Alternative method of generation of Cerenkov 
radiation or shock wave

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Abstract

An alternative method of generation of Cerenkov radiation is pro-
posed over here with the help of a rotating source and a reflector. The
principle is that, if we focus a narrow beam of light on to source of
light is rotated with certain angular velocity then the light spot on the
surface will move with very high velocity which may exceed the velocity
of light. As a consequence of this we shall observe an effect very similar
to Cerenkov radiation.

Introduction

It is an well established fact that a beam of light from a rotating source may
sweep out a distant path faster than the speed of light [1, 2]. This can also be
established in the following way. A narrow beam of light of monochromatic
wavelength $\lambda$ from a source O rotates in the anticlockwise direction with an
angular velocity $\omega$ and describes an angle $\Delta \theta$ in time $\Delta t$ (Fig. 1). The radius
r of the circle is large (or $\Delta \theta$ be very small) to consider the path of the light
spot BC straight line (Fig. 2)

$$BC = l = r \Delta \theta$$

$$\Delta \theta = 1/r$$
\[ \omega = \Delta \theta / \Delta t \]

The time taken by the light ray to travel from O to B (Fig. 3) i.e. the distance r is t. In time \( \Delta t \) the light at O is rotated by an angle \( \Delta \theta \) and is in the direction OC. Since, light takes a time t to travel a distance r, so it will reach the point C after a time \( (t + \Delta t) \). so, \( \Delta t \) is the time taken by the light spot to travel a distance \( BC = l \). Therefore the velocity of the light spot is \( \nu = 1/\Delta t \)

or, \( \nu = r \Delta \theta / \Delta t \) (Since, \( l = r \Delta \theta \))

or, \( \nu = r \omega \)

So, the velocity of the light spot = angular velocity of the source \( \times \) radius of the circle on which the light spot moves.

We can make the velocity of the light spot \( \nu \) greater than the velocity of light, either by increasing \( \omega \) or by increasing \( r \) or both. As an example (Fig. 4) if a beam of laser is rotated at the surface of moon with one rotation per second (i.e. \( T = 1 \) sec, and \( \omega = 2\pi / T = 2\pi / 1 \)), then the velocity of the light spot which touches the earth will move with a velocity

\[ \nu = r \omega = r \cdot 2\pi / T \]

\[ \nu = 21.6 \times 10^{10} \text{cm/sec.} \]

(taking, \( r = 3.37 \times 10^{10} \) cm, the distance between moon and earth and \( T = 1 \) sec.)

Which is about seven times greater than the velocity of light.

The possibility that a light-spot can move faster than light is discussed in references 1 and 2. So, when a spot of light moves faster than the light itself then we can expect an effect very similar to Cerenkov radiation [3].
Thought Experiment

Light from the rotating source O after reflection from the points like B will generate reflected or secondary waves (Fig. 2 and Fig. 5). Since the velocity of this reflected wave is equal to the velocity of light c, which is less than of the velocity of the light-spot, so Cerenkov radiation will be generated. This is explained in the following paragraph.

Suppose at a given moment light from the rotating source O (Fig. 3) falls at $B_1$ and a reflected or secondary wave is generated at the point $B_1$. Then in the next moment as the light spot (whose velocity $\nu$ is greater than the velocity of light $c$) moves to $B_2$, the reflected wave from $B_1$ (whose velocity is the velocity of light $c$) expands by a radius $r_1$, smaller than the distance the light-spot moves, then another wave starts from $B_2$. When the light spot moved still further to $B_3$ and a wave is starting there, the wave from $B_2$ has now expanded to $r_2$ and the one from $B_1$ has expanded to $r_3$. So, we have a series of wave circles with a common tangent line which goes through the light spot. The angle $\theta$ (angle between the common tangent and the line $B_1B_3$) can be calculated easily. In a given amount of time the light-spot moves a distance $(B_3 - B_1)$, which is proportional to $\nu$, the velocity of the light spot. In the mean time the wavefront has moved a distance $r_3$, proportional to the velocity of light $c$, therefore, $\sin \theta = c/\nu$.

Conclusion

The effect is very similar to the Cerenkov radiation effect where an object moving through a medium faster than speed at which the medium carrier waves will generate waves. When a fast moving charged particle passes through a
block of glass (say), and if the speed of moving particle is greater than the
speed of light in the medium then it will produce conical waves with its apex
at the source. Here, since the light-spot can move faster than the speed of light,
so it also give rise to the same effect as Cerenkov radiation. The difference is
that the Cerenkov radiation emitted by the fast moving light-spot can be seen
even in vacuum. If the source O is replaced by a source of sound, then sock
waves will be generated. The source O may be replaced by a beam of electron,
proton etc. then also we will observe the similar type of effect as discussed
above.

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References

[1] Milton A. Rothman, “Things that go faster than light”, Scientific Ameri-
ican, 203, 142 (July 1960).

[2] Robert Resnic, Introduction to special relativity, Wiley Easten Ltd., New
Age international Limited, 1994, p.82.

[3] P. A. Cerenkov, Compt. Rend. Acad. Sci. U.S.S.R. 8, 451 (1934).
Figure 1.
Figure 2.

Figure 2:
Figure 3.

Figure 3:
Figure 4:

Earth

Moon

Laser

Path of light spot

Figure 4
Figure 5: