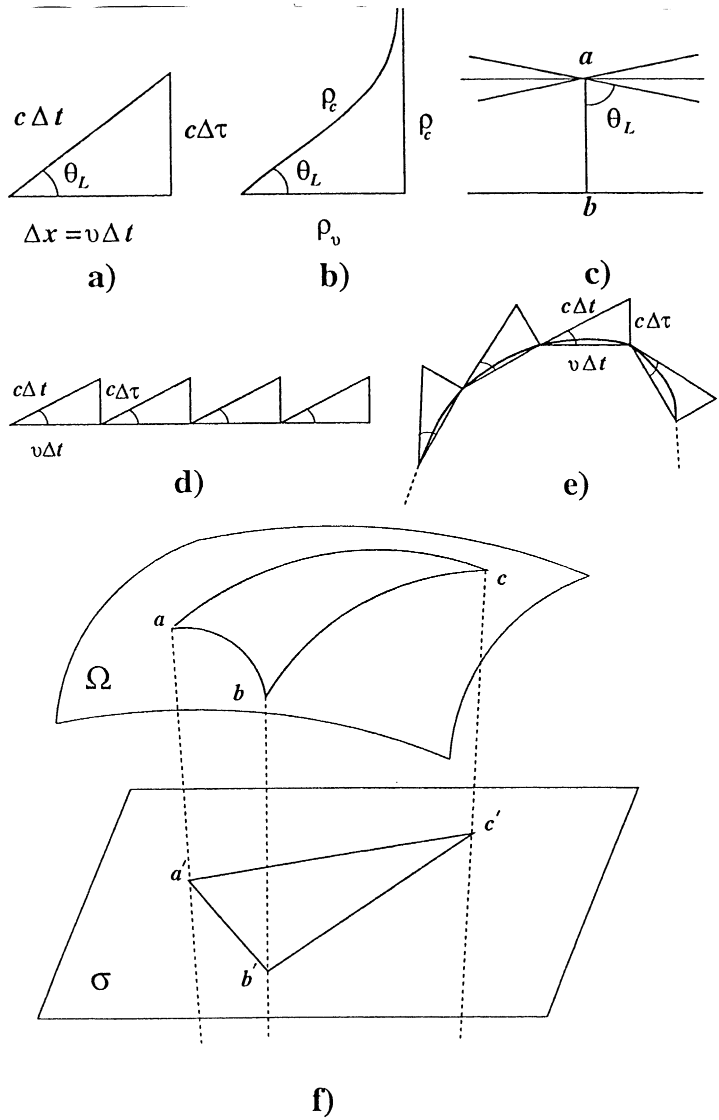

Fig.2 Geometrical views of the time-like interval invariance for euclidean a)-, d)-, e)- and noneuclidean b)-, c)-, f)- spaces.

It seems also important to note that, time-like finite interval (9) is a result of summation of elementary or simplest motions (displacements and rotations) and an decomposition of an arbitrary complex motion into the simplest ones is just equivalent to the splitting time integration region into a pieces. From this point of view the Heisenberg uncertainty principle $\Delta x_i \Delta p_i \simeq \hbar$ ($\hbar$ – Plank's constant) may be considered as the way to decompose a complex motion into the simplest ones. To do that decomposition, one should choose such time intervals Δt_i for the product of a particle displacement $\Delta x_i = \bar{v}_i \Delta t_i$ and momentum transfer Δp_i (over Δt_i) should be of the order $\simeq \hbar$. In such an interpretation this principle is a method to investigate an arbitrary motion.

The euclidean and noneuclidean geometrical interpretations of the interval invariance is useful to define such characteristic time Δt_o (or $\Delta \tau_o$), which depends only on the particle parameters, its mass and velocity (or Lobachevsky parallel angle), and on the universal Plank's constant.

3 Particle characteristic time

For simplicity let us look at the free particle motion along x-axis with momentum p. Then one can measure the side lengths of the euclidean triangle at some time moment t (from the starting point, $\Delta t = t$) in units of λ ($\lambda = h/p$ is de-Brogle wave, $\lambda = h/(mc\ sh\rho) = h/(mc)\ tg\theta_L$):

$$v\Delta t = n_v \lambda, \quad c\Delta t = n_c \lambda, \quad c\Delta\tau = n_\tau \lambda\,, \tag{16}$$

where n_v, n_c, n_τ – some numbers (not necessary integers) which define the length of sides at the time moment t. From (16), taking into account (7) and (14) one can get:

$$n_c^2 - n_v^2 = n_\tau^2, \quad n_c = n_\tau ch\rho, \quad n_v = n_\tau sh\rho\,, \tag{17}$$

the relations between wave numbers analogous to energy-momentum relations ($c = 1$):

$$E^2 - p^2 = m^2, \quad E = mch\rho, \quad p = msh\rho. \tag{18}$$

The geometrical interpretation of (18) for LVS was done in [8]. It was shown that on the surface of the limited sphere (orisphere) the relation (18) was represented as an ordinary (euclidean) right-angled triangle. The stereometry of LVS contains also the euclidean planimetry on the orisphere [2,7,8]. Therefore, on this surface in LVS one can constrain a triangle with the sides proportional to numbers n_v, n_c, n_τ. Let us choose c– light velocity – as a proportional coefficient . Then the lengths of the sides are $n_v c, n_c c, n_\tau c$, and triangle area is:

$$\Delta S_{\Delta O} = 1/2c^2 n_v n_\tau = 1/2c^2 n_\tau^2 sh\rho\,. \tag{19}$$

The area of the triangle formed by rapidities on the Lobachevsky plane is [2,7]:

$$\Delta S_{\Delta L} = c^2(\pi - (A + B + C)) = c^2(\pi/2 - \theta_L)\,, \tag{20}$$

where $(A + B + C)$ – the sum of noneuclidean triangle angles. In our case the sum is defined by the particle velocity ($\cos\theta_L = \beta$). Comparing (19) and (20) and putting in (20) coefficient $\kappa (0 \le \kappa \le 1)$ one can find:

$$\Delta S_{\Delta O} = \kappa \Delta S_{\Delta L}\ , \quad n_\tau = \sqrt{\kappa(\pi - 2\theta_L)/sh\rho} = \sqrt{\kappa(\pi - 2\theta_L) tg\theta_L}\,, \tag{21}$$

and, coming back to (17) and (16), one can have:

$$\Delta\tau_o = n_\tau \lambda / c \ , \quad \Delta t_o = n_\tau ch\rho \lambda / c = (n_\tau / \sin\theta_L) \lambda / c \, . \tag{22}$$

Let us call this time ((21)-(22) with $\kappa = 1$) a particle characteristic time. The coefficient κ was introduced to agree a finite interval with the characteristic time: changing κ, one can change the scale of time.

Let us look at (21-22) in more detail. The LVS is a part of the projective space [7,8] (fig.2f). In the projective space the Lobachevsky plane (with the triangle formed by rapidities) is a tangent plane to the orisphere. Both vertices of parallel angles (from both triangles – one on the plane and the other on the orisphere) touch the common point. The triangle's area on the plane depends on the particle velocity (or on the θ_L – see (20)), the triangle's area on the orisphere depends both on the velocity and on the time (through the wave numbers – see (16)). Hence, equations (21-22) define the element of time when both areas are equal.

So, for free particle motion there exists some geometrical figure as on the Lobachevsky plane ($\Delta S_{\Delta L}$), as on the orisphere ($\Delta S_{\Delta O}$). Sience the inner geometry of the orisphere is euclidean, then its figure is similar to that on the plane in the euclidean space ($\Delta S_{\Delta E}$) and they differ only in units. Comparing three areas of these geometrical figures in appropriate units: $\Delta S_{\Delta E}/\lambda^2 = \Delta S_{\Delta O}/c^2 = \Delta S_{\Delta L}/c^2$ one can get the time-angle relation.

For free particle motion the angle is the Lobachevsky parallel angle. But in this case there is no problem to integrate an interval. Let us come to the particle motion in the scattering processes.

4 Time estimation for an interacting particle

Due to angular momentum conservation one can define the so called scattering plane of the colliding particles for the euclidean as well as for noneuclidean velocity spaces. The particle complex motion in the coordinate (euclidean) space is represented in LVS by the points corresponding to the velocities of the particle relative to the special point, chosen as the reference point (*c*-system, for instance). Without loosing generality, let us assume that a particle velocity as a function on scattering angle is known (for example, see (4)).

For the full time Δt a particle scatters on a full angle θ_f, measurable in experiments. For the small time dt the particle rapidity in LVS on scattering plane sweeps up some area of the sector with the spread of angle $d\theta$. Let us find the area of this sector. The area of the circle with radius ρ is [2]:

$$S_L = c^2 2\pi (ch\rho - 1) \ . \tag{23}$$

Then the area of the sector with the infinitesimal angle $d\theta$ can be expressed in the form:

$$dS_L = c^2 d\theta (ch\rho - 1) = c^2 2 sh^2 \frac{\rho}{2} d\theta \ . \tag{24}$$

Corresponding to this motion, the area of the euclidean sector obviously is:

$$dS_E = 1/2 R^2 d\theta = \lambda^2 1/2 (R/\lambda)^2 d\theta \, , \tag{25}$$

where R/λ is the radius of the sector measured in units of λ. Sience the geometry of the orisphere (in LVS) is euclidian, then the area of the sector on the orisphere dS_O is

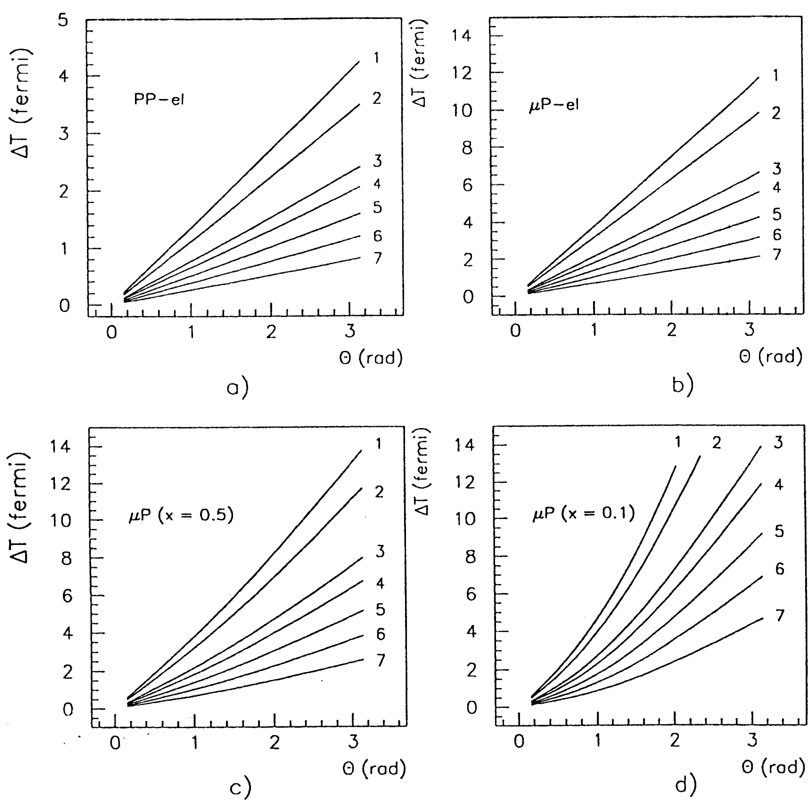

Fig.3 The dependence of time interaction of the projectile particle on the scattering angle (in *c*-system) for elastic *pp* (a)-, μp (b)- and inelastic μp (c-d)- reactions. The results are shown for 5, 10, 50, 100, 500, 1000 and 5000 GeV (in lab. system and numbered from 1 to 7 correspondingly).

proportional to dS_E and they differ only in units of measure. As the area unit for LVS is c^2, then:

$$dS_E/\lambda^2 = dS_O/c^2 \ , \ dS_O = c^2 1/2(R/\lambda)^2 d\theta \,. \tag{26}$$

Comparing areas dS_O and dS_L:

$$dS_O = dS_L \ , \ \ 1/2(R/\lambda)^2 = 2sh^2\frac{\rho}{2} \,, \tag{27}$$

one can find the expression for R:

$$R = \lambda 2sh\frac{\rho}{2} = \frac{h}{mc}\frac{2sh(\rho/2)}{sh\rho} \,, \tag{28}$$

and, using the velocity definition:

$$dl/dt = Rd\theta/dt = c\beta = cth\rho \,, \tag{29}$$

one can get the time - angle relation:

$$dt = \frac{h}{mc^2}\frac{2sh(\rho/2)}{sh\rho th\rho}d\theta \,. \tag{30}$$

So, the usage of LVS allows one to find two important functions: (4) and (30). Using function (4) and making integration of the time-angle relation (30) from $\theta = 0$ up to $\theta = \theta_f$, one can get numerical estimations of the full time Δt.

The estimations of interaction time Δt (for *c*-system) in elastic pp and μp, and inclusive inelastic μp (for fixed x and for the allowed scattering angle region ($0 - \pi$ for *c*-system)) at the energies from 5 GeV up to 5 TeV (in *lab*-system) were calculated (see fig.3). The results have shown increasing of the interaction time with increasing the scattering angle (or Q^2) and with decreasing x (with decreasing x the particle velocity is also decreasing and contribution to the integral as seen from (17) becomes larger). The interaction time decreases with increasing the beam energy (such behavior is usually expected).

5 Relative velocity and Lorentz transformations

Let us show how one can get the relative velocity formula on the base of Lobachevsky function. Assume, two particles are moving along x-axis. The first particle has a velocity v_o, the second – v. Let us suppose, that the moving system coincides with the first particle and $v > v_o$. The reference point for the counting time is chosen at the moment when both particles have the same x - coordinate. The question is: what is the velocity v' of the second particle relative to the first one?

One can get the answer by following the logic of classical physics [5] and applying Lobachevsky parallel angle:

$$v_o/c = \cos\theta_{VO} \,, \ \ v/c = \cos\theta_V \,. \tag{31}$$

We should consider the $x-$ positions of particles at the two time moments: at time $t = 0$ and t (so, $\Delta t = t$). At time $t = 0$ as it was chosen $x = 0$ for both particles. At the time moment t the $x-$ positions of particles are $v_o t$ and vt, and the corresponding light beams are emitted under parallel angles from the starting point (see fig.4a).

As we search for a derivative **relative the moving system**, then to find a displacement (for the second particle) one should subtract from the particle a new position vt instead its primary $x = 0$ but some x_B. The point x_B (see [5]) should obviously coincide with the new position of the moving system $v_o t$, thus:

$$\Delta x_B = vt - x_B = t(v - v_o) = ct(\cos\theta_V - \cos\theta_{VO}). \tag{32}$$

In mechanics the relative velocity v' is defined as the limits of the ratio Δx_B to the full time $\Delta t = t$ [5]. This ratio does not coincide with the known relativistic formula for v', because the value Δx_B is only a part of the full particle displacement vt. So, the time, needed for displacement Δx_B, should be corrected.

Sience the starting point to the counting displacement is shifted by $v_o t$, then we have also to move the starting point for the time counting. Let us shift the reference time point at the moment when the front of the light beam (corresponding to velocity v) reaches the reference point of the moving system $x_B = v_o t$ (Guigens principle). The time of light $\Delta t_f = t_f - 0 = t_f$ needed for that is (see fig.4a):

$$ct_f = v_o t\cos\theta_V = ct\cos\theta_{VO}\cos\theta_V. \tag{33}$$

Then the reminder part of the full increment $\Delta t_B = t - t_f$ can be assumed as the time, needed for the particle displacement Δx_B:

$$c\Delta t_B = ct - ct_f = ct(1 - \cos\theta_{VO}\cos\theta_V). \tag{34}$$

Finally, for v' one can find:

$$v'/c = \lim_{\Delta t_B \to 0}\frac{\Delta x_B}{c\Delta t_B} = \frac{\cos\theta_V - \cos\theta_{VO}}{1 - \cos\theta_V\cos\theta_{VO}} = \frac{v - v_o}{c(1 - vv_o/c^2)}. \tag{35}$$

This expression is the same as the well- known relativistic formula for v'. The corresponding picture for the moving system is shown on fig.4b.

Now, if one knows the right formula for $v' = dx'/dt'$, it is possible to get the Lorentz transformations as the solution of the system of two equations: for v' - (35), and the equation for any interval invariance of:

$$(cdt)^2 - dx^2 = (cdt')^2 - dx'^2. \tag{36}$$

The previous method of correcting time for v' formula shows another simple way to obtain Lorentz transformations from the geometrical form of the time-like interval in euclidean space and using the Lobachevsky's function.

Let us put a perpendicular from the point $x = vt$ on the hypotenuse ct (see fig.4c). Then ct is splitted into two pieces $ct = ct_f + ct_B$ and the angle between this perpendicular and ct' is equal to parallel angle θ_V. In this case for ct_B one can write:

$$ct_B = ct'\sin\theta_V, \tag{37}$$

and, as previously:

$$ct_B = ct - ct_f = ct - x\cos\theta_V. \tag{38}$$

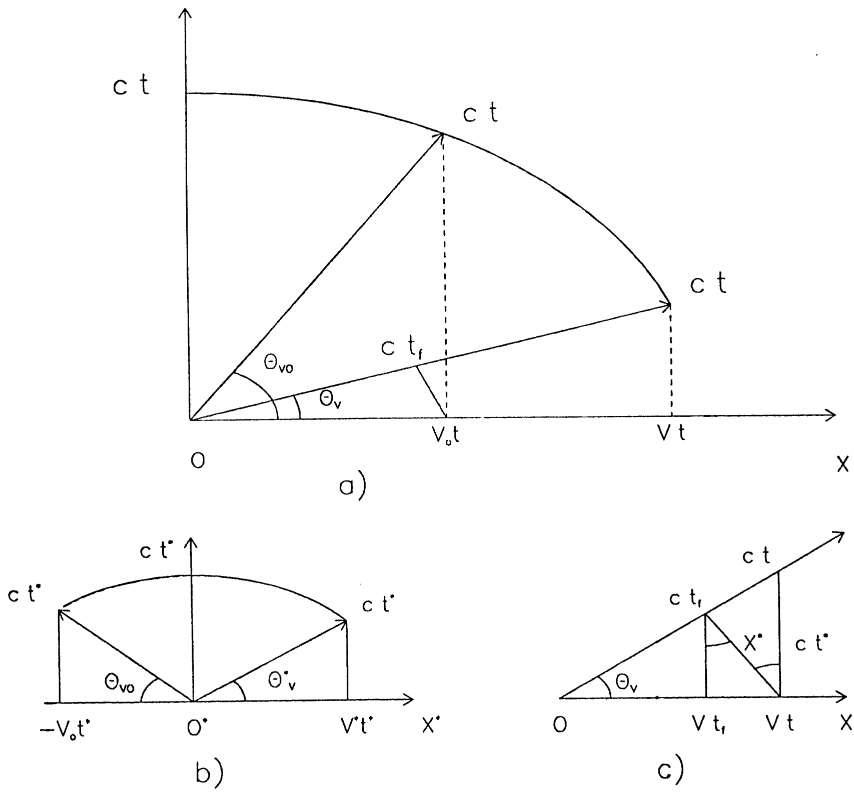

Fig.4 The diagram of the positions of two particles moving with velocities v_o and v and their corresponding light beams: a) – for the rest system; b) – for the moving system; c) – geometrical views of Lorentz transformations in euclidean space.

From (37) and (38) for t' one can get:

$$t' = \frac{t - x\cos\theta_V/c}{\sin\theta_V} = \frac{t - xv/c^2}{\sqrt{1 - v^2/c^2}}. \quad (39)$$

Again, using (39) and (36), one can find Lorentz transformation for x'.

It is interesting to note that the length l' of our perpendicular corresponds to the x' value for the point $x = vt$, but for the time t_f. To see that, let us put another perpendicular from the point ct_f to the x-axis. Then one can write:

$$x - vt_f = l'\sin\theta_V\,, \quad l' = \frac{x - vt_f}{\sqrt{1 - v^2/c^2}} = x'\,. \quad (40)$$

Thus, the Lorentz transformations can be derived in a visible geometrical way (for euclidean space) using the Lobachevsky's function.

6 Conclusion

Let us formulate the main results:

1. It is shown that the definition of the time-like interval invariance contains the Lobachevsky's function which provides the unity of the special relativity theory and the theory of the parallel lines.

2. Based on geometrical views of the time-like interval for euclidean and noneuclidean Lobachevsky velocity spaces:

a) it has been shown that a decomposition of an arbitrary motion into the simplest ones is equivalent to the splitting time interval integration region on arbitrary parts; this shows that Heisenbrg uncertainty principle may be considered as a way to decompose a complex particle motion into the simplest ones: shifts and rotations.

b) the particle characteristic time has been introduced for free particle motion; it depends on the mass and on the Lobachevsky parallel angle (or velocity) of the particle (and on Plank's constant);

3. Based on geometrical views of the particle scattering processes for euclidean and noneuclidean Lobachevsky velocity spaces:

a) the hypothesis of automodelity is released for LVS and a particle rapidity (velocity) was expressed as the function on the current scattering angle;

c) the new time - angle relation $dt = (h/mc^2)2sh(\rho/2)/(sh\rho th\rho)d\theta$ is found for particle scattering processes (in c - system) by analogy with the characteristic time for the free particle motion.

4. The estimations of the particle time interaction for elastic pp, μp and inclusive inelastic μp interactions at the energies from 5 GeV to 5 TeV have been calculated. The results have shown the increasing of the interaction time with increasing the scattering angle (or Q^2) and with decreasing x, at energy increasing – the time decreases.

5. The relativistic formula for the particle relative velocity and Lorentz transformations have been derived in a visible geometrical way (for euclidean space) using the Lobachevsky's function.

6. The presence of the Lobachevsky function at the interval invariance definition and the new way to get a relative velocity formula and Lorentz transformations indicates

new ability of the analytical expression of the space-time properties with the Lobachevsky function: for the given point (dx, dt) in some reference system or, which is the same, for the given velocity $\beta = dx/(cdt)$ there is the light cone with the axis direction coinciding with the direction of the motion dx and with the light beam cdt emitted under Lobachevsky parallel angle: $\cos\theta_L = \beta$.

7. The proposed ideas open new opportunities to investigate the problem of relativistic description of the system of two and more interacting particles.

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Автомодельность, лоренц-инвариантность и оценка времени взаимодействия сталкивающихся частиц

На основе геометрических свойств инвариантности интервала в евклидовом пространстве и пространстве скоростей Лобачевского установлено соотношение время — угол: $dt = (h/mc^2)\, 2sh(\rho/2)/(sh\rho\; th\rho)\; d\theta$ для процессов рассеяния частиц (ρ — быстрота частицы, c — система). С привлечением гипотезы автомодельности вычислены оценки времени взаимодействия рассеянной частицы в *pp*-и μp-столкновениях при энергиях от 5 ГэВ до 5 ТэВ. Предложен наглядный геометрический способ вывода формул для относительной скорости и преобразований Лоренца в евклидовом пространстве на основе применения функции Лобачевского.

Работа выполнена в Лаборатории физики частиц ОИЯИ.

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Automodelity, Lorentz Invariance and Interaction Time of the Particle Scattering Processes Estimations

Based on geometrical properties of interval invariance in Euclidean, as well as in non-Euclidean velocity spaces, time-angle relation $dt = (h/mc^2) 2sh(\rho/2)/(sh\rho\; th\rho)\; d\theta$ is found for particle scattering processes (ρ — particle rapidity, c — system). Using also the hypothesis of automodelity, a numerical estimations for the particle interaction time is obtained for *pp* and μp interactions at the energy of 5 GeV to 5 TeV. The transparent geometrical way to get a relative velocity formula and Lorentz transformations in Euclidean space using the Lobachevsky's function is also shown.

The investigation has been performed at the Laboratory of Particle Physics, JINR.

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