B.Sc. Part-I

Paper-I

Theory of Relativity.

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Source and receiver both in circular motion around a common center :-

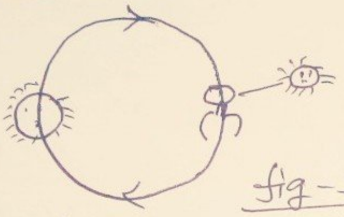

fig-5

Source and receiver are placed on opposite ends of a rotor, equidistant from the center.

Suppose source and receiver are located on opposite ends of a spinning rotor, as illustrated in fig(5). Kinematic arguments and arguments based on noting that there is no difference in potential between source and receiver in the pseudogravitational field of the rotor both lead to the conclusion that there should be no Doppler shift between source and receiver.

In 1961, Champeney and Moon conducted a Mossbauer rotor experiment testing exactly this scenario and found that the Mossbauer absorption process was unaffected by rotation. They concluded that their findings supported special relativity.

fig (6) Presents the Scenario from the frame of the receiver, with the Source Moving at Speed v at an angle θ_r measured in the frame of the receiver. The radial Component of the source's Motion along the line of sight is equal to $v\cos\theta_r$.

The equn below can be interpreted as the classical Doppler Shift for a stationary and moving source modified by the Lorentz factor γ.

$$f_r = \frac{f_s}{\gamma(1+\beta\cos\theta_r)} \quad \text{—— (6)}$$

In the Case when $\theta_r = 90^\circ$, one obtains the transverse Doppler effect $f_r = \frac{f_s}{\gamma}$

Einstein obtained a somewhat different looking equ^n for the doppler shift equ^n. After changing the variable names in Einstein's equ^n to be consistent with those used here, his equ^n reads

$$f_r = \gamma(1-\beta\cos\theta_s)\, f_s \quad \text{—— (7)}$$

The differences stem from the fact that Einstein evaluated the angle θ_s with respect to the source rest frame rather than the receiver rest frame. θ_s is not equal to θ_r because of the effect of relativistic aberration. The relativistic aberration equation is

$$\cos\theta_r = \frac{\cos\theta_s - \beta}{1-\beta\cos\theta_s} \quad \text{—— (8)}$$

Substituting the relativistic aberration equ^n (8) into equ^n (6) yeilds equ^n (7).

Rather Than being equidistant from The Center Suppose The emitter and absorber were at differing distances from The rotor's center for an emitter at radius R' and the absorber at radius R anywhere on The rotor, the ratio of The emitter frequency ν' and The absorber frequency ν is given by

$$\frac{\nu'}{\nu} = \left(\frac{1-R^2\omega^2}{1-R'^2\omega^2}\right)^{1/2} \quad (5)$$

where ω is The angular velocity of The rotor. The Source and emitter do not have to be 180° apart, but can be at any angle with respect to The Center.

Motion in an arbitrary direction

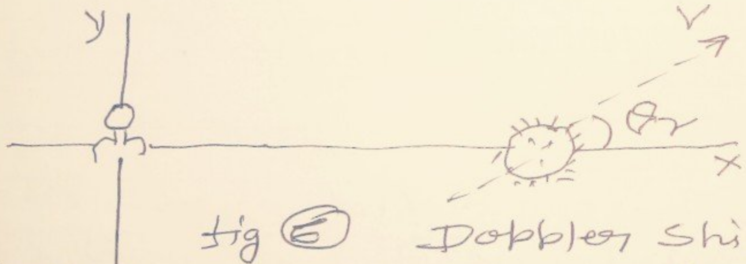

fig (6) Doppler shift with source moving at an arbitrary angle with respect to the line between source and receiver.

The analysis used in section Relativistic longitudinal Doppler effect can be extended in a straightforward fashion to calculate The Doppler shift for The case where The inertial motions of The sources and receiver are at any specified angle.

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This Conclusion generated some Controversy. A certain persistent critic of relativity maintained that although the experiment was consistent with general relativity, it refuted special relativity, his point being that since the emitter and absorber were in uniform relative motion, special relativity demanded that a Doppler shift be observed. The fallacy with this critic's argument was as demonstrated in section point of null frequency shift, that it is simply not true that a Doppler shift must always be observed between two frames in uniform relative motion. Furthermore, as demonstrated in section source and receiver are at their points of closest approach, the difficulty of analyzing a relativistic scenario often depends on the choice of reference frame. Attempting to analyze the scenario in the frame of the receiver involves much tedious algebra.

As a matter of fact however Champeney and Moon's experiment said nothing either pro or con about special relativity. Because of the symmetry of the setup, it turns out that virtually any conceivable theory of the Doppler shift between frames in uniform inertial motion must yield a null result in this experiment.

Teacher's Signature ______________

demonstrating the consistency of these alternate equns for the Doppler Shift.

Setting $\theta_r = 0$ in equn (6) or $\theta_s = 0$ in equn (7) yields equn (1), the expression for relativistic longitudinal Doppler Shift.