B.Sc. Part-I

Paper-I

Theory of Relativity

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Receiver Sees The Source as being at its closest Point :-

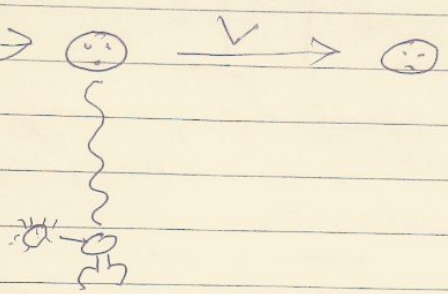

fig. (2)

Transverse Doppler shift for The Scenario where The receiver sees the Source as being at its closest Point —

This Scenario is equivalent to the receiver looking at a direct right angle to the Path of the Source. The analysis of this Scenario is best Conducted from the frame of the receiver. fig (2) shows the receiver being illuminated by light from when the Source was closest to the receiver, even though the Source has moved on. because the Source's clock is time dilated as measured in the frame of the receiver and because there is no longitudinal Component of its motion. The light from the Source, emitted from this closest Point is redshifted with frequency $f_r = \frac{f_s}{\gamma}$ — (4)

so The literature most reports of transverse Doppler shift analyze the effect in terms of the receiver Pointed at direct right angles to the Path of the Source, thus seeing the Source as being as its closest Point and observing a redshift.

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Point of null frequency shift :-

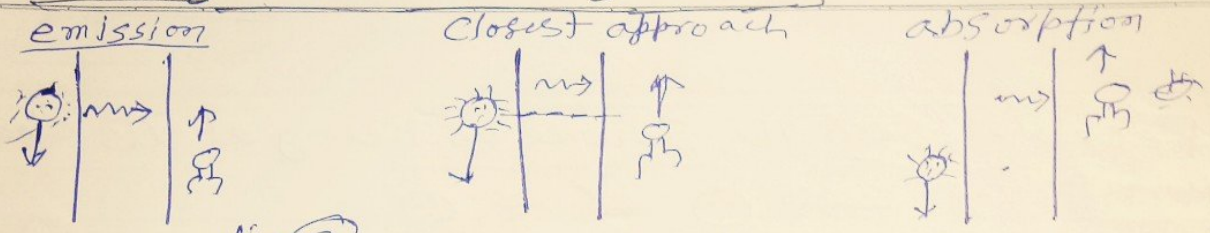

fig (3) Null frequency shift occurs for a pulse that travels the shortest distance from source to receiver.

Given that in the case where the inertially moving source and receiver are geometrically at their nearest approach to each other, the receiver observes a blueshift, whereas in the case where the receiver sees the source as being at its closest point, the receiver observes a redshift, there obviously must exist a point where blueshift changes to a redshift in fig (1), the signal travels perpendicularly to the receiver path and is blueshift. in fig (2), the signal travels perpendicularly to the source path and is redshifted.

As seen in fig (3) null frequency shift occurs for a pulse that travels the shortest distance from source to receiver. When viewed in the frame where source and receiver have the same speed, this pulse is emitted perpendicularly to the source's path and is received perpendicularly to the receiver path. The pulse is emitted slightly before the point of closest approach, and it is received slightly after.

One object in circular motion around the other

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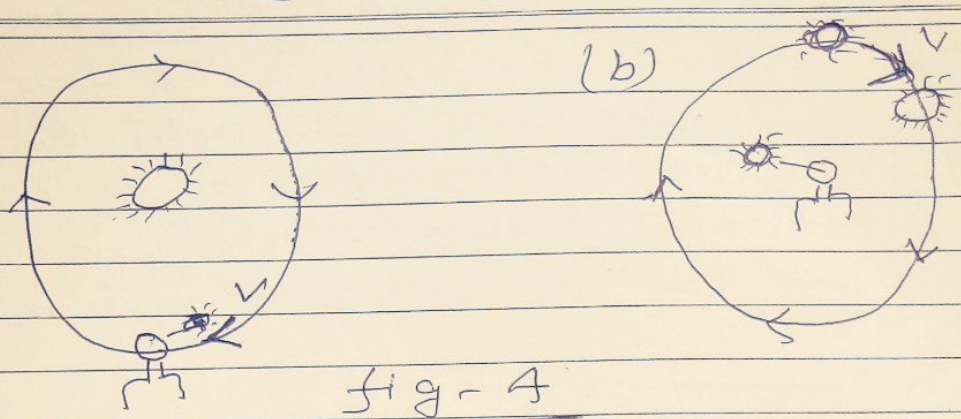

fig - 4

Transverse Doppler effect for two scenarios (a) receiver moving in a circle around the source (b) source moving in a circle around the receiver.

Fig 4 illustrates two variants of this scenario. Both variants can be analyzed using simple time dilation arguments. fig. 4(a) is essentially equivalent to the scenario described in ~~fig (1)~~ fig 1(b) and the receiver observes light from the source as being blueshifted by a factor of in fig 4(b) is essentially equivalent to the scenario described in fig (2) and the light is redshifted.

The only seeming complication is that the orbiting objects are in accelerated motion. An accelerated particle does not have an inertial frame in which it is always at rest. However, an inertial frame can always be found which is momentarily comoving with the particle. This frame, the momentarily comoving reference frame (MCRF), enables application of special relativity to the analysis of accelerated particles.

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of an inertial observer looks at an accelerating clock, only the clock's instantaneous speed is important when computing time dilation.

The converse, however is not true. The analysis of scenarios where ~~both~~ both objects are in accelerated motion requires a somewhat more sophisticated analysis. Not understanding this point has led to confusion and misunderstanding.