Apparent Super-luminal Jets as a Test of Special Relativity

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Due to the nature of their orientation with respect to the line-of-sight to Earth, jets of gas leaving energetic sources occasionally have the appearance of moving faster than light when viewed from the Earth. While the inferred velocities of such jets with respect to their source, calculated under the tenets of SRT, are less than c*, they are still very close to* c*. However, certain orientations require that, under the assumptions of SRT, the jets must have a velocity with respect to their source which exceeds* c*. Under models other than SRT, the velocities required under these same configurations remain less than* c*. Studying such jets throughout the cosmos presents a great test for Einstein's second postulate, since there may indeed be jets who's orientation to the line-of sight imply, under SRT, an inferred speed with respect to their source in excess of* c*. Even considering configurations already observed, a comparison of the energy required to produce jets at speeds approaching* c *under SRT (including relativistic mass increase) to the energy available from the source should provide a strong test of SRT.*

Super-luminal Gas from GRS 1915+105

Utilizing the Very Large Array radio telescope to study gas emitted from X-ray source GRS 1915+105, astronomers conclude that the gas jet approaching the Earth has a velocity across our line-of-sight of 1.25 c (Cohen 1994). In actuality, a trick of the orientation of the jet and the angle it forms with the Earth produces the apparent super-luminal speed. If we consider Einstein's second postulate, concerning the constancy of the speed of light, then this illusion can be explained with the aid of Figure 1-A as follows, where we assume, as did the researchers, that the angle of the jet with respect to our line-of-sight is 71 degrees, and its velocity with respect to its source is .92 c.

The gas jet begins at t_o and the first light is emitted at that time as well. The light reaches the base of the triangle after a time given by the length of the leg (.326 ly) divided by c, the velocity of light. Thus, t'_o =.326 yr, the time of apparent emission from the base of the triangle as viewed by a distant observer. The jet travels the hypotenuse (1.0 ly) at a velocity of .92 c, and arrives at the base at time $t_1 =$ 1.08 yr. Now, $t_1 - t'_o =$ .754 yr, which is the apparent time it took the jet to move from one side of the triangle's base to the other, a distance of .946 ly. Thus, the apparent velocity is .946 ly divided by .754 yr, or 1.25 c.

Now, the researchers assumed, for various reasons, that the angle of the jet to our line-of-sight is 71 degrees. But what if the angle is actually 79 degrees? How would the analysis proceed in this case?

From the same analysis as above, utilizing Figure 1-B, the velocity of the jet along the hypotenuse, its velocity with respect to its source, must be 1.02 c in order to produce the observed results. This is demonstrated as follows. The gas jet begins at t_o and the first light is emitted at that time as well. The light reaches the base of the triangle after a time given by the length of the leg (.191 ly) divided by c, the velocity of light. Thus, $t'_o =$ .191 yr, the time of apparent emission from the base of the triangle as viewed by a distant observer. The jet travels the hypotenuse (1.0 ly) at a velocity of 1.02 c, and arrives at the base at time $t_1 =$ .980 yr. Now, $t_1 - t'_o =$ .789 yr, which is the apparent time it took the jet to move from one side of the triangle's base to the other, a distance of .982 ly. Thus, the apparent velocity is .982 ly divided by .789 yr, or about 1.25 c.

If such is the actual orientation of GRS 1915+105, or if such a jet were observed, then Einstein's second postulate would be violated. There are obviously many combinations of angle and apparent velocity with respect to the observer which require a velocity of the jet with respect to its source equal to or greater than c. One additional example is a jet of gas streaming from the center of M87, with an apparent velocity of 2.5 c. The example of Figure 1-B should warrant an analysis of all apparently faster-than-light jets observed to date, in order to determine if any jets exceed the speed of c as seen from their source, and thus violate the second postulate and with it SRT.

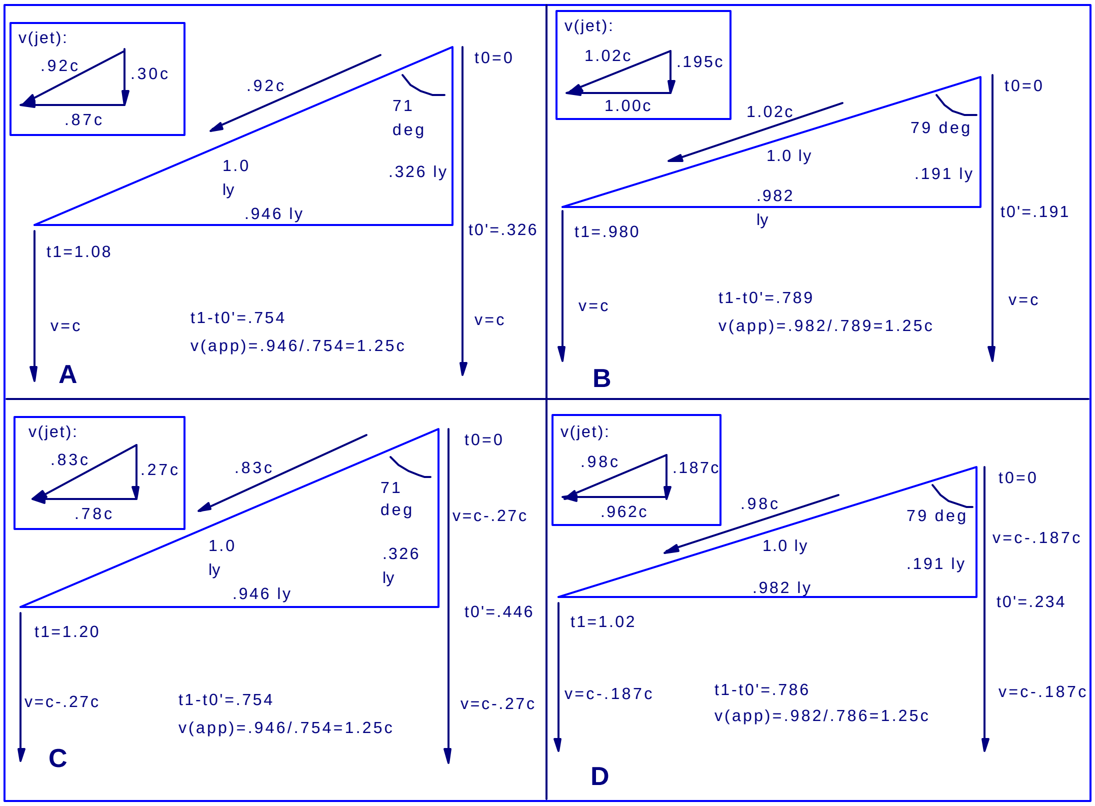

Figure 1 - Different orientations and light emission theories require different inferred jet velocities with respect to their source to produce apparently super-luminal velocities.

A Non-Relativistic Example

We can analyze these jets under any competing theories to SRT. Among these are the non-ether Galilean invariant theory proposed by Jacques Trempe (Trempe 1992), and the Galilean invariant model proposed by Martin (Martin 19xx). Another example is the radiation continuum model (RCM) of EM radiation. It has been shown in a previous paper (Renshaw 1996) thatEM radiation may be modeled as emanating from a source at all velocities from 0 to some upper value *C*, which is greater than *c*, and may be infinite. In this model, a photon may be (loosely) viewed as a piece of stretching elastic, anchored at one end while the other is being pulled forward at a velocity *C*. As a result, there can be found a component of this extended photon with any velocity one chooses between 0 and *C*. Any observer is thus susceptible to that component with a velocity of *c* relative to the observer. For example, an observer moving away from the source with a velocity of v would be susceptible to that component which leaves the source with a velocity of $c + v$, and thus has a velocity of *c* with respect to the observer. This model, the radiation continuum model, or RCM, has been shown to allow a Galilean invariance of Maxwell's equations (Renshaw 1996a), and to support all experimentally verified Doppler shift results, including those which are contrary to the equations of SRT (Tolchelnikova-Murri 1993).

Utilizing the RCM, we can analyze the case of GRS 1915+105 with the aid of Figure 1-C. If we assume that it is only the relative velocity of light passing an observer which must be equal to *c*, and the source (in this case the gas jet) has a velocity toward the observer of v, then the component velocity of light leaving the source need be only $c - v$. This velocity, added to the velocity of the source, then produces an effective velocity past the observer of *c,* as required. Without arguing the merits of this or any other emission theory, we simply analyze the results of applying this theory to GRS 1915+105. If the jet has a velocity of .83 *c* with respect to its source, this will be made up of a component toward the observer of .27 *c*, and perpendicular to the observer at .78 *c*, as illustrated. Thus the velocity of light leaving the source is $(c - .27\,c)$ or .73 *c*. This light will cover the .326 ly to the base in a time of .446 years, thus $t_o' =$ .446 yr. The gas jet will travel the length of the hypotenuse in a time equal to $(1\text{ ly}/.83\,c) = 1.2$ years $= t_1$. Thus, $t_1 - t_o' =$ .754 yr, and the apparent velocity along the base is again .946/.754 = 1.25 *c*. Thus, in RCM, the velocity required of the gas jet with respect to its source to produce an apparent velocity of 1.25 *c* is ten percent less than that required under SRT.

Next we will look at the case of a 79-degree jet, which proved problematic for SRT. This case is analyzed under RCM with the aid of Figure 1-D. We assume the jet has a velocity with respect to its source of .98 c, made up of a component moving toward the observer at .187 c, and perpendicular to the observer at .962 c, as illustrated. Thus the velocity of light leaving the source is (c – .187 c) or .813 c. This light will cover the .191 ly to the base in a time of .234 years, thus $t'_o = .234$ yr. The gas jet will travel the length of the hypotenuse in a time equal to (1 ly/.98 c) = 1.02 years $= t_1$. Thus, $t_1 - t'_o =$ .786 yr, and the apparent velocity along the base is .982/.785 = 1.25 c. Thus, in RCM, the velocity with respect to its source required of the gas jet to produce an apparent velocity of 1.25 c is less than c, while under SRT the required velocity exceeds c.

Figure 2 illustrates the relation between apparent velocity and angle of approach with respect to the line-of-sight to Earth. For any viewing angle, an observed apparent velocity above the shaded region in the figure indicates a violation of SRT.

Determining the angle of the jet is not an exact science and may prove quite difficult in many cases. One must be certain that the determination of jet angle presented by researches is derived by independent means, such as intensity or subtended angle of matter distribution, and not by assuming that the angle must be small enough to ensure that the actual jet velocity is less than c.

Energy Considerations

Returning to the observed behavior of GRS 1915+105, we can calculate the energy required to produce the gas jet seen utilizing SRT and RCM. If the mass of the gas emitted from the source is m, and its final velocity is v, then we have the following two formulas for the energy required to expel the jet under SRT and RCM respectively, where relativistic mass increase has been included in the SRT expression, but not in the RCM expression:

$$\begin{aligned} E_{SRT} &= \tfrac{1}{2} mgv^2 \\ &= \tfrac{1}{2} m(1-(.92c/c)^2)^{-1/2}(.92c)^2 \\ &= 1.08mc^2 \end{aligned} \qquad (1)$$

$$E_{RCM} = \tfrac{1}{2} mv^2 = \tfrac{1}{2} m(.83c)^2 = .345mc^2 \qquad (2)$$

$$E_{SRT} / E_{RCM} = 3.13 \qquad (3)$$

Thus we see that the energy required to produce the jet under SRT is three times greater than that required under RCM. Even if we apply mass increase in the RCM calculation, the energy required under SRT is still twenty-five percent greater than that required under RCM. These differences in energy requirements also appear when comparing SRT to the theories set forth by Martin and Trempe.

Conclusions

The unique laboratory of the vast cosmos presents many opportunities for tests of SRT (Renshaw 1996b). There are many examples of gas jets emanating at various angles with respect to our line-of-sight and exhibiting a wide range of apparent velocities. Many of these have apparent velocities several times greater than c. While it is generally assumed that an analysis of the configuration of jet angle to line-of-sight will always result in an inferred velocity of the jet with respect to its source less than c, this paper demonstrates that such is not necessarily the case. Determining the angle of the

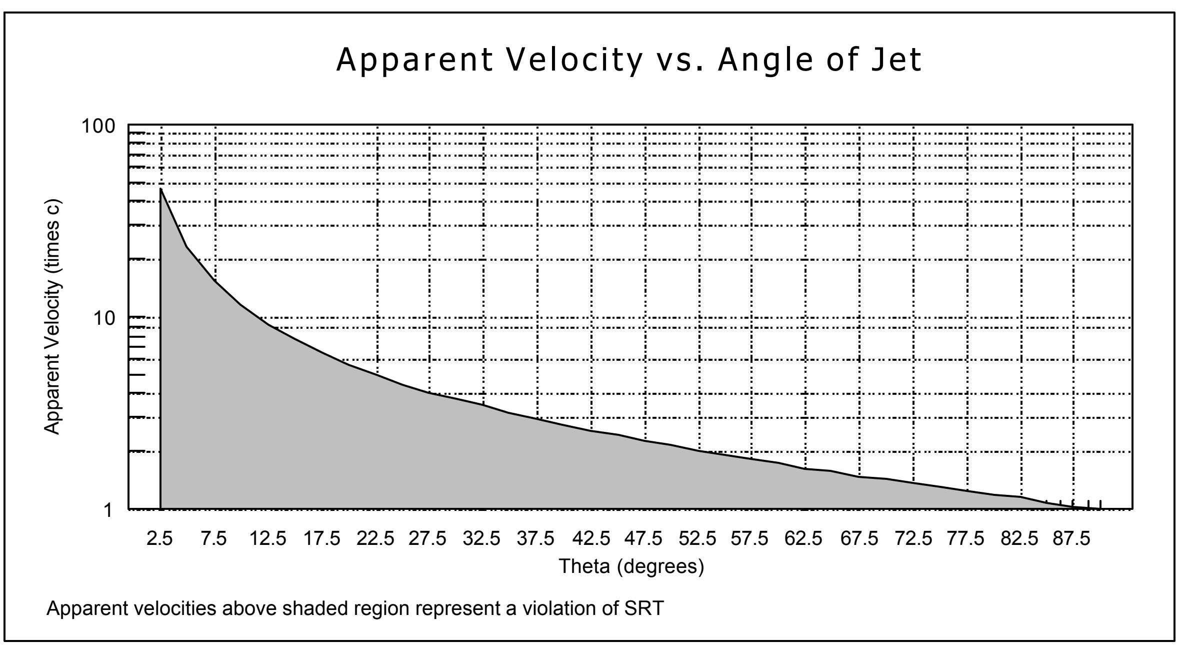

Figure 2 - Apparent velocity versus angle of jet with respect to line-of-sight

jet is in many cases problematical, and may sometimes be erroneously derived by working backwards from the assumption that the jet must have a velocity with respect to its source that is less than *c*. One must guard against the researcher's tendency to do such back-solving. The analysis presented in this paper clearly warrants a search of all such apparently super-luminal jets to determine whether, under SRT, any of them require a velocity with respect to their host greater than *c*, as in the 79 degree case presented. If any are found that meet this criteria, then clearly the second postulate, and with it, SRT, are invalidated. Possibly more difficult, but of potentially greater value, is an analysis of the energy available to produce the observed jets. In the case of GRS 1915+105, the energy required under SRT is more than three times greater than that required under any of the Galilean invariant alternatives referenced herein. A careful study of the source might indicate that there is simply not enough energy available to produce the jets observed under the assumptions of SRT. Other orientations of jet to line-of-sight produce even greater energy differentials, and thus provide even stronger tests.

References

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Renshaw, Curtis E., 1996a, The radiation continuum model of light and the Galilean invariance of Maxwell's equations, *Galilean Electrodynamics* 7(1):13.

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Tolchelnikova-Murri, Svetlana A., 1993, The Doppler observations of Venus contradict the SRT, *Galilean Electrodynamics* 4(1):3.

Trempe, J., 1992, Light Kinematics in Galilean Space-Time, *Physics Essays* 5(1):121

Corrections

Volume 2, No. 4:

Page 102 Section 1 point 5 should read:

> *"5. Another point to be taken into account... For example,* Emilio Santos *was able to explain Aspect's experiment..."*

Page 102, col. 2, lines 26-28 should read:

> *"However, this meaning does not constitute a singular property of quantum mechanics..."*

Volume 3, No. 1:

Page 6, line after equation (1.2) should read:

> *"where* $w_e = \frac{e}{2}(\mathrm{grad} f)^2$ *—the density of..."*

Page 7, equation (point 1) should read:

$$\mathbf{S}_e = [\mathbf{E}\times\mathbf{H}] = e(\mathrm{grad}\, j\,)^2\mathbf{v}$$

Page 7, equation (1.4) should read:

$$\mathbf{S}_e = [\mathbf{E}\times\mathbf{H}] = 0$$

Page 8, equation (2.9) should read:

$$I = \frac{1}{2}\int r\frac{\P f}{\P t}\mathrm{d}t = -\frac{e}{2}\int \Delta f \frac{\P f}{\P t}\mathrm{d}t$$

where $\mathrm{d}t$ *is a volume element.*

Page 8, equation 2.12 should read:

$$\oint \mathbf{S}_u \mathbf{n}^\circ \mathrm{d}s + \int \frac{\P}{\P t} w_e \mathrm{d}t = 0$$

Page 8, right column, line 17 should read:

> *"The field* $\mathbf{E} = -grad\, f$ *is not..."*

Page 8, equation after (3.2) should read:

$$\int \mathbf{E}\ \Delta\mathbf{M}\ \mathrm{d}t = \oint [\mathbf{E}\mathrm{div}\mathbf{M} + \mathbf{E}\times\mathrm{rot}\mathbf{M}]\mathbf{n}^\circ \mathrm{d}t - \int(\mathrm{div}\mathbf{E}\ \mathrm{div}\mathbf{M} + \mathrm{rot}\mathbf{E}\ \mathrm{rot}\mathbf{M})\mathrm{d}t$$

Page 8, right, 11 lines from bottom should read:

> *"Let* $\mathbf{E} = -\frac{1}{2}(\P\mathbf{A}/\P t)$ *be the field..."*

Equation (3.4) should read:

$$p_k = -\frac{1}{2}\mathbf{j}\frac{\P\mathbf{A}}{\P t} = -\frac{\P}{\P t}\left(\frac{\mathbf{jA}}{4}\right)$$

Equation (3.5) should read:

$$w_k = \frac{1}{4m}\left[(\mathrm{div}\mathbf{A})^2 + (\mathrm{rot}\mathbf{A})^2\right]$$

Page 9, equation (4.2) should read:

$$\mathrm{d}^2 w_k = \frac{m}{2}\left(\frac{I(t)\mathrm{d}\mathbf{l}}{4pr^2}\right)^2$$

Page 9, equation (A.1) should read:

$$S = \iint\left[-m^*\left(1 - \frac{\mathbf{v}^2}{2c^2}\right) + \Lambda\right]\mathrm{d}t\ \mathrm{d}t$$

Page 10, equation (A.5) should read:

$$p_k = -\mathbf{v}\frac{\P}{\P t}m_e^*\mathbf{v} = -\frac{1}{2}\mathbf{j}\frac{\P\mathbf{A}}{\P t} = -\frac{\P}{\P t}\left(\frac{\mathbf{jA}}{4}\right)$$

Throughout the article by Kuligin *et al.*, the symbol j should read f.

Page 25, equation (9) should read:

$$v_r = c_1\sqrt{1 - \frac{h^2}{c_1^2 r^2} - A\left[1 - \frac{v_{ro}^2}{c_1^2} - \frac{h^2}{c_1^2 r_o^2}\right]}$$

$$A = \exp\left[\frac{2\cdot m_1}{c_1^2}\left(\frac{1}{\sqrt{r^2 - \frac{h^2}{c_1^2}}} - \frac{1}{\sqrt{r_o^2 - \frac{h^2}{c_1^2}}}\right)\right]$$