TIME-REVERSED WAVES AND SUPER-RESOLUTION

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The origin of diffraction limit in wave physics, and the way to overcome it, can be completely revisited using the time-reversal mirror concept and the Green's function formalism, without the explicit use of the evanescent wave concept. Through a careful description of the way a time reversal mirror is working, we will first recall that the time-reversed wave, generated by a closed time-reversal mirror, which converges to its source, is always followed by a spatially diverging wave due to energy flux consideration. Because the focal spot results from the interference of these two waves, the time-reversed field (for a monochromatic wave) can always be expressed as the imaginary part of the Green's function. This statement is very general and is valid for wave propagating in any heterogeneous medium with time-reversal symmetry.

In a homogeneous medium, the imaginary part of the Green function oscillates typically on a wavelength scale. To create focal spots much smaller than the wavelength, we will show that a very efficient method is to introduce a random distribution of subwavelength scatterers in the near field of the source. Therefore the spatial dependence of the imaginary part of the Green's function is modified to oscillate on scales much smaller than the wavelength. We have built such media and we experimentally demonstrated focal spots as small as $\lambda/30$ with microwaves time-reversal mirror located in the far field working at a central frequency of 2.4 GHz and with a bandwidth of 250 MHz (see article to be published in Science on 2007 february 16)

We will also discuss another interpretation of this super-resolution effect with the formalism of evanescent waves: in a medium made of random distribution of sub-wavelength scatterers, a time-reversed wave field interacts with the random medium to regenerate not only the propagating but also the evanescent waves required to refocus below the diffraction limit.

To conclude this talk we will make a comparison of this new approach for super-resolution, experimentally validated, to the negative index material approach.