

## **Invisibility tends to reality**

by Manjil Saikia - Sunday, December 18, 2011

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*Can invisibility be reality?* A query which has been in the back of curious minds of the scientific giants and even the common masses throughout many generations, has finally found a positive answer and the credit for it unquestionably goes to science and particularly to physics.

For decades, science fiction writers have authored stories where characters employ faster than light propulsion systems, time travel and other devices of which we can only dream about. Amongst them invisibility cloaks have been one of the most fascinating entities. Invisibility is a long term dream that may date back to the very beginning of human civilization. The concept of being unseen and hence undetectable has appeared numerous in myths, legends and folklore as well.

It needs special mention that what mankind has been trying to achieve in all these years, has already been implanted in the gown of Mother Nature. She has been gifted with most of the ingredients atleast partially which science has been struggling to accomplish and invisibility is no exception to it.

In order to proceed with our discussion of the range of schemes to obtain the desired invisibility effect, we first clarify what the word "Invisibility" really implies. Literally invisibility represents the state of an object staying in plain view of an observer without being seen. Invisibility can be grouped into various categories. One of them is referred to as Camouflage where an otherwise visible object can stay indiscernible from the surrounding environment due to similarities in colors and patterns. Another method of being undetectable is to prevent information about the object from reaching the detectors (like radars). The stealth technology which is usually accomplished by using absorptive surfaces along with special shapes and materials, all intended to reduce the cross-section of the object against particular sources. The ultimate version of invisibility is to make an object reflect no light and absorb no energy i.e. the object is given same properties as those of vacuum. This last method of invisibility is the eventual goal of cloaking devices.

To be completely effective, an invisibility cloak should operate at all wavelengths of electromagnetic radiation. Light should not be absorbed by the cloak because that would betray the cloaked object as a patch of blackness. A true cloak should bend light around the object cloaked. These conditions are impossible in conventional materials due to various complex scientific parameters. So after years of struggle, scientists have finally found a solution and named it as "metamaterials", (meta-man made). It is not a conventional material found in nature; rather it's a creation of science. As we know that matter is made from atoms or molecules, in case of metamaterials the atoms are artificial known as 'meta-atoms'. These meta- atoms are made from some special composition of two or more conventional materials depending upon their properties.

Out of the various types of Metamaterials we are here mainly concerned about Negative Refractive Index Metamaterials (NIM) or Double Negative Metaterials (DNG). One of the most important aspects of metamaterials is to achieve negative refraction. Refraction is defined as the change in the direction of

light when it travels from one medium to another. To have negative refractive index is the main criteria for metamaterials used in cloaking devices. In general, all materials found in nature have positive refractive index, measure of the ratio of the speed of light in vacuum to medium.

In a classic illustration of how refraction works, the submerged part of a pole inserted into water will appear as if it is bent upwards towards the water's surface. If water exhibited negative refraction, the submerged portion of the pole would instead appear to jut out from the water's surface. Or to give another example, a fish swimming underwater would instead appear to be moving in the air above the water's surface.

The concept of negative refraction was discussed as far back as 1904 by Schuster in his book *An Introduction to the Theory of Optics*. And the revolutionary theoretical work on metamaterials was first done by Victor Veselago in 1968 which was proved experimentally after thirty years in 1998 and work is progressing rapidly in this area which is still virgin.

In case of metamaterials the atoms are arranged in such a way that light does not go through the material creating its absorbance and rather it bends round the object due to negative refraction, which creates no loss of light and hence we cannot determine whether an object was placed in its path. This is the concept of cloaking devices. One of the important conditions for making cloaking devices is that the meta-atoms must be smaller than the wavelength of light used.

Recently, enormous progress has been made and invisibility has been possible to a great extent and its is expected that within the next ten years or so complete invisibility in all the wavelengths of electromagnetic spectrum would be possible, which would be one of the most important inventions in the history of science and mankind.

***[This article is contributed by our Consulting Editor, Madhurrya P. Talukdar. Madhurrya's research interests include meramaterials and astrophysics. He has published one research paper in this field and has communicated one more.]***

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