B.Sc Part-(I)

ABERRATION

When an observer is in relative motion with respect to the source of a wave, in some arbitrary direction, the angle of incidence of the wave is different as seen by two observers in relative motion. Aberration refers to this difference in the angle between angle of incidence of the wave as seen in the two reference frames.

A spacecraft in motion along the x direction with speed V as seen from earth. The angle at which the observer in the spacecraft sees a distant star is different from the angle between the star and the spacecraft as seen from earth.

The case of stellar aberration is shown in the fig. from the two reference frames. A spacecraft moves along the common x direction with velocity V as seen in the earth reference frame. A star frame this angle is θ'. If the wave four-vector as seen the earth reference frame is

$$(K) = K\underline{t} - K\cos\theta x - K\sin\theta y \quad \text{——(1)}$$

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Then the components in the spacecraft reference frame are, by Lorentz transformation.

$$K' = \gamma K + \gamma \beta K \cos\theta$$

$$-K' \cos\theta' = -\gamma \beta K - \gamma K \cos\theta$$

$$-K' \sin\theta' = -K \sin\theta \quad \text{——} \ (2)$$

Therefore,

$$\sin\theta' = \frac{K}{K'} \sin\theta$$

$$\boxed{\sin\theta' = \frac{\sin\theta}{\gamma(1 + \beta\cos\theta)}} \quad \text{——} \ (3)$$

As seen from eqn (3), the angle as seen by the spacecraft is smaller than the angle noticed from earth $-\theta' \leq \theta$ if the observer is moving towards the source. Similarly $\theta' \geq \theta$ if the observer is moving away from the source.