9.2 A Constant Background

9.2.1 The Born approximation in *f*-*k* space

page 191, equation (9.10):misplaced subscript

$$D_{ri}\left(\tilde{\boldsymbol{k}}_g \,|\, \tilde{\boldsymbol{k}}_s;\, \omega\right) = \frac{\mathfrak{w}(\omega)}{4\, k_{gz}\, k_{sz}\, \rho_0{}^2\, c_r{}^2\, c_i{}^2} \int\int\int d^3 x\, e^{-i\, \boldsymbol{k}_g \cdot \boldsymbol{x}}\, \mathcal{V}_{ri}(\boldsymbol{x},\, \omega)\, e^{+i\, \boldsymbol{k}_s \cdot \boldsymbol{x}}, \tag{9.10}$$

page 192, modify equations (9.16)-(9.17) and text above (9.16)

To form an expression in terms of a reflectivity function, invoke its definition (8.56), with $C_r{}^2 = \rho_0\, c_r{}^2$; i.e.,

$$\mathbb{V}_{ri}(\boldsymbol{x},\, \sigma) = \frac{-2\, i\, \rho_0\, c_r \cos\gamma_r}{\omega}\, \mathcal{R}_{ri}(\boldsymbol{x},\, \sigma). \tag{9.16}$$

Then,

$$D_{ri}\left(\tilde{\boldsymbol{k}}_g \,|\, \tilde{\boldsymbol{k}}_s;\, \omega\right) = -\, i\, \omega\; \mathfrak{w}(\omega)\, \frac{\mathcal{R}_{ri}(\boldsymbol{k}_m,\, \sigma) \cos\gamma_r}{2\, k_{gz}\, k_{sz}\, \rho_0\, c_r\, c_i{}^2}\,. \tag{9.17}$$

page 196, modify equations (9.42) and (9.46) by replacing $c_r{}^2\, c_i$ with $c_r\, c_i{}^2$

$$D_{ri}\left(\tilde{\boldsymbol{k}}_g \,|\, \tilde{\boldsymbol{k}}_s;\, \omega\right) = -\, i\, \omega\; \mathfrak{w}(\omega)\, \frac{R_{ri}(\sigma)\, e^{-i\, \boldsymbol{k}_m \cdot \boldsymbol{x}_0} \cos\gamma_r}{2\, k_{gz}\, k_{sz}\, \rho_0\, c_r\, c_i{}^2}\,. \tag{9.42}$$

$$D_{ri}\left(\tilde{\boldsymbol{k}}_g \,|\, \tilde{\boldsymbol{k}}_s;\, \omega\right) = -(2\,\pi)^2\, i\, \omega\; \mathfrak{w}(\omega) \sqrt{1 + q_x{}^2 + q_y{}^2}\, \cdot \frac{R_{ri}(\sigma) \cos\gamma_r\, e^{-i\, k_z\, z_0}\, \delta(k_x + q_x\, k_z)\, \delta(k_y + q_y\, k_z)}{2\, k_{gz}\, k_{sz}\, \rho_0\, c_r\, c_i{}^2}\,. \tag{9.46}$$

Modify equations (9.49), (9.50), (9.51), (9.65), (9.66), (9.67), (9.71), (9.72), (9.90), (9.91), (9.92), (9.96), (9.97), (9.98), (9.105), and (9.106) by replacing $c_r{}^2\, c_i$ with $c_r\, c_i{}^2$.

$$D_{ri}(\tilde{\boldsymbol{x}}_m,\, \tilde{\boldsymbol{x}}_h;\, \omega) = \frac{-1}{(2\,\pi)^4}\, \frac{i\, \omega\, \mathfrak{w}(\omega)}{8\, \rho_0\, c_r\, c_i{}^2} \int\int d^2\tilde{k}_m\, e^{i\, \tilde{\boldsymbol{k}}_m \cdot \tilde{\boldsymbol{x}}_m} \int\int d^2\tilde{k}_h\, e^{i\, \tilde{\boldsymbol{k}}_h \cdot \tilde{\boldsymbol{x}}_h}\, \frac{\cos\gamma_r}{k_{gz}\, k_{sz}} \int\int\int d^3 x\, e^{-i\, \boldsymbol{k}_m \cdot \boldsymbol{x}}\, \mathcal{R}_{ri}(\boldsymbol{x},\, \sigma), \tag{9.49}$$

$$D^{(3\,\mathrm{DZO})}{}_{ri}(\tilde{\boldsymbol{x}}_m;\, \omega) = D_{ri}\left(\tilde{\boldsymbol{x}}_m,\, \tilde{\boldsymbol{0}};\, \omega\right) = \frac{-1}{(2\,\pi)^4}\, \frac{i\, \omega\, \mathfrak{w}(\omega)}{8\, \rho_0\, c_r\, c_i{}^2} \int\int d^2\tilde{k}_m\, e^{i\, \tilde{\boldsymbol{k}}_m \cdot \tilde{\boldsymbol{x}}_m} \int\int d^2\tilde{k}_h\, \frac{\cos\gamma_r}{k_{gz}\, k_{sz}} \int\int\int d^3 x\, e^{-i\, \boldsymbol{k}_m \cdot \boldsymbol{x}}\, \mathcal{R}_{ri}(\boldsymbol{x},\, \sigma). \tag{9.50}$$

$$D^{(3\,\mathrm{DZO})}{}_{ri}(\tilde{\boldsymbol{x}}_m;\,\omega) = \frac{-1}{(2\,\pi)^4}\,\frac{i\,\omega\,\mathfrak{w}(\omega)}{8\,\rho_0\,c_r\,c_i^2} \int\!\!\int d^2\tilde{k}_m\, e^{i\,\tilde{\boldsymbol{k}}_m\cdot\tilde{\mathbf{x}}_m} \int\!\!\int\!\!\int d^3x\, e^{-i\,\tilde{\boldsymbol{k}}_m\cdot\,\tilde{\mathbf{x}}} \int\!\!\int d^2\tilde{k}_h\, e^{-i\,k_{mz}\,\boldsymbol{z}}\,\frac{\cos\gamma_r}{k_{gz}\,k_{sz}}\,\mathcal{R}_{ri}(\boldsymbol{x},\,\sigma). \tag{9.51}$$

$$D^{(3\,\mathrm{DZO})}{}_{ri}(\tilde{\boldsymbol{x}}_m;\,\omega) \simeq \frac{1}{(2\,\pi)^3}\,\frac{\mathfrak{w}(\omega)\,\underline{c}}{2\,\rho_0\,c_r\,c_i^2} \int\!\!\int d^2\tilde{k}_m\, e^{i\,\tilde{\boldsymbol{k}}_m\cdot\tilde{\mathbf{x}}_m} \int\!\!\int\!\!\int d^3x\, e^{-i\left(\tilde{\boldsymbol{k}}_m\cdot\,\tilde{\mathbf{x}}\,+k_{mz}{}^{\mathrm{ZO}}\,\boldsymbol{z}\right)}\left(\frac{\mathcal{R}_{ri}}{z}\right)(\boldsymbol{x},\,0). \tag{9.65}$$

$$D^{(3\,\mathrm{DZO})}{}_{ri}\left(\tilde{\boldsymbol{k}}_m;\,\omega\right) \simeq \frac{1}{(2\,\pi)}\,\frac{\mathfrak{w}(\omega)\,\underline{c}}{2\,\rho_0\,c_r\,c_i^2}\left(\frac{\mathcal{R}_{ri}}{z}\right)\left(\tilde{\boldsymbol{k}}_m,\,k_{mz}{}^{\mathrm{ZO}},\,0\right). \tag{9.66}$$

$$\frac{d}{d\,k_{mz}{}^{\mathrm{ZO}}}\,D^{(3\,\mathrm{DZO})}{}_{ri}\left(\tilde{\boldsymbol{k}}_m;\,\omega\right) \simeq \frac{1}{(2\,\pi)}\,\frac{\underline{c}\,\mathfrak{w}(\omega)}{2\,\rho_0\,c_r\,c_i^2}\,\frac{d}{d\,k_{mz}{}^{\mathrm{ZO}}}\left(\frac{\mathcal{R}_{ri}}{z}\right)\left(\tilde{\boldsymbol{k}}_m,\,k_{mz}{}^{\mathrm{ZO}},\,0\right). \tag{9.67}$$

$$\left(t\,D^{(3\,\mathrm{DZO})}{}_{ri}\right)\left(\tilde{\boldsymbol{k}}_m;\,\omega\right) \simeq \frac{1}{(2\,\pi)}\,\frac{\mathfrak{w}(\omega)}{2\,\rho_0\,c_r\,c_i^2}\,\frac{\mathcal{R}_{ri}\left(\tilde{\boldsymbol{k}}_m,\,k_{mz}{}^{\mathrm{ZO}},\,0\right)}{\sqrt{1-\tilde{k}_m{}^2\,\underline{c}^2\,/\,\omega^2}}. \tag{9.71}$$

$$D^{(\mathrm{ZA})}{}_{ri}(\tilde{\boldsymbol{x}}_m,\,x_h;\,\omega) = D_{ri}(\tilde{\boldsymbol{x}}_m,\,x_h,\,0;\,\omega) = -\frac{1}{(2\,\pi)^4}\,\frac{i\,\omega\,\mathfrak{w}(\omega)}{8\,\rho_0\,c_r\,c_i^2} \int\!\!\int d^2\tilde{k}_m\, e^{i\,\tilde{\boldsymbol{k}}_m\cdot\tilde{\mathbf{x}}_m} \int d\,k_{hx}\, e^{i\,k_{hx}\,x_h} \int\!\!\int\!\!\int d^3x\, e^{-i\,\tilde{\boldsymbol{k}}_m\cdot\,\tilde{\mathbf{x}}} \int d\,k_{hy}\; e^{-i\,k_{mz}\,\boldsymbol{z}}\,\frac{\cos\gamma_r}{k_{gz}\,k_{sz}}\,\mathcal{R}_{ri}(\boldsymbol{x},\,\sigma). \tag{9.72}$$

$$D^{(ZA)}{}_{ri}(\tilde{\boldsymbol{x}}_m,\,x_h;\,\omega) = \frac{1}{(2\,\pi)^{7/2}}\,\frac{\sqrt{i}\;\omega\,\mathfrak{w}(\omega)}{4\,\rho_0\,c_r\,c_i^2} \int\!\!\int d^2\tilde{k}_m\, e^{i\,\tilde{\boldsymbol{k}}_m\cdot\tilde{\mathbf{x}}_m} \int d\,k_{hx}\, e^{i\,k_{hx}\,x_h}\,\frac{\cos\gamma_r{}^{\mathrm{ZA}}}{\sqrt{k_{mz}{}^{ZA}\,k_{gz0}\,k_{sz0}}} \int\!\!\int\!\!\int d^3x\; e^{-i\,\left(\tilde{\boldsymbol{k}}_m\cdot\,\tilde{\mathbf{x}}\,+\,k_{mz}{}^{ZA}\,\boldsymbol{z}\right)}\,\frac{\mathcal{R}_{ri}\left(\boldsymbol{x},\,\sigma^{ZA}\right)}{\sqrt{z}}, \tag{9.90}$$

$$D^{(ZA)}{}_{ri}\left(\tilde{\boldsymbol{k}}_m,\, k_{hx};\, \omega\right) = \frac{1}{(2\,\pi)^{1/2}}\, \frac{\sqrt{i}\;\, \omega\, \mathfrak{w}\,(\omega)}{4\,\rho_0\, c_r\, c_i{}^2}\, \frac{\cos\, \gamma_r{}^{ZA}}{\sqrt{k_{mz}{}^{ZA}\, k_{gz0}\, k_{sz0}}}\left(\frac{\mathcal{R}_{ri}}{\sqrt{z}}\right)\left(\tilde{\boldsymbol{k}}_m,\, k_{mz}{}^{ZA},\;\sigma^{ZA}\right), \tag{9.91}$$

$$D^{(2.5\,\mathrm{D})}{}_{ri}\,(x_m,\, x_h;\, \omega) = \frac{\sqrt{i}}{(2\,\pi)^{5/2}}\, \frac{\omega\, \mathfrak{w}\,(\omega)}{4\,\rho_0\, c_r\, c_i{}^2} \int d\,k_{mx}\, e^{i\,k_{mx}\,x_m}$$
$$\int d\,k_{hx}\, e^{i\,k_{hx}\,x_h}\, \frac{\cos\, \gamma_r{}^{\mathrm{ZA}}}{\sqrt{k_{mz}{}^{\mathrm{ZA}}\, k_{gz0}\, k_{sz0}}} \int d\,x \int d\,z\, e^{-i\,\left(k_{mx}\,x + k_{mz}{}^{\mathrm{ZA}}\,z\right)} \left(\frac{\mathcal{R}_{ri}}{\sqrt{z}}\right)\left(x,\, z,\, \sigma^{\mathrm{ZA}}\right). \tag{9.92}$$

$$D^{(2.5\,\mathrm{D})}{}_{ri}\,(x_m,\, x_h;\, \omega) = \frac{\sqrt{i}}{(2\,\pi)^{5/2}}\, \frac{\omega\, \mathfrak{w}\,(\omega)}{4\,\rho_0\, c_r\, c_i{}^2} \int d\,k_{mx}\, e^{i\,k_{mx}\,x_m}$$
$$\int d\,k_{hx}\, e^{i\,k_{hx}\,x_h}\, \frac{\cos\, \gamma_{r0}}{\sqrt{k_{mz0}\, k_{gz0}\, k_{sz0}}} \int d\,x \int d\,z\, e^{-i\,\left(k_{mx}\,x + k_{mz0}\,z\right)} \left(\frac{\mathcal{R}_{ri}}{\sqrt{z}}\right)(x,\, z,\, \sigma_0). \tag{9.96}$$

$$D^{(2.5\,\mathrm{D})}{}_{ri}\,(k_{mx},\, k_{hx};\, \omega) = \frac{\sqrt{i}}{(2\,\pi)^{1/2}}\, \frac{\omega\, \mathfrak{w}\,(\omega)}{4\,\rho_0\, c_r\, c_i{}^2}\, \frac{\cos\, \gamma_{r0}}{\sqrt{k_{mz0}\, k_{gz0}\, k_{sz0}}} \left(\frac{\mathcal{R}_{ri}}{\sqrt{z}}\right)(k_{m\,x},\, k_{mz0},\, \sigma_0). \tag{9.97}$$

$$D^{(2.5\,\mathrm{DZO})}{}_{ri}\,(x_m;\, \omega) = \frac{\sqrt{i}}{(2\,\pi)^{5/2}}\, \frac{\omega\, \mathfrak{w}\,(\omega)}{4\,\rho_0\, c_r\, c_i{}^2}$$
$$\int d\,k_{mx}\, e^{i\,k_{mx}\,x_m} \int d\,x\, e^{-i\,k_{m\,x}\,x} \int d\,z \int d\,k_{hx}\, \frac{\cos\, \gamma_{r0}}{\sqrt{k_{mz0}\, k_{gz0}\, k_{sz0}}}\, e^{-i\,k_{mz0}\,z}\, \frac{\mathcal{R}_{ri}\,(\mathbf{x},\, \sigma_0)}{\sqrt{z}}. \tag{9.98}$$

$$D^{(2.5\,\mathrm{DZO})}{}_{ri}\,(x_m;\, \omega) = \frac{1}{(2\,\pi)^2}\, \frac{\mathfrak{w}\,(\omega)\, \underline{c}}{2\,\rho_0\, c_r\, c_i{}^2}\,\cdot$$
$$\int d\,k_{mx}\, e^{i\,k_{mx}\,x_m} \int d\,x \int d\,z\, e^{-i\,k_{m\,x}\,x}\;\, e^{-i\,k_{mz}\,z} \left(\frac{\mathcal{R}_{ri}}{z}\right)(x,\, z,\, 0). \tag{9.105}$$

$$D^{(2.5\,\mathrm{DZO})}{}_{ri}\,(k_{mx};\, \omega) = \frac{\mathfrak{w}\,(\omega)\, \underline{c}}{4\,\pi\,\rho_0\, c_r\, c_i{}^2} \left(\frac{\mathcal{R}_{ri}}{z}\right)(k_{m\,x},\, k_{m\,z},\, 0). \tag{9.106}$$

Modify the following equations by replacing $c_r(z)$ with $c_i(z)$:

$$D_{ri}\left(\tilde{\boldsymbol{k}}_g \mid \tilde{\boldsymbol{k}}_s;\, \omega\right) = \frac{i\, \omega\, \mathfrak{w}(\omega)}{2\sqrt{\left|k_{gz}(0)\, k_{sz}(0)\right|}\ \rho_0(0)\, c_r(0)\, c_i(0)} \int dz\, e^{-i\int_0^z dz'\, k_{mz}(z')}\, \frac{\mathcal{R}_{ri}\left(\tilde{\boldsymbol{k}}_m,\, z,\, \sigma\right) \cos(\gamma_r(z))}{\sqrt{\left|k_{gz}(z)\, k_{sz}(z)\right|}\ c_i(z)}. \tag{9.117}$$

$$D_{ri}\left(\tilde{\boldsymbol{p}}_g \mid \tilde{\boldsymbol{p}}_s;\, \omega\right) = \frac{i\ \mathfrak{w}(\omega)}{2\,\omega\sqrt{p_{gz}(0)\, p_{sz}(0)}\ \rho_0(0)\, c_r(0)\, c_i(0)} \int dz\, e^{-i\,\omega\int_0^z dz'\, p_{mz}(z')}\, \frac{\mathcal{R}_{ri}(\omega\, \tilde{\boldsymbol{p}}_m,\, z,\, \sigma(z)) \cos(\gamma_r(z))}{\sqrt{p_{gz}(z)\, p_{sz}(z)}\ c_i(z)}. \tag{9.120}$$

$$D_{ri}\left(\tilde{\boldsymbol{p}}_g \mid \tilde{\boldsymbol{p}}_s;\, \omega\right) = \frac{i\ \mathfrak{w}(\omega)}{2\,\omega\sqrt{p_{gz}(0)\, p_{sz}(0)}\ \rho_0(0)\, c_r(0)\, c_i(0)} \int d\tau\, e^{-i\omega\tau}\, \frac{\mathcal{R}_{ri}(\omega\, \tilde{\boldsymbol{p}}_m,\, z,\, \sigma(z)) \cos(\gamma_r(z))}{p_{mz}(z)\sqrt{p_{gz}(z)\, p_{sz}(z)}\ c_i(z)}. \tag{9.122}$$

$$D^{(2.5\,\mathrm{D})}{}_{ri}(k_{mx},\, k_{hx};\, \omega) = \frac{\sqrt{i}}{(2\,\pi)^{1/2}}\, \frac{\omega\, \mathfrak{w}(\omega)}{4\,\rho_0(0)\, c_r(0)\, c_i(0)} \int dz\, \frac{e^{-i\int_0^z dz'\, \hat{k}_{mz}(z')}}{c_i(z)}\, \frac{\cos\gamma_r\, \mathcal{R}^{(2.5\,\mathrm{D})}{}_{ri}(k_{mx},\, z,\, \sigma(z))}{\sqrt{\hat{k}_{gz}(0)\, \hat{k}_{sz}(0)\, \hat{k}_{gz}(z)\, \hat{k}_{sz}(z) \int_0^z dz'\, \frac{\hat{k}_{mz}(z')}{\hat{k}_{gz}(z')\, \hat{k}_{sz}(z')}}}. \tag{9.132}$$

Modify the following equations by replacing $\frac{C_i^2}{c_i}$ with $\frac{C_r^2}{c_r}$:

$$D_{ri}(\tilde{\mathbf{x}}_g \mid \tilde{\mathbf{x}}_s;\, \omega) = -2\, i\, \omega\, \mathfrak{w}(\omega) \int\!\!\int\!\!\int d^3x\, \mathcal{R}_{ri}(\mathbf{x},\, \sigma)\, \frac{C_r{}^2 \cos\gamma_r}{c_r}\, g_i(\mathbf{x} \mid \tilde{\mathbf{x}}_s)\, g_r(\tilde{\mathbf{x}}_g \mid \mathbf{x})\, \mathrm{e}^{i\,\omega\,\tau\left(\tilde{x}_g|\mathbf{x}|\tilde{x}_s\right)}, \tag{9.143}$$

$$D_{ri}(\tilde{\mathbf{x}}_g \mid \tilde{\mathbf{x}}_s; \omega) = -2\, i\, \omega\, \mathfrak{w}(\omega) \int\!\!\int_S d^2x\, \mathcal{R}_{ri}(x, y, \varsigma, \sigma) \frac{C_r^2 \cos\gamma_r}{c_r \cos\alpha} g_i(x, y, \varsigma \mid \tilde{\mathbf{x}}_s)\, g_r(\tilde{\mathbf{x}}_g \mid x, y, \varsigma)\, e^{i\,\omega\,\tau(\tilde{\mathbf{x}}_g|x,y,\varsigma|\tilde{\mathbf{x}}_s)}, \tag{9.145}$$

$$D_{ri}(\tilde{\mathbf{x}}_g \mid \tilde{\mathbf{x}}_s; \omega) = -2\, i\, \omega\, \mathfrak{w}(\omega) \int\!\!\int_S ds_1\, ds_2\, \mathcal{R}_{ri}(x, y, \varsigma, \sigma) \frac{C_r^2 \cos\gamma_r}{c_r} g_i(x, y, \varsigma \mid \tilde{\mathbf{x}}_s)\, g_r(\tilde{\mathbf{x}}_g \mid x, y, \varsigma)\, e^{i\,\omega\,\tau(\tilde{\mathbf{x}}_g|x,y,\varsigma|\tilde{\mathbf{x}}_s)}. \tag{9.147}$$

$$D_{ri}(\tilde{\mathbf{x}}_g \mid \tilde{\mathbf{x}}_s; t) = \frac{1}{\pi} \int\!\!\int_S ds_1\, ds_2\, \mathcal{R}_{ri}(x, y, \varsigma, \sigma) \frac{C_r^2 \cos\gamma_r}{c_r} g_i(x, y, \varsigma \mid \tilde{\mathbf{x}}_s)\, g_r(\tilde{\mathbf{x}}_g \mid x, y, \varsigma)\, \dot{\mathfrak{w}}(t - \tau(\tilde{\mathbf{x}}_g \mid x, y, \varsigma \mid \tilde{\mathbf{x}}_s)). \tag{9.148}$$

$$D_e(\tilde{\mathbf{x}}_g \mid \tilde{\mathbf{x}}_s; t) = \frac{2}{c_r} C_r^2 \cos\gamma_r\, R_{ri}(\mathbf{x}_e, \sigma_e) \left(\frac{g_i(\mathbf{x}_e \mid \tilde{\mathbf{x}}_s)\, g_r(\tilde{\mathbf{x}}_g \mid \mathbf{x}_e)}{\sqrt{|\mathrm{Det}\, \tau_e''|}} \right) \mathfrak{w}(t - \tau_e(\tilde{\mathbf{x}}_g \mid \mathbf{x}_e \mid \tilde{\mathbf{x}}_s)). \tag{9.150}$$

$$D_e(\tilde{\mathbf{x}}_g \mid \tilde{\mathbf{x}}_s; t) = \frac{2}{c_r} C_r^2 \cos\gamma_r\, R_{ri}(\mathbf{x}_e, \sigma_e) \frac{g_i(\mathbf{x}_e \mid \tilde{\mathbf{x}}_s)\, g_r(\tilde{\mathbf{x}}_g \mid \mathbf{x}_e)}{\sqrt{|\mathrm{Det}\, \tau_e''|}} [H * \mathfrak{w}](t - \tau_e(\tilde{\mathbf{x}}_g \mid \mathbf{x}_e \mid \tilde{\mathbf{x}}_s)). \tag{9.151}$$

$$D_e(\tilde{\mathbf{x}}_g \mid \tilde{\mathbf{x}}_s; t) = \frac{2}{3\, c_r \sqrt{\pi}} \sqrt{\frac{\tau_1}{\tau_{111} |\tau_{22}|}}\, C_r^2 \cos\gamma_r\, R_{ri}(\mathbf{x}_e, \sigma_e)\, g_i(\mathbf{x}_e \mid \tilde{\mathbf{x}}_s)\, g_r(\tilde{\mathbf{x}}_g \mid \mathbf{x}_e)\, [w_{hS_2}(\tau_d) * \mathfrak{w}](t - \tau_e(\tilde{\mathbf{x}}_g \mid \mathbf{x}_e \mid \tilde{\mathbf{x}}_s)). \tag{9.152}$$

Modify the followoing equations by replacing $c_r^2\, c_i$ with $c_r\, c_i^2$.

$$D_{ri}\left(\tilde{\mathbf{k}}_g \mid \tilde{\mathbf{k}}_s; \omega\right) = -\, i\, \omega\; \mathfrak{w}(\omega) \frac{\mathcal{R}_{ri}(\mathbf{k}_m, \sigma) \cos\gamma_r}{2\, k_{gz}\, k_{sz}\, \rho_0\, c_r\, c_i^2}. \tag{9.167}$$

$$D_{ri}(\tilde{x}_m, \tilde{x}_h; \omega) = \frac{-1}{(2\pi)^4} \frac{i\,\omega\,\mathfrak{w}(\omega)}{8\,\rho_0\, c_r\, c_i^2} \int\!\!\int d^2\tilde{k}_m\, e^{i\,\tilde{k}_m\cdot\tilde{x}_m} \int\!\!\int d^2\tilde{k}_h\, e^{i\,\tilde{k}_h\cdot\tilde{x}_h} \frac{\cos\gamma_r}{k_{gz}\,k_{sz}} \int\!\!\int\!\!\int d^3x\, e^{-i\,k_m\cdot x}\, \mathcal{R}_{ri}(x, \sigma), \tag{9.169}$$

- **3-D Constant-Velocity Zero-Offset Wavenumber-Frequency Born Approximation**

$$D^{(3\,DZO)}{}_{ri}\left(\tilde{k}_m; \omega\right) \simeq \frac{1}{(2\pi)} \frac{\mathfrak{w}(\omega)\,\underline{c}}{2\,\rho_0\, c_r\, c_i^2} \left(\frac{\mathcal{R}_{ri}}{z}\right)\left(\tilde{k}_m, k_{mz}{}^{ZO}, 0\right). \tag{9.170}$$

$$\left(t\, D^{(3\,DZO)}{}_{ri}\right)\left(\tilde{k}_m; \omega\right) \simeq \frac{1}{(2\pi)} \frac{\mathfrak{w}(\omega)}{2\,\rho_0\, c_r\, c_i^2} \frac{\mathcal{R}_{ri}\left(\tilde{k}_m, k_{mz}{}^{ZO}, 0\right)}{\sqrt{1 - \tilde{k}_m{}^2\, \underline{c}^2 / \omega^2}}. \tag{9.171}$$

- **3-D Constant-Velocity Zero-Azimuth Wavenumber-Frequency Born Approximation**

$$D^{(ZA)}{}_{ri}\left(\tilde{k}_m, k_{hx}; \omega\right) = \frac{1}{(2\pi)^{1/2}} \frac{\sqrt{i}\;\omega\,\mathfrak{w}(\omega)}{4\,\rho_0\, c_r\, c_i^2} \frac{\cos\,\gamma_r{}^{ZA}}{\sqrt{k_{mz}{}^{ZA}\, k_{gz0}\, k_{sz0}}} \left(\frac{\mathcal{R}_{ri}}{\sqrt{z}}\right)\left(\tilde{k}_m, k_{mz}{}^{ZA}, \sigma^{ZA}\right). \tag{9.172}$$

- **2.5-D Constant-Velocity Wavenumber-Frequency Born Approximation**

$$D^{(2.5\,D)}{}_{ri}(k_{mx}, k_{hx}; \omega) = \frac{\sqrt{i}}{(2\pi)^{1/2}} \frac{\omega\,\mathfrak{w}(\omega)}{4\,\rho_0\, c_r\, c_i^2} \frac{\cos\,\gamma_{r0}}{\sqrt{k_{mz0}\, k_{gz0}\, k_{sz0}}} \left(\frac{\mathcal{R}_{ri}}{\sqrt{z}}\right)(k_{mx}, k_{mz0}, \sigma_0). \tag{9.173}$$

- **2.5-D Constant-Velocity Zero-Offset Wavenumber-Frequency Born Approximation**

$$D^{(2.5\,DZO)}{}_{ri}(k_{mx}; \omega) = \frac{\mathfrak{w}(\omega)\,\underline{c}}{4\,\pi\,\rho_0\, c_r\, c_i^2} \left(\frac{\mathcal{R}_{ri}}{z}\right)(k_{mx}, k_{mz}, 0), \tag{9.174}$$

Modify the following equations by replacing $c_r(z)$ with $c_i(z)$:

$$D_{ri}\left(\tilde{k}_g \,|\, \tilde{k}_s; \omega\right) = \frac{i\,\omega\,\mathfrak{w}(\omega)}{2\sqrt{|k_{gz}(0)\, k_{sz}(0)|}\;\rho_0(0)\, c_r(0)\, c_i(0)} \int dz\, e^{-i\int_0^z dz'\, k_{mz}(z')} \frac{\mathcal{R}_{ri}\left(\tilde{k}_m, z, \sigma\right)\cos(\gamma_r(z))}{\sqrt{|k_{gz}(z)\, k_{sz}(z)|}\;\, c_i(z)}. \tag{9.177}$$

■ 2.5-D Depth-Variable Velocity Wavenumber-Frequency Born Approximation

$$D^{(2.5\,\mathrm{D})}{}_{ri}\,(k_{m\,x},\ k_{hx};\ \omega) = \frac{\sqrt{i}}{(2\,\pi)^{1/2}}\ \frac{\omega\,\mathfrak{w}\,(\omega)}{4\,\rho_0\,(0)\,c_r\,(0)\,c_i\,(0)} \int d z\ \frac{e^{-i\int_0^z dz'\,\hat{k}_{mz}\,(z')}}{c_i\,(z)}$$

$$\left(\frac{\cos\gamma_r\,\mathcal{R}_{ri}\,(\mathbf{x},\,\sigma)}{\sqrt{\hat{k}_{gz}\,(0)\,\hat{k}_{sz}\,(0)\,\hat{k}_{gz}\,(z)\,\hat{k}_{sz}\,(z)\int_0^z d z'\,\frac{\hat{k}_{mz}\,(z')}{\hat{k}_{gz}\,(z')\,\hat{k}_{sz}\,(z')}}}\right). \tag{9.179}$$

■ 3-D General Variable Velocity Born Approximation

Modify the following equation by replacing $\frac{C_i^2}{c_i}$ with $\frac{C_r^2}{c_r}$:

$$D_{ri}\,(\tilde{\mathbf{x}}_g\,|\,\tilde{\mathbf{x}}_s;\ \omega) = -2\,i\,\omega\,\mathfrak{w}\,(\omega)\int\!\!\int\!\!\int d^3x\ \mathcal{R}_{ri}\,(\mathbf{x},\,\sigma)\ \frac{C_r{}^2\cos\gamma_r}{c_r}\ g_i\,(\mathbf{x}\,|\,\tilde{\mathbf{x}}_s)\,g_r\,(\tilde{\mathbf{x}}_g\,|\,\mathbf{x})\,\mathrm{e}^{i\,\omega\,\tau\left(\tilde{\mathbf{x}}_g|\mathbf{x}|\tilde{\mathbf{x}}_s\right)}\,. \tag{9.181}$$