and that required for $\lambda = 532$ nm is

$$B_{0z} = \frac{\theta_F}{Vl} = \frac{\pi/4}{-190 \times 5 \times 10^{-2}}\,\text{T} = -82.7\ \text{mT}.$$

Note that the magnetic induction has to point in the direction opposite to the forward-propagating direction of the optical wave because the Verdet constant of TGG is negative.

10.4.3 Acousto-optic Modulation

An acoustic wave causes a space- and time-dependent periodic permittivity change in a medium, as discussed in Section 2.6. For a traveling acoustic wave of the form expressed in (2.79), which has a wavevector of $\mathbf{K}$ and a frequency of Ω, the acousto-optically induced permittivity change can be generally expressed in the form of (2.88) as

$$\Delta\epsilon = \Delta\tilde{\epsilon}\sin(\mathbf{K}\cdot\mathbf{r} - \Omega t), \tag{10.80}$$

where the acoustic wavevector $\mathbf{K}$ depends on both the polarization and the propagation direction of the acoustic wave. The wavenumber of the acoustic wave is $K = 2\pi/\Lambda = 2\pi f/v_a$, where v_a is the acoustic wave velocity, $f = \Omega/2\pi$ is the acoustic wave frequency, and $\Lambda = v_a/f$ is the acoustic wavelength. The space- and time-dependent periodic permittivity change $\Delta\epsilon$ is effectively a time-dependent grating, which diffracts an optical wave. In general, as expressed in (2.89), $\Delta\tilde{\epsilon}$ is a function of the strain and the rotation generated by the acoustic wave in the medium, the elasto-optic coefficients of the medium, the mode and direction of the acoustic wave, and the frequency and polarization of the optical wave, but it is independent of the values of K and Ω. When an optical wave at a frequency of ω is incident on this medium, the interaction between the optical wave and the periodic modulation described by (10.80) can generate diffracted optical waves at the frequencies of $\omega \pm \Omega$. The diffracted waves at $\omega \pm \Omega$ can successively be diffracted to generate waves at the frequencies of $\omega \pm 2\Omega$. If this process is allowed to cascade, it is possible to generate a series of diffracted optical waves at the frequencies of $\omega + q\Omega$, where q admits both positive and negative integers and is the *order of acousto-optic diffraction*:

$$\omega_q = \omega + q\Omega. \tag{10.81}$$

The phase-matching condition for the qth-order diffraction is

$$\mathbf{k}_q = \mathbf{k}_i + q\mathbf{K}, \tag{10.82}$$

where $\mathbf{k}_i$ is the wavevector of the incident optical wave.

Acousto-optic modulation is fundamentally diffraction modulation. Because the frequency of each diffraction order is shifted by an integral multiple of the acoustic frequency, digital frequency modulation can be accomplished by switching between discrete acoustic frequencies while analog frequency modulation can be performed using a continuously time-varying acoustic frequency of $\Omega(t)$. Because $\Delta\tilde{\epsilon}$ is generally a tensor, even when the medium is an isotropic material, the polarization of a diffracted wave can be different from that of the incident wave. Therefore, polarization modulation of a desired polarization change from the incident