Scattering of the Polarized Gaussian Beam on the Metamaterial Slab

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Abstract - The scattering of Gaussian beam on the metamaterial slab with negative refractive index is considered. Modeling is based on the spectral decomposition of the beam field in plane waves. The effect of different parameters on the polarization characteristics of the electromagnetic field reflected from the metamaterial layer and transmitted through it is investigated. The possibility of control of the beam polarization is shown.

Simulation of Gaussian beams propagation in inhomogeneous material media allows to define the regularities of interaction between the fields of real microwave and optical sources of radiation with various objects. The most common method of the Gaussian beam electromagnetic field describing is the expansion in the angular spectrum of plane waves [1-3]. In this case the spatial distribution of the amplitude or intensity of the beam field as well as other characteristics of the electromagnetic field is calculated through the inverse Fourier transform.

In this report the scattering of polarized Gaussian beam on the slab of the material with negative permittivity and permeability (metamaterial) is described. Scheme of the beam incidence on the metamaterial slab is shown in Fig. 1. Here \( d \) is the thickness of the slab. Here we can see the well-known phenomenon – negative refraction of the wave beam at the metamaterial interface.

On the basis of spectral method the simulation of the Gaussian beam scattering on the metamaterial slab for different values of the incident angle, layer thickness and refractive index of the metamaterial slab is performed. The cases of the linearly-polarized and elliptical polarized incident radiation are considered.

Consideration of the six components of the wave beam electromagnetic field is necessary to producing of the radiation elliptical polarization. On the other hand, the arbitrary polarization of the radiation is formed by superposition of two perpendicular linear polarizations. Parallel and perpendicular polarization (relative to the plane of incidence) is usually chosen in the problem of the wave beam incidence on the flat interface.

Fig. 2 shows the calculation results of the polarization ellipses of the reflected field from the metamaterial slab for the case of the initial elliptical polarization and different incident angles \( \theta \) of the wave beam on the slab.

It is clear that the elliptical polarization of the radiation remains for a given set of the system parameters but the axis of the polarization ellipse rotates relative to the starting position. Consequently, the amplitude of the electromagnetic field components and the phase shift between them are changed when reflecting from the metamaterial slab.

![Fig. 1. Schematic view of the Gaussian beam incidence on the metamaterial slab.](image1)

![Fig. 2. Polarization ellipses of the reflected field for different values of the wave beam incident angle.](image2)
The thickness of the slab also effects on the polarization characteristics of the wave beam field. Fig. 3 shows the polarization ellipses for the radiation that transmitted through the metamaterial slab. Polarization of the radiation that incident on the slab was linear. In this case linear polarization is transformed into the elliptical polarization. Change the thickness of the slab results in the rotation of the polarization ellipse axis and the change of the ellipticity.

Fig. 4 shows the results of the polarization ellipses calculation for the reflected and transmitted radiation. Initial polarization was assumed to be elliptical. It should be noted that in this case the polarization of the reflected wave beam is circular. Furthermore the major axis of the polarization ellipse of radiation that transmitted through the slab is perpendicular to the plane of incidence. These results were obtained by appropriate choice of system parameters: slab thickness, incident angle, permittivity and permeability of the metamaterial slab.

Additional calculations results show that in the case of the linear polarization of the initial wave beam the transformation into circular polarization is possible too.

The simulation results can be used to study of the Gaussian beams interaction with multilayer metamaterial media and to create devices that control the polarization characteristics of wave beams.

REFERENCES