

Invisibility Cloak: Science Fiction Transforming into Reality

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ABSTRACT

The famous science fiction writer H.G. Wells when wrote the book “The Invisible Man”, nobody would have thought that the idea of an innovative man can be transformed from fiction to reality one day. Researchers at various institutes all over the world have already taken a step further in order to make that dream reality when the human is able to disappear i.e. not visible to human eyes even when he is already there. This paper reviews about the latest trending technology in this field known as optical camouflage. This phenomenon can create an illusion to the human eye that the person next to him is partially invisible. However we are trying to advance this technology to make the object fully disappear. The material that would help us do that is known as meta-material. It is not found or discovered but it is designed using the modern science and engineering by making specific pattern.

Keywords

Optical Communication, Phase Array optics and invisibility

1. INTRODUCTION

From the beginning of universe and mankind humans are surrounded by energy in one form or the other from the heat energy to the mechanical or electrical energy. Of all the energies that human are aware of the light energy is known to be the most fascinating and complex. Even world’s greatest mind of all time Albert Einstein spends his entire life understanding the concept of light. The light is the only thing that is responsible each and every thing in this universe to become visible to our eyes. The visibility of a particular object is because of the reflection of the light rays from that object. So what would it be like if we are able to deceive the light rays and make the object invisible? Well, though the thought is fantasizing it’s not new. The famous science fiction writer H.G. Wells had a thought on it in back 1897 in his novel ‘The Invisible Man’. Today the modern science is only trying to make it practical and reliable.

2. INVISIBILITY

Invisibility is the state of any human or object that is present in the real world still not visible to the eyes. From the past recent years scientist have completely disagreed with the possibility of invisibility since it would break the laws of

physics. But today the modern science have found some ways that would though not make the object completely invisible to eyes but put us a step closer in that long run. The latest trending and developing phenomenon that can create an illusion of objects not completely visible is known as Optical Camouflage.

3. OPTICAL COMOUFLAGE

Optical camouflage is a hypothetical phenomenon in which the user or the invisible object wears the fabric on which the image of the scene behind the wearer is projected which leads to developing an illusion that the object is not visible.[1] This happens as follows:

1. There is a camera installed at the back of the user that captures the scene behind that person and transmits the signal direct to the computer in real time.
2. The computer then processes the image received and send it to the projector for projecting the images on to the cloak.
3. Before projecting the image on to the cloak the light beam would pass through a block of mirrors known as combiner which when looked through another camera appears as invisible.

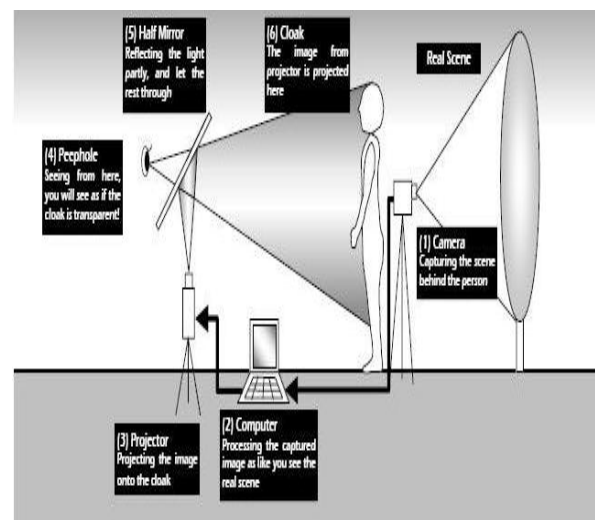


Fig1. The working diagram of the phenomenon of Optical Camouflage

On the basis of this technology Mercedes in a short time is going to launch the world's first invisible car. There is a camera on the passenger side of the car which captures the images of the rear side of the car and simply projects the picture on the front side of the car which constitutes of tons of LED's which gives an illusion that the car is not there, almost partially![3]

So until now science has succeeded to make a human partially invisible but will it satisfy the whole mankind? Well, probably not, that mean what the use of being invisible if

Anuone is fifty percent visible. This concept is effective even practical but isn't the ultimate.

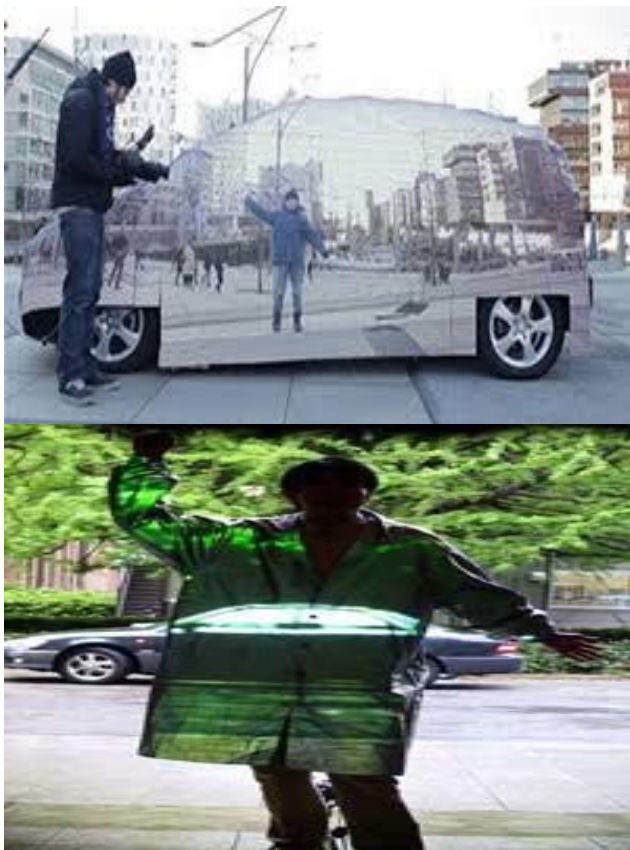


Fig 2. Applications of optical camouflage (a) Mercedes launches the first invisible car (b) Invisibility cloak

However, one man in London had already taken an initiative to make individual atom invisible. Prof Chris Phillips has invented a laser that when shoots on specially arranged atoms make them invisible for a one millionth of a second. The basic idea is developed on the properties of an atom in the quantum level. Each time when a light beam is projected on the atom, it absorbs light the electrons in the outer shell jumps to the higher energy level and when they comes back to their original energy state they emit light of their own. This set of lasers is preventing them from absorbing the light. As a result the atoms are still there but are not visible to the eyes. Though this idea is incredible but there might be some problems which must be solved before making it practical. [4]

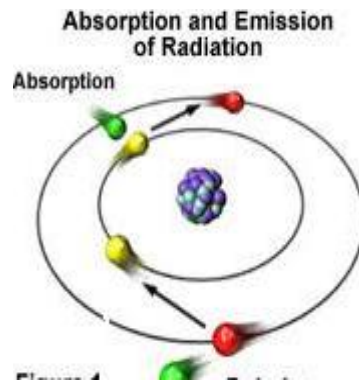


Fig3. Atomic structure of state excitation

First of all the laser that the experiment constitutes of is of single frequency. It can make all the atoms invisible for a fraction of seconds because they are all identical. On the contrary if the atoms are different it would take an infinite number of lasers to make them all disappear. Moreover if that kind of light can make someone invisible it will surely make him blind also. The light will ground the electrons of the atoms orbiting the eyeballs and light will go straight through the retina. Well it is not at all a great situation.[7]

As light reflect through them and reach at eye retina and project the image. So it can make something invisible if the light doesn't reflect through any object. Though it can't make the light to pass through the object but it can make the light bend around that object and pass through. Before anyone thinks that to be impossible, let us introduce the concept of meta-materials.

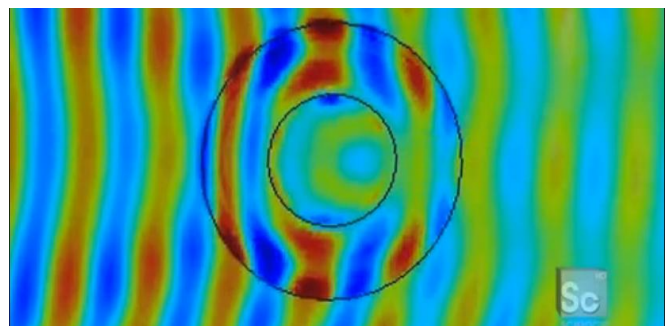
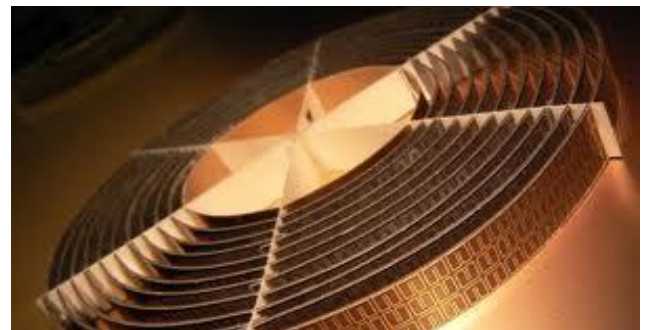


Fig 4. Structure and working of meta-material

Meta materials are the materials that contain complex copper patterns at a distance of about $1\mu\text{m}$. They are unique not because of their composition but because of their specific patterns.

The basic property of the meta-material is that it bends the microwaves. However, for waves (energy) to propagate, a μ must be paired with a ϵ in order to satisfy the wave number dependence on the material parameters

$$k = \omega \sqrt{\mu \epsilon}$$

Where μ is permeability and ϵ is the permittivity of the material.

This is because the refractive index of the medium has distinct values for the left and right, given by

$$n = \sqrt{\mu_r \epsilon_r} + k \quad \text{OR}$$

$$n = \sqrt{\mu_r \epsilon_r} - k$$

The circle in the figure is the copper coil so anything inside that circle will not be visible when seen through microwave light. If it bends the microwave it should also bend the visible light as they are both the type of same electromagnetic radiation if one problem can be solved. Microwaves have a larger wavelength about 3 inches long. So the circles around the meta-material are to be some inches long. But on the other hand the visible light has got wavelength of about 400-700 nm. [10]

As a result the circumference is to be minimized a million times. But the problem doesn't end here. If the scientists are able to scale down the size of the meta-material to nanometers it will act as an opaque material. Light could not pass through it so it would not be a cloak anymore. Though it will be very difficult for us to make the meta-material disappear in visible light, still it is an incredible idea that will surely lay the foundation that would prove the law of optics wrong.

The concept of meta-materials will surely have a great influence in the discovery of invisibility cloak. Each type of meta-material is able to bend light of specific wavelength. As each color is formed by the combination of colors of three different frequencies i.e. red, color, blue so it require a suit made of three layers of meta-materials that will produce negative refraction to these three colors. However, there is only one tiny problem left. [13] The light will bend around us so it doesn't have anything to do on our retina and again we are blind. But this time we have a solution. Scientists at the Groove School of Engineering have found something known as beam splitter.

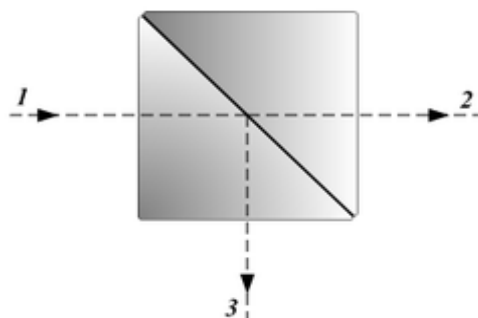


Fig5. Working and diagram of beam splitter

A beam splitter is an optical device which is usually a combination of two triangular prisms that splits the light beam into two parts. In the above diagram, 1 represents the incident light, 2 represents the 50% transmitted light and 3 represents the 50% reflected light which is perpendicular to the transmitted light. So in our basic design of an invisibility cloak, if we use these beam splitters as a lens, the half amount of light going perpendicular to the bending light and imaging on our retina. Though this is half of the visible light that usually experience still it can see other objects as well as remain invisible.[14]

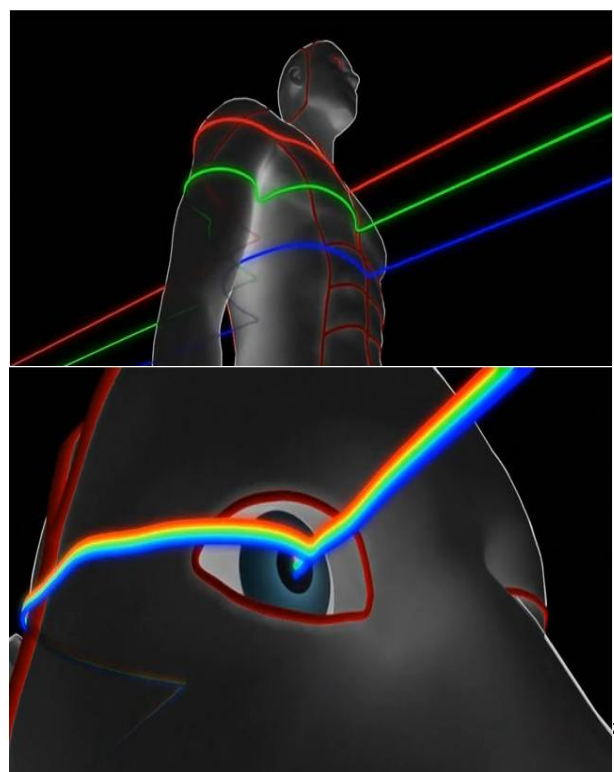
4. APPLICATIONS

This technology is basically used for invisibility purposes.

1. Such technology is useful in defense for hiding from the enemies.
2. The stealth planes have sort of this application and that they absorb all the radar waves coming to it and as a result of which the radar stations cannot detect it. So it can attack any time because it is hidden
3. Also used for other vehicles like car, you will put the car into the garage easily.

5. CONCLUSION

So the concept of invisibility is not at all pure fiction any more. It is going to be possible in less than few years. So here is the idea. One can have a suit made of three layers of meta-materials that will bend the light of three different wavelengths producing three different types of colors i.e. red, green and blue.



To prevent human from getting blind one can use beam splitter lens above the eye retina that will split the light beam and half the amount of light projecting on retina. As a result it can have an invisible that can see the surrounding environment without being visible.

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