Macro Optical Clocking Product Design By Ray Optics

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Abstract

Introduction: One of the focus area for optical metamaterials research is stealth technology such as cloaking. Developments in experimental optical cloaking is based on transformation optics, metamaterials and patterned dielectrics with the use of quasi-conformal mapping [1-4]. Experimental demonstration of broadband, phase and amplitude cloaking at visible spectrum is a challenge due to limitations in nanoscale fabrications. In this paper, ray optics based marco cloaking concepts are investigated for practical industrial applications. Optical principles such as, Reflection, Refraction, focus, Total Internal Reflection are leveraged using optical components such as mirrors, concave and convex lens, Fresnel lens, for creating cloaking region, which makes the object hidden. COMSOL® based numerical parametric models are developed for cloaking product design for industrial applications.

Ray Optical Cloaking Simulations: Electromagnetic wave propagation can be simulated using wave or ray optic formulations. In this paper, we design optical products with feature size much greater than the wavelength of optical spectrum and hence Ray optics module is considered for numerical investigation. The Geometrical Optics interface under Ray Optics is used to compute the trajectories of electromagnetic rays for performance evaluation macro optical cloaks.

Reflection, Refraction, Focus and Total internal reflection based macro optical cloaking concepts are simulated. Simple optical components such as mirror, lens, prisms, sheets, slabs are used to construct the cloaking products. Common materials such as air, water, plastics (polycarbonate), glass with refractive index from 1 to 1.6 are considered. Parametric model of 4 type cloaking concepts are developed . The effect of size, distance, focal length, material combination are investigated for maximising the cloaking region and minimising the size of the device.

The Ray optical simulation results are shown in Figure 1 to 4. Figure 1 shows, the ray optical trajectories for reflection based cloak using simple mirrors. The ray trajectories from background object to the observer around the clock is shown. Figure 2, shows the macro clocking by refraction. The lens based clocking results are shown in figure 3. The black region between the rays are cloaked, in all the figure. The parametric numerical models helps to optimise the design parameters for perfect cloaking. Figure 4 shows a practical device fabricated based on the simulations results of Figure 1. Left side of Figure 4 is the background image and right side the the background image through the cloak. Figure 4, shows the background through the cloak. These Numerical models will be used

for Innovative industrial cloaking devices.

Conclusions: Numerical simulation of reflection, refraction and focus based macro optical cloak was given. The ray optical simulations demonstrated the feasibility of macro optical cloaking. Based on the simulation results, a practical cloaking device was also fabricated using simple mirrors. The simulation models will be used for developing innovative industrial scale cloaking devices.

Reference

1. John C. Howell,1,* J. Benjamin Howell,2 and Joseph S. Choi3 ,”Amplitude-only, passive, broadband, optical spatial cloaking of very large objects”, Issue :20 March 2014 / Vol. 53, No. 9 / APPLIED OPTICS
2. H. Ichikawa,Invisibility cloaking based on geometrical optics for visible light ,Received March 14, 2013; revised ms. received May 15, 2013; published June 08, 2013, www.jeos.org.
3. Hongsheng Chen, Bin Zheng and Lian Shen,”Ray-optics cloaking devices for large objects in incoherent natural light”. DOI: 10.1038/ncomms3652 on Nature Communications.
4. Bin Zheng,”A Simple Unidirectional Optical Invisibility Cloak Made of Water”, Progress In Electromagnetics Research, Vol. 146, 15, 2014.

Figures used in the abstract

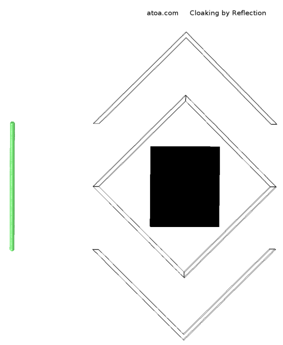

Figure 1: Ray Trajectories of Reflection based Cloak.

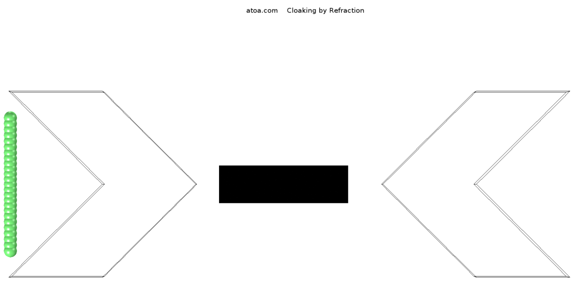

Figure 2: Ray Trajectories Refraction based Cloak .

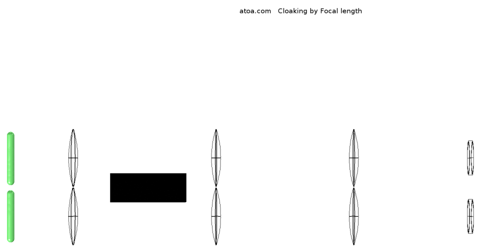

Figure 3: Ray Trajectories of Cloaking by Focal Length.

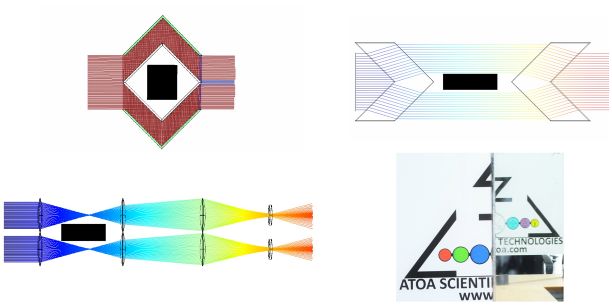

Figure 4: Combined Simulation results with Experiments