2.2

$$\mathcal{E}_\omega(\varphi, z') = \left[e^{-ikz'\varphi^2/2}\right]\left[\frac{e}{4\pi\epsilon_0 \lambda^2}\right]\left[\frac{3\gamma(\varphi)}{2\omega_c(\varphi)}\right]\int d\zeta \left[\zeta\hat{x} - \varphi\gamma(\varphi)\hat{y}\right] e^{\left(\frac{3i\omega(\zeta+\zeta^3/3)}{4\omega_c(\varphi)}\right)}$$

$$\gamma(\varphi) = \frac{\gamma}{\sqrt{1+\gamma^2\varphi^2}}$$ => decreases as φ increases

$$\gamma(\pi) = \frac{\gamma}{\sqrt{1+\gamma^2\pi^2}}$$ max decrease in γ at $180°\,(\pi)$
i.e, behind the source

$$\omega(\varphi) = \frac{3\gamma(\varphi)^3 c}{2\rho}$$ => frequency decreases (red-shift) as you move off-axis

$$\frac{dP_x}{d\varphi} \propto \frac{1}{[1+\gamma^2\varphi_y^2]^{5/2}} = \frac{1}{[1+(\gamma\varphi)^2]^{5/2}}$$

$$\frac{dP_y}{d\varphi} \propto \frac{5\gamma^2\varphi_y^2}{[1+\gamma^2\varphi_y^2]^{7/2}}$$

$$\frac{\Delta\omega}{\omega} \approx \frac{1}{N_q}$$