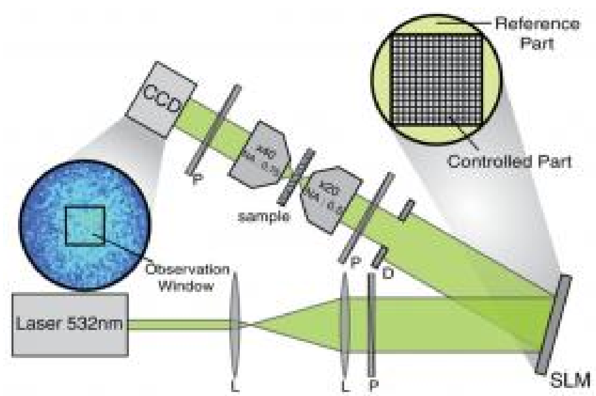
'Seeing' through paint

March 18 2010, By Miranda Marquit



Schematic of the apparatus. The laser is expanded and reflected off a SLM. The phase-modulated beam is focused on the multiple-scattering sample and the output intensity speckle pattern is imaged by a CCD camera: lens (L), polarizer (P), diaphragm (D). Image (c) 2010 American Physical Society, DOI:10.1103/PhysRevLett.104.100601

(PhysOrg.com) -- When light passes through materials that we consider opaque, such as paint, biological tissue, fabric and paper, it is scattered in such a complex way that an image does not come through. "It is possible to see the light, but not the information," Sylvain Gigan tells *PhysOrg.com*. "We wanted to create a way to see the information through opaque media."

Gigan is a scientist at the City of Paris Industrial Physics and Chemistry Higher Educational Institute (ESPCI). Gigan worked in a group with Popoff, Lerosey, Carminati, Fink and Boccara to create an experiment that demonstrates that it is possible to construct a transmission matrix that allows them to "see" through some opaque materials. The results of their experiment are described in Physical Review Letters: "Measuring the Transmission Matrix in Optics: An Approach to the Study and Control of Light Propagation in Disordered Media."

"When people try to look into an opaque medium, especially biological material, they use the ballistic light, the light that has not been mixed up by the medium due to scattering. But as you go into the medium, the ballistic light becomes less intense, limited by the scattering process."

Instead of being limited by scattering, though, the group at ESPCI instead looked for ways to use scattering to their advantage. Gigan and his colleagues passed light through zinc oxide, which is common in paint. They observed the way the light of a laser scattered as it passed through, and then created a numerical model to describe the result. "This transmission matrix is a map through the medium," Gigan explains. "Once we have the transmission matrix, it is possible to analyze whatever pattern goes through."

The process provides the means to put together an image of something on the other side, allowing the researchers to "see" through the zinc oxide layer, even though it is opaque. Reversal is also possible, offering a way to tailor a beam that could pass through opaque material, and then focus. "Such a method could allow for applications in imaging of biological material, among other applications," Gigan says. "This provides a way to transmit information or focus light in a medium that wouldn't by any classical means allow that."

There are limitations, however. "This should not be construed to mean that we can see through walls with this technique," Gigan points out. "Some degree of light has to be able to pass through, and a wall stops light from coming out the other side. You could use white fabric, paint, or paper, though. Even biological tissue, like a chicken breast, could work."

Gigan also admits that so far the process is rather slow. "Getting the matrix is a slow process, taking minutes. We used paint because it is so stable. If you wanted to actually go through biological media, or through liquid, it wouldn't work with our current set-up, since the light transmission changes as the medium moves."

For now, the group at ESPCI is working on tackling the problems presented by technology. "The main limitation for using this technique in biological microscopy is technical. There are some hints of how to get the transmission matrix faster, but at the moment we're not really ready."

Despite the limitations, Gigan sees some current applications. "There are implications for nanotechnology, and the propagation of light in this system is interesting. It offers a basis for the idea of manipulating the light wave, and we believe this could be a promising approach to imaging. Perhaps in five years we will have the technology to take this even further."

More information: Popff, et. al., "Measuring the Transmission Matrix in Optics: An Approach to the Study and Control of Light Propagation in Disordered Media," *Physical Review Letters* (2010). Available online: link.aps.org/doi/10.1103/PhysRevLett.104.100601