Invisible Glass

More Details

Is transparent not exactly transparent?

For light, there is indeed a decisive difference: optical density. Any transparent material slows down light, although the difference between the speed of light in a vacuum and in air is tiny. However, glass, water and other materials from the group of dielectric media interact strongly with light. Every time light and a medium meet, the light is slowed down in its course. The refractive index of the material determines how strongly it is slowed down. The container in the experiment contains a rather viscous silicone oil. This has exactly the same refractive index as the glass that makes up the lens and some of the glass rods. One rod is the exception. It consists of flint glass, which has a very high optical density due to its high lead oxide content. It is the only one that remains visible in the oil, as light is still refracted on it.

Braking at the corner

But why does a change in speed lead to a bend in the ray? Although light is actually an electromagnetic wave, we see a ray-shaped propagation of light. This simplification makes sense because the range of wavelengths that we perceive as colours is between 0.0004 and 0.0008 millimetres. Much too small to notice any wobbling.

At the transition from air to glass, i.e. generally from an optically thinner to an optically denser medium, the light is slowed down. A ray arriving at an angle changes its direction because it is slowed down unevenly. While one side of the beam is already immersed in the glass, the other is still in the more permeable air for a tiny period of time and can thus overtake the neighbouring side. The result is a bend in the ray. Lenses are designed in their shape and optical density so that they refract the light in the desired shape.

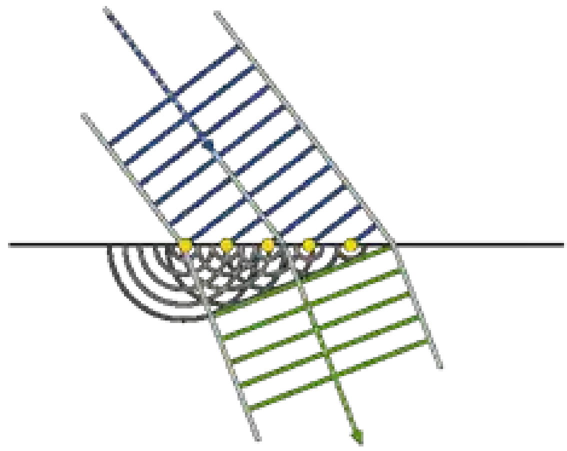

Fig. 1: A ray of light bends when it passes from one medium into another – it is refracted.

Snell's law

Without knowing the exact physical background, the Dutch scholar Willebrord Snel van Royen, also called Snellius, noticed the law of refraction at the beginning of the 17th century. Born in Leiden in 1580, he went abroad soon after his studies of law. His interest in mathematics and astronomy led him all over Europe, and he finally took his father's place as professor of mathematics in Leiden in 1613. Snell's law of refraction is a very useful mathematical description of the motion of light. It was used to calculate in advance how to build a properly functioning telescope.

The successors of Snellius established ever finer theories of the propagation of light and in 1864, the Scot James Clerk Maxwell was able to describe the behaviour of waves at interfaces very precisely.

Snellius' findings and the ray model of light can be physically substantiated with Maxwell's equations.