Extraordinary Optical Transmission as an Electromagnetic Phenomenon

Keith D. Foote
Ann Arbor, MI

This thesis describes the phenomenon of Extraordinary Optical Transmission using an electromagnetic field paradigm.

The Discovery of Extraordinary Optical Transmission

In 1998, while working at NEC Research Institute, T. W. Ebbesen, Peter Wolff, H. F. Ghaemi, Tineke Thio, D. E. Grupp, and H. J. Lezec, discovered a major new optical phenomenon. They found that, contrary to the then accepted theory, it was possible to transmit light extremely efficiently through subwavelength holes milled in opaque metal films under certain conditions. 100 million identical holes were made in the foil, each hole 300 nanometers wide, or 200 times smaller than the diameter of a human hair. According to basic optical theory, only 0.01 % of the visible light should have passed through, yet their experiments showed 100%, or more. Ebbesen & team began their research because of a peculiar phenomenon. A gold foil, made 14 years prior for another experiment, was discovered to be transmitting visible light through holes theoretically too small to allow its passage. The phenomenon, known as extraordinary optical transmission, involves surface plasmons. It has raised fundamental questions and is finding applications in broad variety of areas from chemistry to opto-electronics. (T. W. Ebbesen has received several awards for the discovery of the extraordinary optical transmission such as the 2005 France Telecom Prize of the French Academy of Sciences and the 2009 Quantum Electronics and Optics Prize of the European Physics Society.)

Light as Transverse Waves

It should be noted, the author of this paper believes the description of light as transverse waves is an historical misinterpretation of the evidence with far reaching consequences.[1] In fact, transverse waves are the reason academic physicists have dropped the electromagnetic field from classrooms and text books. In this thesis, light is treated as longitudinal waves, with the ability of individual quanta (units of energy being transported from oscillator to oscillator, per Maxwell Planck) to transport polarization characteristics until interference distorts the pattern.

Plasmonics as a portion of the Electromagnetic Field

In a previous paper[2], plasmonics was described as a part of the electromagnetic field. Research and descriptions of the electromagnetic field are currently very unfashionable, and rarely used. Technicians use the terminology of EM waves all the time out of necessity (frequency, dispersion, interference), and academics combine EM wave terminology with photons on a regular basis.

Some of it is pure silliness. For example, a gamma ray photon. Gamma rays, and all EM waves, transport energy with '*each*' wave. The more energy received per second, the more energy that frequency is assigned. Intensity is a factor, but that is a separate issue. A single gamma ray photon has no more energy than a single infrared photon. It is the difference of waves per second which causes variations in the amount of energy received.

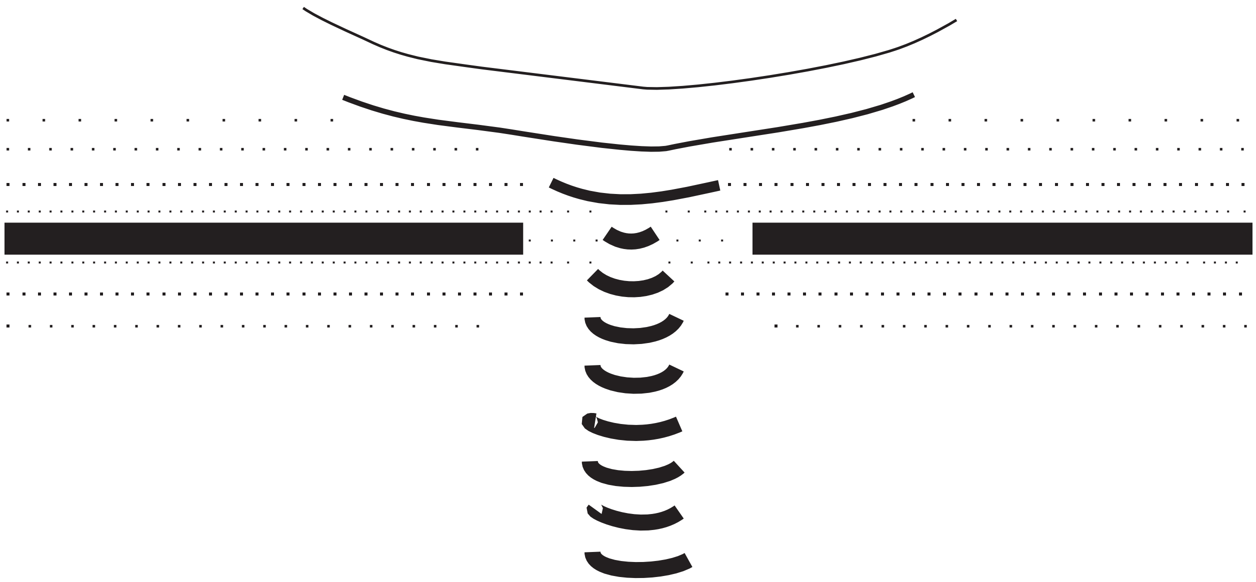
It should also be noted the photon model has been crippled severely by the discovery individual photons (massless, chargeless particles traveling in a vacuum) do not travel in a straight line, but tend to meander.[3] The term quanta, bits o' energy tranferring from oscillator to oscillator, seems a better fit.

Extraordinary Optical Transmission per an Electomagnetic Wave Model

Ebbesen & team used a photon model interacting with a plasmonic surface in explaining the phenomenon of EOT. This seems to have become the common model used in EOT investigations and is reductionisic in nature.

For purposes of understanding, a model of the electromagetic field transporting electromagnetic waves might be more useful. It is common knowledge in physics light travels more slowly through air than in a vaccum, and more slowly through glass than through air. This suggests the the speed of light is a variable, becoming slower in denser mediums and faster in thinner, more rarefied mediums.

Applying the EM wave model to extraordinary optical transmission, we find light is traveling more quickly through the center of the nanohole where the metal foil's EM field is weakest. The density of the EM field condenses with proximity to the edge of the holes, meaning that light near the edges is moving more slowly than at the center. A form of lensing is taking place, with light literally being funneled by back pressure, towards and through the center of the hole, where resistance to movement is at a minimum.



In the above diagram, the metal foil's EM field is represented by the surrounding dots. The waves become more concentrated (intense) as they meet with less resistance at the center of the hole. Sound waves and even surface water waves behave the same way.

This model simply seems more functional and much easier to visualize than the plasmonic field version.

References

[1] 'Ultra-Space Field Theory', K. Foote, Cosmos Books, Ann Arbor, 2005. (Available at Google Books.)

[2] 'Plasmonics per the Ultra-Space Field Theory', K. Foote @http://vixra.org/abs/1302.0116

[3] 'Quantum Interference': http://whatis.techtarget.com/definition/0,,sid9_gci815065,00.html and ' Lab 2. Single Photon Interference' www.optics.rochester.edu/.../2007_stud_rep_ Lab2_Report_MalikLi_ F07.pdf