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Non-reciprocity of acousto-optic interaction at high acoustic frequencies

Yury Dobrolenskiy[a], Vitaly Voloshinov[a] and Yury Zyuryukin[b]
[a]M.V. Lomonosov Moscow State University, Faculty of Physics, Vorob'evy Gory, MSU, 119991 Moscow, Russian Federation
[b]Saratov State Technical University, Politechnicheskaja str., 77, 410054 Saratov, Russian Federation

Modern acousto-optic (AO) tunable filters have reached the values of spectral resolution exceeding 104 and operate with acoustic frequencies up to a few gigahertzes. At such high frequencies and such narrow bandwidths, there appear effects so far neglected. Among them there is non-reciprocity of AO interaction. It consists in the fact that acoustic frequency of light diffraction by ultrasound is different when optic beams propagate in directions opposite to each other. In the present research, the new effect has been studied theoretically and experimentally for the example of collinear AO diffraction. Theoretical analysis and calculations related to particular AO materials have shown that the effect is essential at acoustic frequencies about 1 GHz and higher. The value of the non-reciprocal shift of acoustic frequency can be as high as the frequency bandwidth of the filter. The effect has also been registered and investigated experimentally in a sample of lithium niobate crystal. The experimental data has totally confirmed the theoretical analysis. Therefore, it has been proved that the non-reciprocal effect influences the parameters of AO diffraction and, consequently, operation of AO filters at high frequencies. On the other hand, one can design devices, e.g. directional couples, exactly based on the non-reciprocity.