Exact analysis of a Veselago Lens using eigenstates of Maxwell’s equations

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Abstract - A new approach is applied to the discussion of perfect imaging by a Veselago Lens. This is based upon the eigenstates of Maxwell’s equations. Sub-wavelength resolution is obtained, but not at the geometric optics foci. This is related to an incipient divergence of the local electric field which occurs when $\varepsilon_1 = -\varepsilon_2$.

The Veselago Lens is analyzed by expanding the electric field of a time dependent point charge in a complete set of eigenstates of Maxwell’s equations for a two-constituent composite medium with electric permittivities $\varepsilon_1, \varepsilon_2$, and a magnetic permeability equal to 1 everywhere which has the appropriate microstructure, i.e., a flat slab of $\varepsilon_1 < 0$ material in an otherwise uniform $\varepsilon_2 > 0$ material. An exact expression for the local electric field in the form of a one dimensional integral is obtained from which we are able to calculate that field numerically very rapidly and with great precision. In the quasistatic regime it was found earlier that this field diverges in some parts of the system when $\varepsilon_1/\varepsilon_2 = -1$ and $\varepsilon_1, \varepsilon_2$ are both real$^1$. That is precisely where the Veselago Lens had earlier been predicted to provide imaging the resolution of which is not limited by the wavelength$^2$. Moreover, the dissipation rate then also diverges sometimes. Among the surprising results found already in a previous quasistatic calculation is the fact that the best sub-wavelength resolution is obtained not at the geometric optics foci of the Veselago Lens but at points on the $\varepsilon_1, \varepsilon_2$ interface$^3$. This is due to the fact that the divergence of the local electric field when $\text{Im}(\varepsilon)\to0$ is strongest at that interface. Extension of the previous discussion to the non-quasistatic regime of Maxwell’s equations will be presented.

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REFERENCES