Superluminal Motion

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The possibility of Faster-than-Light (FTL) motion has been a subject of study for several decades. Special Relativity allows for certain phenomena wherein FTL motion may be observed. For example, when a sufficiently energetic particle travels through a material medium, its velocity may exceed c/n, n being the refractive index of the medium. The particle then travels faster than the local speed of light. For a discussion on the physics of this phenomenon, see ref.[1].

Apparent FTL motion can arise as an optical illusion when, for example, a laser beam directed from the earth is swept fast enough across the surface of the moon [2]. Another example of apparent FTL motion involves observations of relativistic jets emitted by active galactic nuclei (AGN) sources [3], [4]. The apparent velocities of these jets can be measured using radio astronomy techniques, and have been known to reach as high as $6c$ [5]. The explanation of these observed velocities is (ironically) a consequence of the constancy of c, and rests on the fact that the jet velocity we observe is only the projection in the night sky of the true velocity vector. Most jets that we observe are inclined with our line of sight at angles less than $90°$. This means that radiation leaving a particle in the jet at different times, has to travel different distances, at the same speed c (see fig.1). Simple algebra shows that the apparent transverse velocity we measure (β_{app}), depends on the true jet velocity (β) and the angle between the jet and our line of sight (θ), as

$$\beta_{\mathrm{app}} = \frac{\beta \sin\theta}{1 - \beta\cos\theta} \tag{1}$$

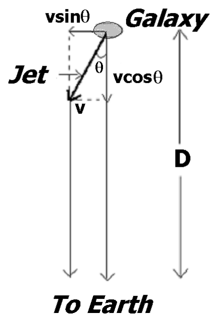

Figure 1: A galaxy at distance D from the earth, emitting a jet with velocity $\beta = v/c$.

In the case of the galaxy M87, the apparent velocity has been measured as $6c$, with an inferred value of the Lorentz factor $\gamma = \left(1-\beta^2\right)^{-1/2} \geq 6$, at an angle of $19°$ with the line of sight [5]. M87 is an extremely energetic AGN, emitting across the spectrum in radio, optical as well as X-ray bands. For pictures of the M87 jet, see ref. [6].

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