The Highly Collimated Jet Stream of Quasars

Abstract: Basic facts common to quasars:

(1) Highly compact both in mass and energy,
(2) Having a supermassive material center,
(3) Excluding the material center, the general existence of mass is in a state of plasma,
(4) Rapidly spinning,
(5) Periodical variation in luminosity,
(6) Highly remotely located from Earth with high value of redshift.

In addition to the above common facts, a high percentage of quasars are also found containing jet streams. The strange thing is that the jet always comes in a set, with one from the set pointing in the opposite direction of the other, and both jets are highly collimated.

As a thumb of rule, the higher the energy content is found in any physical entity, the higher chance of randomness is associated with this entity. Special filtering mechanism must be present for orderly output of anything to come out of this entity. Without a lens-like arrangement, how would the jet stream of a quasar stay highly collimated and remain in pair?

In modern science, when high energy and high speed are involved, it has been so natural for many people to apply Einstein's Theory of Relativity to explain many puzzles that classic physics appears incompetent in explaining. As such, when superluminal movement are observed with the jet streams from the group of quasars, called blazars, many physicists conclude it as an illusion because of the effect imagined led by special relativity.

Illusion? Special relativity is a product of mathematical derivation that must restrict itself with an implicit condition of speed $v=0$ between inertial frames. Such an implicit condition must in turn leads relativity to have speed of light $c=0$, absolutely contradicting to the relativity's assumption as well as conclusion of ***c=300,000 km/sec***, which is concluded by so many observations and experiments.

Obviously, then, nature and relativity cannot tolerate each other!

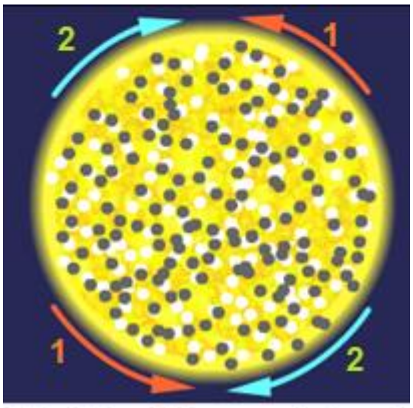
Key Words plasma, spinning, electric field, magnetic field, neutron core, superluminal movement, relativity

Material Distribution in a Quasar Disk The typical characteristics of a quasar include huge quantity of mass, extraordinary high rate of self-spinning, intensive heat and illumination, and having jet streams pointing away from it along the spinning axis of the quasar. The intensity of the heat and illumination alternates periodically. The heat and illumination from them can be so intense that, for example, a quasar named 3C 273 is said to shine in the sky as brightly as our Sun if it is placed at 33 light-years from us.

It may be considered controversial as to how the quasars to have obtained their power, both kinetic and electromagnetic, to begin each of their lives, nonetheless scientists all accept that the major substance state within the quasar is of hot plasma.

Rapid self-spinning is an inevitable consideration if no one can reject that the birth of a quasar is a result of some off-center collision between some huge quantities of mass. To give support to this speculation, many theories suggest that the Andromeda Galaxy and our own Milky Way Galaxy could collide and form a quasar someday in the remote future. If this becomes fact, a new and huge material formation inheriting a formidable residual angular momentum must be the result; its self-spinning shall be extraordinary. Let’s simply imagine what amount of gravitational energy these two galaxies could contribute to the collision when their rectilinear movement must subsequently end at said collision; if the materials from both galaxies contract into a small conglomeration due to the overall elevation of gravitational force after the collision, the new formation so raised must spin at high angular velocity.

In a plasma, all subatomic elementary particles, being in a charge state or neutral, just move in a ‘lawless” manner, declining any summoning for forming steady association from any others (Fig. 01). As to protons, with their pronounced mass as well as positive charge, they are potentially designated to concentrate at the outskirts of the spinning bulk as much as possible by two forces: Force one is the centrifugal force produced out of the spinning; force two is their own electrical repelling force they exert on each other. However, whether or not they would finally occupy that area would also be determined by another force: magnetic force. We will elaborate this further a little later.



The disk could have spun in the red direction (1) or the green direction (2)

White Particles = Protons;
Dark Particles = Neutrons

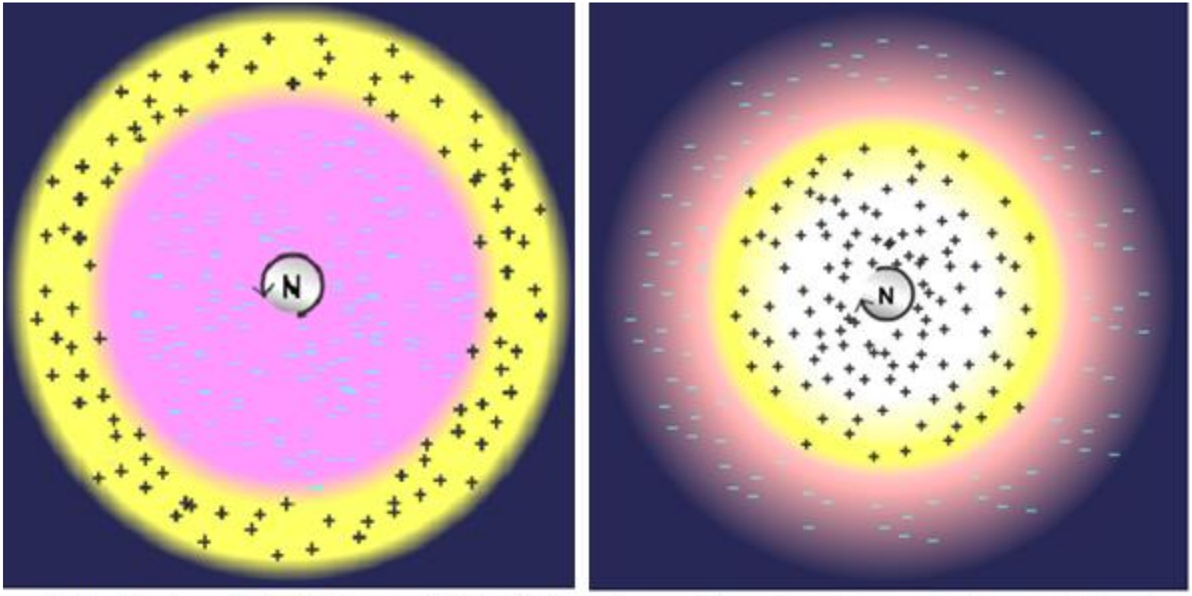
Fig. 01 A Quasar Disk at Its Early Stage

Lacking the electrical repelling force, but with mass compatible to that of protons, neutrons stealthily move toward the central region of the spinning bulk. The sinking movement may be slow at the beginning, but gravitational principle would sooner or later accelerate this process, because few of them have an opportunity to get closer than others and to come together subsequently forming small gatherings here and there. As such, tiny gathering of neutrons gradually increases its population across the entire plasma. Some gravitational predators would eventually come into shape and accelerate the aggregation processing until only one can exist and rein itself at the center of the plasma, or the quasar disk.

Lacking a repelling force between each neutron member, which grants the gravitational force an opportunity to dominate, is not the only reason for the neutron aggregate to become highly compact. Observation tells us that all neutron stars carry strong magnetism. Although the reason why neutron stars carry strong magnetism is not yet clear, the magnetism so unexceptionally carried by all of them, however, would tell us that any formation rich of neurons must be some potential candidate of magnetic body. Driven by the magnetic force, all the members in the aggregate must clench each other as much as possible. At the very early age of the quasar, when both the protons and the neutrons are spread across and thus share the same area, the bulk of protons and the bulk of the neutrons must also share about the same magnitude of angular momentum of the entire quasar. However, gradually the bulk of neutrons sinks into a small aggregate and become a core body at the center of the quasar. The original momentum possessed by the entire neutron bulk must now enable the small core to spin at a rate far above that of the bulk of the protons, which is the major material occupier of the far spread disk. In other words, the spinning revolution rate between the neutron core and the material bulk spreading away from the core are contrastingly different from each other.

Electrons, as an entire bulk of substance, may have two ranges in the disk for them to reside. If, as we mentioned above, the dynamic situation of the quasar disk happens to have the protons occupy the outskirt of the disk, the electrons will be located in and around the central region of the disk. If the dynamic situation of the quasar disk had designated the protons to stay about the central region, the electrons will take the outskirt. Which of these two types of mass distribution would prevail is solely determined by one dynamic factor: The spinning direction of the neutron core that must have carried a strong magnetism.

With all that is illustrated above, an observer stationary to the outskirt of the quasar disk can have two different dynamical views in his observation, depending on which spinning direction of the neutron core appears in his detection. Fig. 02 would tell him that he may have detected either clockwise or counterclockwise direction for the neutron core if he takes a bird's eye-view on the disk while facing the north magnetic pole of the neutron core. If, for example, the neutron core spins in a counterclockwise direction, as shown in the left diagram in Fig. 02, the magnetic flux from the core will herd all the positive charge particles, majorly protons, to



"+" = Protons; "–" = Electrons; "N" = Neutron Core. Viewer is stationary with the outskirt of the disk but directly faces the North pole of the magnetic field generated by the neutron core.

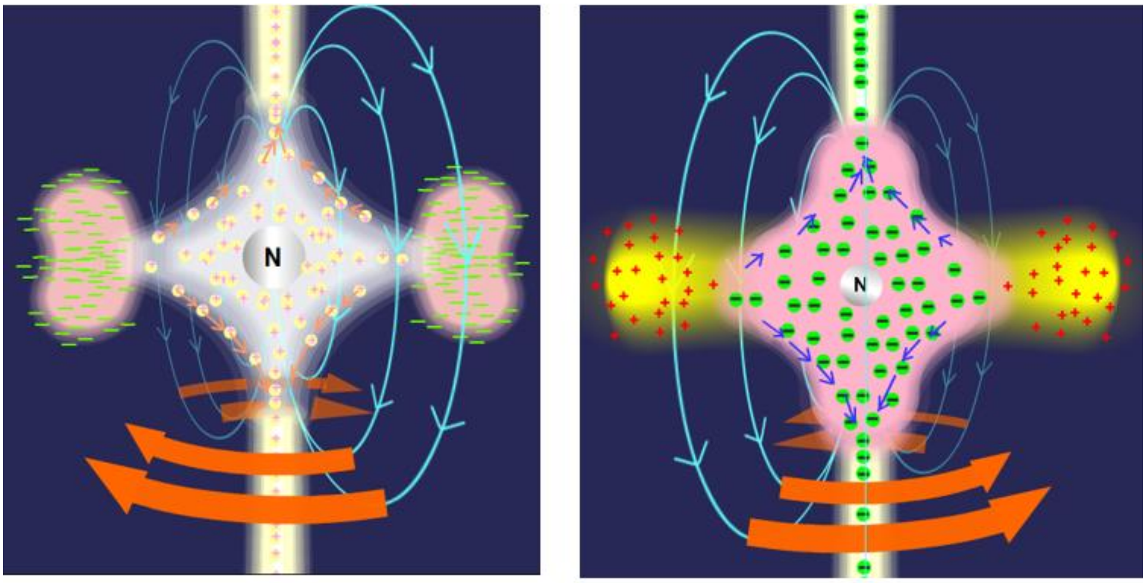
!!! Different rotation direction of the core causes different distribution of the charge particles !!!

Fig.02 Bird's Eyeview on a Quasar Disk

go far away from the core and thus stay at the outskirt of the quasar disk. Likewise, electrons are herded to stay in the central region about the core by the same flux. If the core is found to spin in opposite direction, the protons and electrons will change their residing locations.

Formation of the Jet Streams In the upcoming paragraphs, the illustration focuses on one dynamical situation: The spinning of the core has caused the central region to be the place where the major bulk of protons is found, while the electrons stay at the outskirt of the disk. So, naturally in such situation, the central region of the quasar can only be an electrical field of exceedingly strong positive potential. Any positively charged particle entering this region would be compelled to move along a designated direction by two forces: (1) electrical repelling force and (2) electromagnetic force. While force (1) should result in an isotropic scattering movement, force (2) would decline any scattering movement but confine all particles to move along the axis of the magnetic field as much as possible. Both forces working together then compel the particle to leave the disk with high speed but at a definite direction; a jet stream is thus constructed. The force for the positive particles to leave the disk is so strong that no gravitational force can ever hinder their movement. Force (2), being produced by a spinning magnetic field, causes a helix path to appear in the jet for the movement of the protons. With the same reason that one jet stream can be constructed on one side of the disk, another jet must also be constructed on another side of the disk. This is why jet streams always appear in pair for the quasars.

With more protons or other positive particles having departed from the quasar, nothing else can play the role to retain the excessive electrons to continue staying with the disk; they must evaporate from the quasar under their own mutual repelling force in addition to the expelling force generated by the spinning magnetic field. The more positive particles that have left through the jet, the more electrons will subsequently vaporize. Gradually, more and more loss of mass will bring the quasar to meet its day of disappearance, leaving only its neutron core, namely, a neutron star, to witness the historical location of the bygone quasar.



The direction of a spinning magnetic field has not only caused different material distribution in a quasar disk, but it has also inevitably caused different substance to form the jet streams

Fig. 03 The Formation of Jet Streams

In a likewise manner, but with opposite spinning direction of a quasar's core with respect to an observer stationary to the outskirt, it would be the electrons that have been "jailed" in the central region of the quasar disk and to form the jet stream as shown in the diagram on the right of Fig. 03; protons are now located at the outskirt.

Overall, that the axial line of a magnetic field is where the strongest magnetic force is found is the reason for the jet stream being so highly collimated, regardless of whether the particles forming the jet are of positive or negative charge.

Alternating luminosity As the plasma rapidly spins, the protons, or other positive particles, must oscillate between two distances with respect to the neutron core. They are either moving closer and closer to the core or farther and farther away from it. Generally, they tend to move toward the core because of the overall gravitational pull of the entire quasar; the neutron core always exerts its pronounced gravitational influence on all materials at its vicinity as well. When the protons are too close, however, the electrical repelling force between each of them increases, and the centrifugal force on them also increases due to excessive angular momentum for an ever shortening spinning radius. When these two forces reach certain magnitude, the bulk of protons must begin to push all elementary members to get away from each other; the bulk then expands its territory. When the members get too far away, their rotation about the core slows down and the distance between each particle increases. Subsequently, the centrifugal force is reduced and their mutual electrical repelling force is weakened. Then the gravitational force once again dominates their movement, pulling them back toward the center. This back and forth moving pattern of protons must be persistent and will not lose itself no matter whether the protons have occupied the outskirt or the central region of the quasar disk to start the oscillation. Of course, whether the protons have occupied the central region or the outskirt to begin the oscillation will cause a different amplitude as well as different extremes of the amplitude with respect to the center of the quasar for the oscillation.

The aforementioned oscillation causes the periodical alternation of a quasar's brightness. The closer the material members of the plasma get to each other, the more illumination of the quasar is concentrated at a smaller area, making the quasar appear brighter, and conversely, dimmer during the period of expansion as the same amount of illumination being diluted in a bigger area.

As of today, about 200,000 quasars are detected at distance of billions of light-years from us. Given the remote distance they are from us, the reason they can show up in our observation is because of their extraordinary power output. The power of some of them, called blazars, are so strong that superluminal motions of the jet materials are seemingly displayed in our observation. It is due to relativity that such superluminal motion is declined to be accepted as a reality, but instead, explained as an illusion. Should the science world rely more heavily on the observation, or more on a theory? How could we trust that we have seamlessly applied relativity in explaining the superluminal movement involving the blazars' jet stream?

Revisiting the Speed Limit Approved by Relativity The mathematical derivation of relativity is usually demonstrated to begin with Lorentz transformation equations. With more direct wording, textbooks introducing Einstein's relativity to students take advantage of an equation set for the transformation that is shown as

$$x' = a_{11}x + a_{12}y + a_{13}z + a_{14}t \qquad (Eq.\ 1)$$
$$y' = a_{21}x + a_{22}y + a_{23}z + a_{24}t \qquad (Eq.\ 2)$$
$$z' = a_{31}x + a_{32}y + a_{33}z + a_{34}t \qquad (Eq.\ 3)$$
$$t' = a_{41}x + a_{42}y + a_{43}z + a_{44}t \qquad (Eq.\ 4)$$

The task of this set is to find all *a*'s as unknowns as if all *t*'s, *x*'s, *y*'s, *z*'s have been known constants. With many supplemental conditions, this set finally shows up as:

$$x' = a_{11}(x - vt) \qquad (Eq.\ 5)$$
$$y' = y \qquad (Eq.\ 6)$$
$$z' = z \qquad (Eq.\ 7)$$
$$t' = a_{41}x + a_{44}t \qquad (Eq.\ 8)$$

If all *a*'s remain as unknowns, (Eq. 5 to 8) is a set with three unknowns but only two relevant equations, unsolvable. To overcome the difficulty, the following conditions describing the expansion of some spheres formed by light traveling are introduced:

$$x^2 + y^2 + z^2 = (ct)^2 \qquad (Eq.\ 9)$$
$$x'^2 + y'^2 + z'^2 = (ct')^2 \qquad (Eq.\ 10)$$

Given that *y'=y* and *z'=z* are redundant and they eventually reduce to zero in assisting the set of (Eq. 5 to 8), the useful information in (Eq. 9 and 10) actually only contains

$$x^2 = (ct)^2 \qquad (Eq.\ 11)$$
$$x'^2 = (ct')^2 \qquad (Eq.\ 12)$$

Putting everything together, all the above information leads to an equation set that reads

$$x' = a_{11}(x - vt) \qquad (Eq.\ 13)$$
$$t' = a_{41}x + a_{44}t \qquad (Eq.\ 14)$$
$$x^2 = (ct)^2 \qquad (Eq.\ 15)$$
$$x'^2 = (ct')^2 \qquad (Eq.\ 16)$$

The introduction of (Eq. 9 and 10), or equivalently, (Eq. 11 and 12), makes it indisputable that the set of (Eq. 13 to 16) is conditioned to be solved in the following way: When two observers, one each on the **X** or **X'** axis respectively, compare the movement between each other, each observer must see that the origin of one's own axis and the center of the light sphere coincide forever in each of his own inspection. Further, this set, an obviously over-conditioned set, mandates the three unknowns to satisfy four equations simultaneously.

Mathematically, the set of (Eq. 9 and 10) is to announce that both spherical space occupied by the light start their expansion at *t=t'=0*. As far as each of the **X** axis and **X'** axis is concerned, light must propagate along them in both the positive and negative directions with speed of equal absolute value, which is *c*. Therefore, in the inspection of the **X** observer, he must say that the **X'** axis and the light front both move in the same direction pointing toward the positive end of his **X** axis. Looking toward the negative end of his **X** axis, he must say that the light front and the **X'** axis move in opposite direction between each other. The distance between the light front and a certain point on the **X**' axis, such as the origin, must continuously changes in his inspection (Fig. 04). Here comes how relativity would guide him to calculate the distance change in identical situation (from *§2* of the Relativity paper of 1905):

Let a ray of light depart from A at the time t_A, let it be reflected at B at the time t_B, and reach A again at the time t'_A. Taking into consideration the principle of the constancy of the velocity of light we find that

$$t_B - t_A = \frac{r_{AB}}{c-v} \qquad \text{(Eq. 17, for the ray and rod moving in same direction)}$$

and

$$t'_A - t_B = \frac{r_{AB}}{c+v} \qquad \text{(Eq. 18, for the ray and rod moving in opposite direction)}$$

where r_{AB} denotes the length of the moving rod—measured in the stationary system.

[Both equation numbers and the comments inside the parentheses are notes from this author]

In this quoted paragraph, right at the very moment of emission of the ray, the location on the stationary system where point ***A*** matches must be seen by relativity as where the light source of the ray is, or equivalently, as the center of a light sphere is. Among all the rays forming this sphere, the ray in the concern of the above quoted paragraph is only one of them. Please note: the light source as a physical entity may be attached to either r_{AB} or the **X** axis, but may not be both. Regardless of how the source is attached, however, in the observation of the **X** observer, the center of the expanding light sphere must, as mandated by (Eq. 9), be stationary to the **X** observer once the light ray emits.

The quoted paragraph further tells us that, for the light and the axis that an observer sees moving in the same direction, the relationship between distance, time, and speed should be established according to (Eq. 17). If the light and the axis are moving in opposite direction, the relationship between distance, time, and speed should be established according to (Eq. 18). In both situations, time is quoted from a clock next to the stationary observer.

Accordingly, then, if the **X** observer sees the light ray and the **X'** axis moving in the same direction, the **X** observer will obtain a distance r'_+ on the **X'** axis such that

$$\frac{r'_+}{c-v} = t \qquad (Eq. \quad 19)$$

where *t* is the amount of time that the ray requires to cover r'_+, starting from *t=0*, of course, and registered by the clock next to the **X** observer. If he sees them moving in opposite direction, with the same amount of time *t*, he will obtain a distance r'_- covered by the light on the **X'** axis as

$$\frac{r'_-}{c+v} = t \qquad (Eq. \quad 20)$$

(Eq. 19) and (Eq. 20) must lead this **X** observer to have

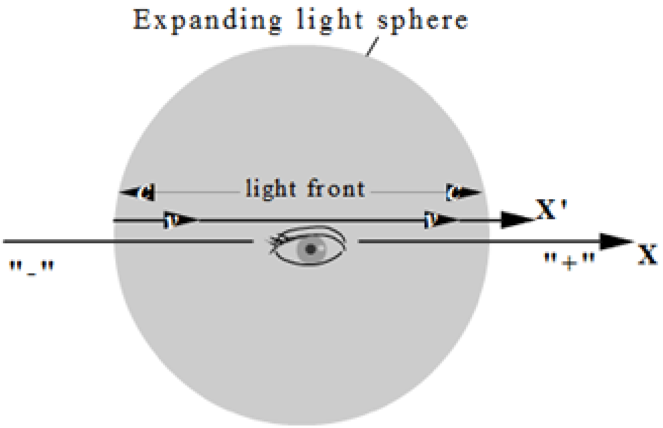


Fig. 04

Movement of the Light Fronts and the X' Axis in the Inspection of the X Observer

$$\frac{r'_+}{c-v} = t = \frac{r'_-}{c+v} \qquad (Eq. \quad 21)$$

or further

$$\frac{r'_+}{r'_-} = \frac{c-v}{c+v} \qquad (Eq. \;\; 22)$$

To the observer on the **X'** axis, with *v=0* for his own frame with respect to himself, and with the center of the light sphere to be seen at a point equivalent to point A (of r_{AB}) and to be motionless to him, (Eq. 12), (Eq. 17) and (Eq. 18) all together require that he must see

$$r_+ = r_- = ct' \qquad (Eq. \;\; 23)$$

where *t'* is quoted from a clock from his **X'** axis, r_+ and r_- are rest lengths seen from his own **X'** axis. Naturally, (Eq. 23) leads to

$$\frac{r_+}{r_-} = 1 \qquad (Eq. \;\; 24)$$

Then, (Eq. 22) and (Eq. 24) lead to the following development:

$$1 = \frac{r_+}{r_-} = \frac{r_+\sqrt{1-\left(\frac{v}{c}\right)^2}}{r_-\sqrt{1-\left(\frac{v}{c}\right)^2}} = \frac{r'_+}{r'_-} = \frac{c-v}{c+v} \qquad (Eq. \;\; 25)$$

where $r'_+ = r_+\sqrt{1-({}^{v}/_{c})^2})$ is the moving length seen by the **X** observer corresponding to the stationary length r_+ seen by the observer on the **X'** axis, and so is r'_- to r_- .

(Eq. 25) can be satisfied only if *v=0*; no other value of *v* can satisfy it. This means (Eq. 1 to 4) are implicitly preconditioned as a set unsolvable if nonzero movement between two frames is found. With *v=0*, the following two consequences must follow relativity:

Consequence 1: *c=0* Since (Eq. 13) is supposed to enable us to study the movement of the origin of the **X** axis, where *x=0*, with respect to the **X'** axis, we naturally have

$$x' = a_{11}(0 - vt) \qquad (Eq. \quad 26)$$

However, in the same set of equations, (Eq. 16) gives $x' = ct'$. Then, (Eq. 26), with the implicit condition *v=0*, inevitably becomes

$$ct' = a_{11}(0 - 0t) = 0 \qquad (Eq. \quad 27)$$

Now, (Eq. 27) becomes an equation for relativity to declare that **the speed of light *c* must be *zero*** whenever and wherever $t' \neq 0$ is found.

Consequence 2: No differential operator can be established. Let's quote a statement from the relativity's 1905 paper again, which is found in *§3, **On the Electrodynamics of Moving Bodies***, by *A. Enistein*:

> *...or, by inserting the arguments of the function τ and applying the principle of the constancy of the velocity of light in the stationary system: —*

$$\frac{1}{2}\left[\tau(0,0,0,t)+\tau\left(0,0,0,t+\frac{x'}{c-v}+\frac{x'}{c+v}\right)\right]=\tau\left(x',0,0,t+\frac{x'}{c-v}\right) \qquad (Eq.\ 28)$$

> *Hence, if x' be chosen infinitesimally small,*

$$\frac{1}{2}\left(\frac{1}{c-v}+\frac{1}{c+v}\right)\frac{\partial\tau}{\partial t}=\frac{\partial\tau}{\partial x'}+\frac{1}{c-v}\frac{\partial\tau}{\partial t}, \qquad (Eq. 29)$$

> *Or*

$$\frac{\partial\tau}{\partial x'}+\frac{v}{c^2-v^2}\frac{\partial\tau}{\partial t}=0 \qquad (Eq. 30)$$

[Note: Equation number (Eq. 28), (Eq. 29), (Eq. 30) are notes added by this author.]

The predetermined condition *v=0* between the two frames **X** and **X'** must disallow $\partial x'$ in the above quotation to be establishing; $\partial x'$ is actually an expression of limit approaching zero but can never be a finite value of zero. Nevertheless, if zero is the value that $\partial x'$ must end up with, it cannot appear in the denominator of a fraction.

If relativity cannot dissociate itself from the two consequences mentioned above, it can hardly convince us how to follow it to visualize the superluminal movements as illusions.

Energy Source of Superluminal Movements According to documents, quasars usually appear not much bigger than the solar system, which can have a radius as large as 30 AU (Neptune's mean orbital radius). It then means that some electrical charge in the quasar disk can have an opportunity of being at a distance of 30 AU away from the neutron core. When it is swept toward the neutron core by the spinning magnetic field, it has a path of 30 AU to gain and accumulate kinetic energy during the movement toward the axial line of the ever escalating magnetic field. This field is not only a strong one by any measure, but also rapidly spins with a rate, the spinning rate of the neutron core, in the order of several hundred turns per second for many of the quasars. When this particle is finally delivered near the axial line of the magnetic field and then expelled as part of the jet stream, the huge energy it has ever so accumulated must now propel this charge particle to move with extraordinary speed.

Let's qualitatively examine some moving potentials that observations have been offering us so far. The energy ***E*** that a charge particle ***q*** can acquire from the movement of a magnetic field of strength ***B*** is

$$E=\int_a^b F\cdot dR=\int_a^b qvB\cdot dR \qquad (Eq.\ 31)$$

In (Eq. 31), dR is the distance element of the entire moving path R of the charge. $\boldsymbol{R}$ covers a distance from point $\boldsymbol{a}$ to point $\boldsymbol{b}$, where $\boldsymbol{a}$ can be as large as 30 AU suggested by observation and $\boldsymbol{b}$ can be any infinitesimally small value. Besides 30 AU being a formidable distance in the equation for a charge to be accelerated, speed v in the equation can be another astounding figure. This speed v, which is tangential to $\boldsymbol{R}$**,** is the relative speed between the moving magnetic flux and the charge particle. Let's assume the relative difference of the angular velocity between the neutron core and the material bulk of the disk to be 400 revolutions/second. At 30 AU, the linear speed v matching this angular velocity will be $1.13 \times 10^{13} km/second$, a value in front of which the speed of light is absolutely dwarfed. When $\boldsymbol{E}$ is obtained with all these extraordinary figures and converted to kinetic energy according to $E = \frac{1}{2} mV^2$, where V is the velocity for the charge particle pointing directly at the center of the quasar, can we imagine what value V can reach? It is equipped with this energy that the charge particle is found riding on the jet and leaving the quasar disk! It is with the speed enabled by this magnitude of energy that a jet stream takes good care of its collimation because particles of the same electrical charge moving in the same direction must keep their traveling path staying together; the higher the speed, the longer the parallelism will survive. This is why blazars can shows collimated jets of millions of light years long.

Of course, the understanding of (Eq. 31) actually needs to be restricted by two more considerations. (1) We cannot be certain whether the assumed figure of 30AU is the dimension covering the area including even the most outskirt of the disk or just the "ball" of the same charge hovering about the neutron core. But even if 30 AU is for the entire quasar disk while only 20 AU is for the ball of the same charge, such huge ball of the same charge is an astonishing phenomenon to be comprehended with our daily experience obtained on Earth. (2) The relative tangential speed $1.13 \times 10^{13} km/second$ between the magnetic flux and the charge particle at 30 AU should not be a value obtained as straightforwardly as we have shown. Because of the manner of propagation of electromagnetic waves, the angular speed of the flux corresponding to the revolution rate of the neutron core but at a distance 30 AU away from the core must be substantially lagging behind, and the corresponding linear speed is then substantially lower than $1.13 \times 10^{13} km/second$. However, further discussion on the nature of propagation of electromagnetic waves is not in the scope of this paper. Therefore the quantitative discussion on (Eq. 31) with precise detail is unable to be explored in this paper. However, the qualitative conjecture based on all these possibilities presented so far should have made us feel difficult not to accept the superluminal movements as a material fact; neither can any theory prevent us from accepting it as material fact.

Reference

[1] Giles Sparrow and Dava Sobel, *Cosmos, a Field Guide*, Publisher: *Quercus, UK*

[2] NASA, *https://www.nasa.gov/mission_pages/GLAST/science/blazers.html*

[3] NASA,*https://apod.nasa.gov/apod/ap981226.html,*

[4] Wikipedia, *https://en.wikipedia.org/wiki/Quasar*

[5] Albert Einstein, *On the Electrodynamics of Moving Bodies,* p 42 & p 44 in *The Principle of Relativity* by *Dover Publications, Inc. USA, 1923, BN 486-60081-5*