

Physics Fun

Bending a light beam

LIGHT TRAVELS at an incredible speed: 186,000 miles per second. At this speed you could travel around the world seven times in less than a second. However, light only travels at this speed in empty space (vacuum). When it travels in a transparent medium, it is slower. How much slower depends on the material: in air, for instance, it still travels at 99.97% of its vacuum speed, but in glass only at 66% of its vacuum speed. Because of this difference, light rays bend when they pass from air into glass. This is shown in Fig. 1.

An easy way to understand what is going on is to imagine that light rays behave more or less as a column of marching soldiers. This is shown in Fig. 2, in which each soldier is shown as a black dot. The soldiers march in rows, with nine soldiers per row, and in each row the soldiers hold hands. Just as light slows down when it passes from air to glass, we will imagine that the soldiers are first marching on a road (where they can march faster), but then go into a field (where they must march slower).

Whenever a row of marching soldiers starts to cross the line that separates the field from the road, the soldier on the left will be slowed down first. So, he will get a little bit behind the rest of his row. A while later, the soldier to his right will have to enter the field, and he also will fall behind a bit. And so on. Eventually, even the soldier on the right will start to slow down. As Fig. 2 shows, the result of all this is that the rows will now be marching

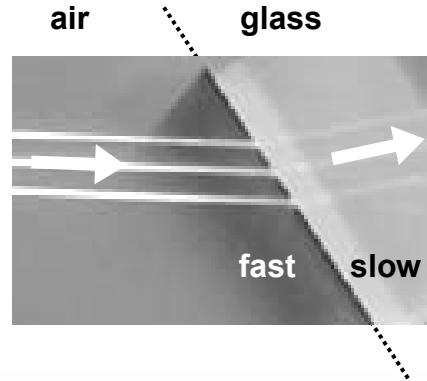


Fig. 1 Light rays traveling from air into a piece of glass.

in a different direction than they did initially. In other words, the column gets bent.

Light rays behave the same as these soldiers do. The physical law that describes the phenomenon, called refraction, is named Snell's Law, after Willebrord Snell, the Dutch astronomer and mathematician who discovered it in 1621. The law explains the operation of important optical elements such as lenses, glasses, and prisms.

- Kees Uitermaal

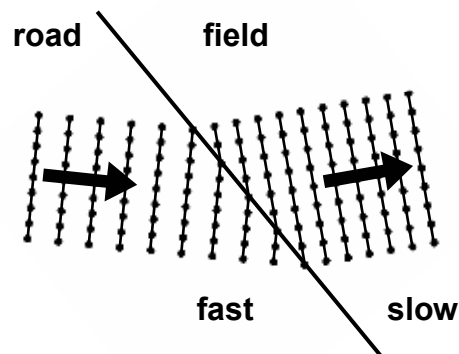


Fig. 2 Soldiers marching from a road into a field.