Working Theory – Magnetic Dipole Contours

By Michael Snyder, November 19, 2008

Remember Birefringence? Some crystals have a different speeds of light based on the direction and polarization of the light ray. Basically you have an ordinary ray moving at one speed and an extraordinary ray moving at another speed of light.

Since the 1800's Birefringence has been studied. For example, the Faraday Effect was studied by Michael Faraday in 1845. He was able to rotate polarizations of a light waves using transparent dielectric materials and a strong magnetic field.

Well, think at the molecule level; imagine a rod shaped molecule that has different speeds of light in areas adjacent to the molecule. For example, if the rod shape is laying along the z axis then there is a area parallel to the z axis with an index of refraction of n=1.3, but along the x axis adjacent to the ends of the molecule, there are two small areas of refraction where n=1.5. Of course the index of refraction is just the speed of light in that area; observed velocity=c/n.

Now if the molecules are in a crystal matrix then we have ordinary and extraordinary vectors of light propagation. What if those molecules are in a liquid? Well, Brownian motion would randomize the alignment of the molecules and ordinary and extraordinary rays wouldn't be observed.

What if we used an external field to align the molecules in the liquid? Now we have a new situation. A light ray from one direction would repeatly pass through areas of indexes of refraction from one angle, but a different ray from a different angle would propagate through an entirely different set of refractions. From our viewpoint, the light rays would be traveling at different speeds because in fact, they really are propagating at different speeds though the medium.

Think of Snell's Law. Each time the index for refraction changes (known as an interface) then the light ray is observed to bend. From our viewpoint, abrupt changes of n is seen as a direct change in ray direction; but small changes of n will look as curves in the light propagation.

This gradient refraction property is used in some low loss fiber optic cables. The fiber optic core is doped in such a way that the index of refraction curves the light back to the central core as it travels in the cable.

So to the observer, an accumulating series of slight changes in the index of refraction (aligned molecule to aligned molecule) would appear as the light curving in the liquid.

Notice depending on the strength of the accumulating series, the light could curve into a circle, or a spirograph! It all would depend on the external field alignment and relative speed changes per molecule.

Here’s a simple one dimension analogy:

“Take a large room and two kinds of glue. Type 'A' glue is sticky, Type 'B' glue is more sticky. Now semi-randomly put 'A' type glue spots and 'B' type glue spots on the floor. Now, by semi-randomly I mean it that it just so happens that here's more 'A' glue spots outside the center of the floor area, and statistically more 'B' spots in the center of the room.

Now, walk around in room. Let's say your left foot hits a less sticky glue spot, and your right foot hits a more sticky glue spot; which then turns your body a little into the center of the room. Keep walking, more and more times, statistically speaking you hit more of the sticky spots with your right foot than your left foot. You are now walking in a circle orbiting the center of the room!”

Now, while my analogy is not perfect, hopefully it does suggest to the reader that a group of optical elements aligned correctly could focus the light into a circle. In the paper “Static Magneto Optical Birefringence of New Electric Double Layered Magnetic Fluids” by J. Depeyrot (http://dx.doi.org/10.1590/S0103-97332001000300008) in the conclusion, they state “Langevin birefringence formalism well works and it has been possible to determine the parameters of the size distribution as well as the optical anisotropy of one particle in solution” which I understand to mean that a single ferrofluid molecule could act as an optical element.

In the paper "Photonic-crystal resonant effect using self-assembly ordered structures in magnetic fluid films under external magnetic fields" by S.Y. Yang (http://dx.doi.org/10.1016/j.jmmm.2006.03.038) in the introduction, “Owing to the ordered structure in the magnetic fluid film, the refractive index varies periodically over the film. Hence, diffraction occurs when lights are incident normally to the film” which I understand to mean, the refractive index is directly related to the external magnetic field.

So, a single molecule can act as an optical component via optical anisotropy, and a group of molecules can vary the refractive index for lights incident normally to the film.

The conclusion is that light within a liquid based lens can be directed into circles or even spirographs by the externally aligned optical elements in the liquid.

Since this conclusion matches experimental results, we can now add that because changing the speed of light in a medium is observed as curving the light in that medium, the following equation must be true.

$$c \propto B$$

The speed of light within the ferrofluid lens is proportional to the magnetic field passing through the ferrofluid lens.