Fitting procedure for InAs

Below is the detailed fitting procedure used to fit the data for Faraday rotation from InAs using single Drude function. Faraday rotation (θ_F) in terms of right and left circularlarly polarized THz light transmission is given by,

$$\theta_F = -\arctan\left[i\frac{T_r - T_l}{T_r + T_l}\right],$$

These transmissions in thin film limit can be written as,

$$T_r(\omega) = \frac{1+n}{1+n+Z_0 d\sigma_r(\omega)} e^{\frac{i\omega(n-1)\Delta\mathrm{L}}{\mathrm{C}}}, \quad T_l(\omega) = \frac{1+n}{1+n+Z_0 d\sigma_l(\omega)} e^{\frac{i\omega(n-1)\Delta\mathrm{L}}{\mathrm{C}}}$$

Where n is the refractive index of the substrate, $\sigma_{r,l}$ are the conductivities for right and left circularly polarized light, d is the thickness of the film and ΔL is the thickness difference of substrates used for reference and the film. Thus Faraday rotation can be written in terms of conductance as,

$$\theta_F = \quad -\arctan\left[\frac{i(G_l - G_r)}{(G_l + G_r) + \frac{2(n+1)}{Z_0}}\right]$$

Conductance in magnetic field can be described by Drude model,

$$G_\pm = -i\epsilon_0\omega d\left[\frac{\omega_{pD}^2}{-\omega^2 - i\Gamma_D\omega \mp \omega_c\omega} + (\epsilon_\infty - 1)\right], \quad Let\ (\epsilon_\infty - 1) = \alpha_\infty$$

Where $G_{r,l} = G_\pm$, ω_{pD}^2 is the plasma frequency, Γ_D is the scattering rate and ω_c is the cyclotron resonance. We can write

$$G_R = \epsilon_0 d\left[\frac{\omega_{pD}^2}{\Gamma_D - i(\omega + \omega_c)} - i\omega \quad {}_\infty\right]$$

$$G_L = \epsilon_0 d\left[\frac{\omega_{pD}^2}{\Gamma_D - i(\omega - \omega_c)} - i\omega\alpha_\infty\right]$$

Thus for small angles,

$$\theta_F \sim \mathrm{Tan}(\theta_F) = \frac{\mathrm{i}(G_R - G_L)}{(G_R + G_L) + 2(n+1)/Z_o}$$

$$Tan(\theta_F) = -\frac{\epsilon_0 d\omega_{pD}^2\omega_c}{\epsilon_0 d\omega_{pD}^2(\Gamma_D - i\omega) + \left[\frac{n+1}{Z_0} - i\epsilon_0 d\alpha_\infty\omega\right][\Gamma_D^2 + \omega_c^2 - \omega^2 - 2i\Gamma_D\omega]}$$

To solve in terms of THz just put $\epsilon_0 = 8.85$. For InP (@4 K) refractive index n= 3.51, Z_0= 377. For the fits I use,

$$Tan(\theta_F) = -\frac{\epsilon_0 a\mathrm{b}}{\epsilon_0 a(\mathrm{c} - ix) + [0.1196 - iex][\mathrm{c}^2 + \mathrm{b}^2 - x^2 - 2icx]}$$

Where, $a = \omega_{pD}^2 d,\ b = \omega_c, c = \Gamma_D\ and\ e = d\alpha_\infty$. I keep a and e constant as they don't vary even when they are not constant. Thus only free parameters are cyclotron resonance ($\omega_c/2\pi$) and scattering rate ($\Gamma_D/2\pi$). Effective mass can be extracted from the field dependence of the cyclotron resonance frequency ($\omega_c = eB/m^*$). The spectral weight ($\omega_{pD}^2 d$) is proportional to the integrated area of each feature in the real part of the conductance. It gives the ratio of carrier density to an effective transport mass:

$$\frac{2}{\pi\epsilon_0}\int G_{D1}d\omega = \omega_{pD}^2 d = \frac{n_{2D}e^2}{m^*\epsilon_0}$$

Mobility is given by, $\mu = e\Gamma_D/m^*$.