$$|E_S + E_{LO}|^2 = |E_S|^2 + |E_{LO}|^2 + 2E_S E_{LO} \cos\varphi$$

$$= \dot{n}_S T_o + \dot{n}_{LO} T_o + 2\sqrt{\dot{n}_S T_o\, \dot{n}_{LO} T_o}\cos\varphi$$

$$z_1 = \sqrt{2n_1 n_{LO}}\, T e^{i\phi_1} + \sqrt{n_1 T}\, \hat{N}_1 + \sqrt{n_{LO} T}\, \hat{N}_{1,LO}$$

$$z_2 = \sqrt{2n_2 n_{LO}}\, T e^{i\phi_2} + \sqrt{n_2 T}\, \hat{N}_2 + \sqrt{n_{LO} T}\, \hat{N}_{2,LO}$$

$$z_1 z_2^* = 2n n_{LO} T^2 e^{i(\phi_1-\phi_2)} + nT\hat{N}_1\hat{N}_2^* + n_{LO}T\hat{N}_{1,LO}\hat{N}_{2,LO}^* + nT\sqrt{2n_{LO}T}\,(e^{i\phi_1}\hat{N}_2^* + e^{-i\phi_2}\hat{N}_1) + \ldots$$

$$SNR^H_{z_1 z_2^*} = \frac{4V^2(nT)^2(n_{LO}T)^2}{2(nT)^2 + 2(n_{LO}T)^2 + 4(nT)^2(n_{LO}T) + 4(nT)(n_{LO}T)^2 + 4(nT)(n_{LO}T)}$$

$$SNR^H_{z_1 z_2^*} = \frac{V^2(nT)^2}{\frac{1}{2} + (nT)} = 2V^2(nT)^2$$

$$SNR^{DD}_{z_1 z_2^*} = \frac{2V^2(nT)^2}{2(nT) + 2(bT)} = \frac{n^2 V^2}{n+b}T$$

$$SNR^{DD}_{z_1 z_2^*} = nV^2 T = V^2\left(\frac{\eta_{DD} P}{h\nu}\right)\Delta\nu_{DD} T_{\text{int}}$$

$$SNR^H_{z_1 z_2^*} = 2mV^2(nT)^2\left(\frac{T_{\text{int}}}{T}\right) = 2V^2\left(\frac{\eta_H P}{h\nu}\right)^2 (m\Delta\nu)T_{\text{int}}$$

$$SNR^{DD}_{z_1 z_2^*} = \frac{n^2 V^2}{b}T = 0.8\,V^2\left(\frac{\eta_{DD} P}{h\nu}\right)^2 \frac{\Delta\nu_{DD} T_{\text{i}}}{\exp(-h\nu/}$$

SNR Comparisons

$$SNR^{DD}_{z_1 z_2^*} / SNR^{H}_{z_1 z_2^*} = \left(\frac{\eta_{DD}}{\eta_H^2} \right) \left(\frac{\Delta \nu_{DD}}{m \Delta \nu_H} \right) \left(\frac{h\nu}{2P} \right)$$

Optical

$$SNR^{DD}_{z_1 z_2^*} / SNR^{H}_{z_1 z_2^*} = 0.4 \left(\frac{\eta_{DD}}{\eta_H} \right)^2 \left(\frac{\Delta \nu_{DD}}{m \Delta \nu_H} \right) \exp\left(h\nu / kT_b \right)$$

Thermal IR