

Hold a Moonbeam in Your Hand
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Every fan of *the Sound of Music* knows the Maria lyrics by the nuns: how do you hold a moonbeam in your hand. Yes, almost everyone takes for granted that light is unstoppable. And according to Maxwell and Einstein, this is correct: traveling at 670 million mph in vacuum, light sets the unbreakable speed record for all moving objects. Even in a medium is light a fast runner. Water, for example, only slows light down by 25%.

Index of refraction is what physicists use to show how many times slower light travels inside a transparent material. For natural materials, index refraction can be as high as 5, yet light still orbits the earth 1.5 times a second at such speed. However, there is never anything impossible for physicists. In 1999, a team at Harvard slowed a laser beam down to 17 m/s [1], slower than the speed limit on highways! Two years later, the same group froze light completely for one thousandth of a second [2], before releasing it again as the fastest runner. Physicists really held a moonbeam in their hands!

The magic control of light was made possible inside a cloud of sodium atoms, which were cold enough to form a Bose-Einstein condensate, a state of matter where the collection of all atoms behave as a single object below a certain temperature. Besides the target laser, there was a much stronger laser shining into the atomic cloud. This beam, known as the control light, acted like a switch. Once it was turned on, the atoms, playing the role of a transparent medium, exhibited an index of refraction millions of times larger than usual, so that the target beam was slowed down considerably. Since the rear part of the beam entered the atomic cloud slightly later, it was almost able to catch up with the head. Because the rear was also slowed down, it could never overtake the head, but the length of the beam was drastically shortened so that the beam could fit into the medium. When this happened, if the control light was turned off, the target light would be locked inside the atomic cloud. When the control light went back on again, the target light slowly moved out of the medium, recovered its length, and continued to travel at 670 million mph. The theory behind this control of light, known as electromagnetically induced transparency, is very quantum mechanical. The basic idea can be more or less described as a competition, or technically speaking, interference, between the two laser transitions.

Although it sounds distant from daily life, this phenomenon has great potential applications. Nowadays information is carried by light over long distances in fibers, but it has to be translated into electronic signals for processing, mainly due to the difficulty in storing of light. If light stopping technique is commercialized, information can be processed in a much more efficient way. Just image a world where movies can be downloaded instantaneously! Of course, for physicists, there is still a long way to go. But let's be prepared for a big surprise one day, possibly in the very near future.

References: [1] Hau *et al.*, Nature **397**, 594 (1999). [2] Hau *et al.*, Nature **409**, 491 (2001).