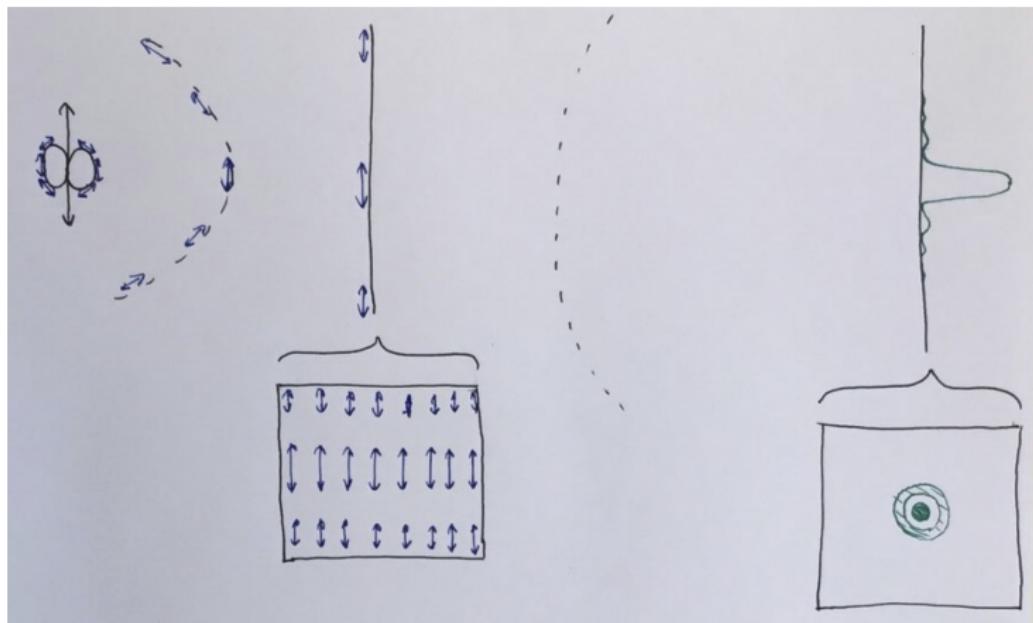


Spatio-angular Transfer Functions

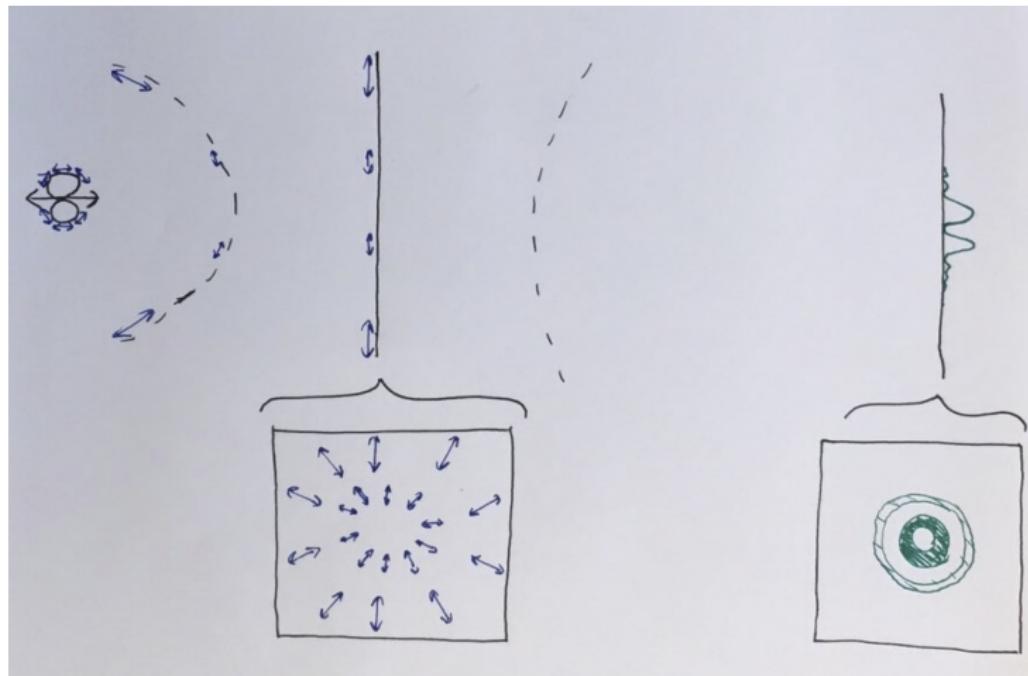
Talon Chandler

March 5, 2018

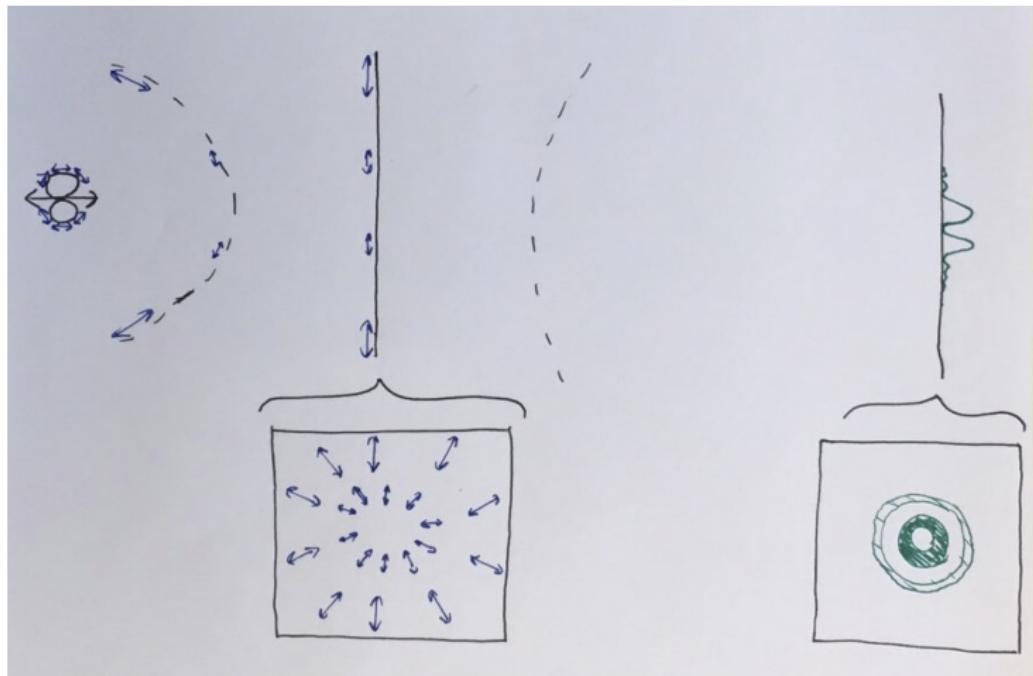
x -oriented dipole point spread function



z -oriented dipole point spread function



Point spread functions—Novotny



Point spread functions—Novotny

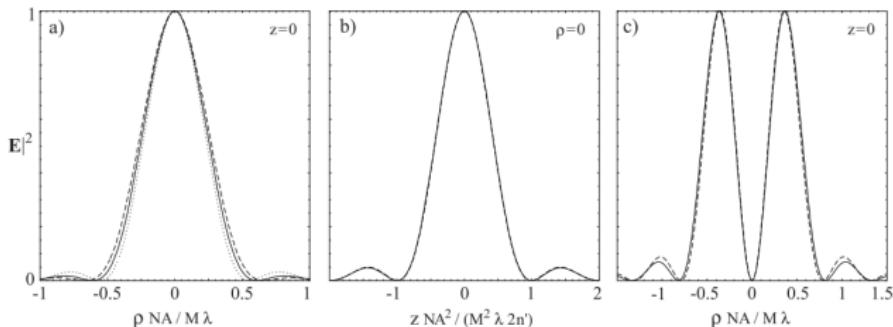
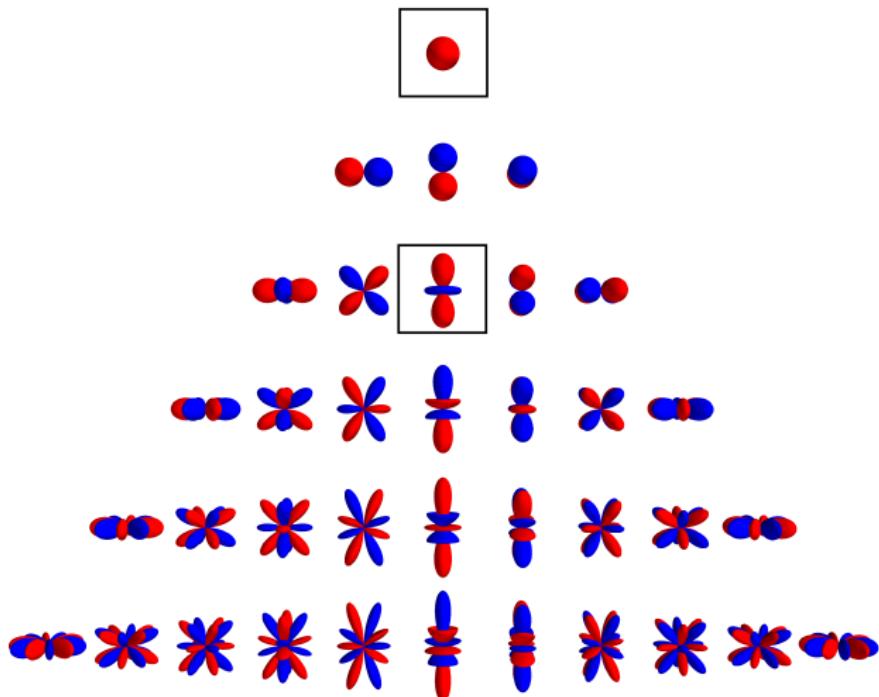


Figure 4.2: a) Point spread function depicted in the image plane ($z=0$) of a dipole with moment $\mu = p_x \mathbf{n}_x$. The solid curve is the paraxial approximation whereas the dashed and dotted curves are the results of exact calculations for a $NA=1.4$ ($n=1.518$) objective lens. The dashed curve has been evaluated along the x -axis and the dotted curve along the y -axis. b) Point spread function evaluated along the optical axis z ($\mu = \mu_x \mathbf{n}_x$). The solid curve is the paraxial approximation and the dashed curve is the exact result for $NA=1.4$. c) Point spread function depicted in the image plane of a dipole with moment $\mu = \mu_z \mathbf{n}_z$. The solid curve is the paraxial approximation and the dashed curve is the exact result for $NA = 1.4$. The figures demonstrate that the paraxial point spread function is a good approximation even for high NA objective lenses!

Only two spherical harmonics in the paraxial
spatio-angular point spread function



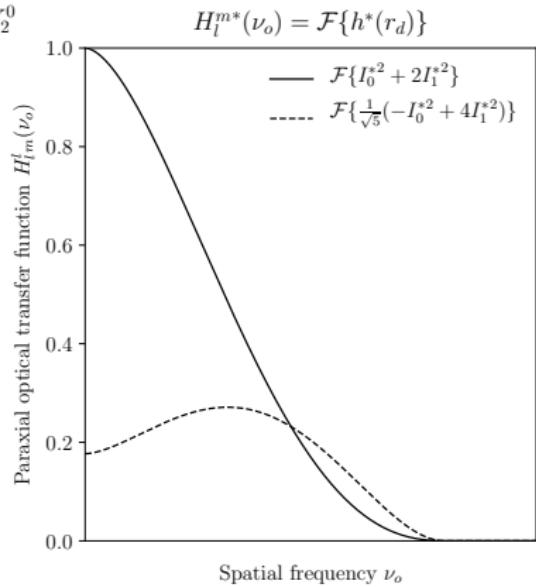
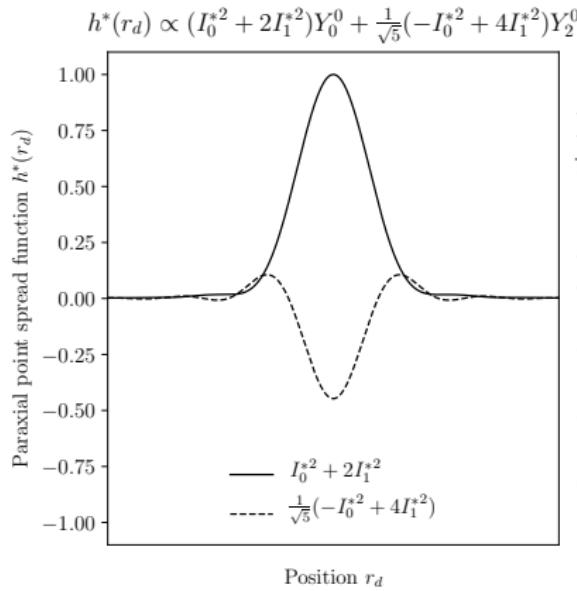
Paraxial spatio-angular point spread function

$$h^*(\mathbf{r}_d; \mathbf{r}_o, \hat{\mathbf{s}}_o) \propto (I_0^{*2} + 2I_1^{*2})Y_0^0(\hat{\mathbf{s}}_o) + \frac{1}{\sqrt{5}} \left(-I_0^{*2} + 4I_1^{*2} \right) Y_2^0(\hat{\mathbf{s}}_o)$$

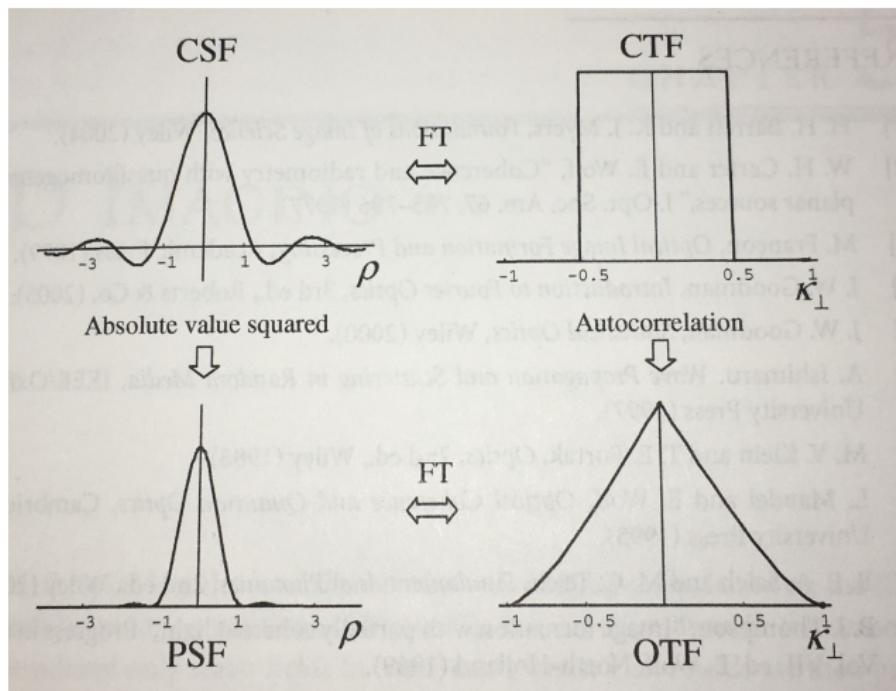
$$I_0^* = \left(\frac{\text{NA}}{n_o} \right)^2 \left[\frac{2J_1(\tilde{r}_d)}{\tilde{r}_d} \right], \quad I_1^* = \left(\frac{\text{NA}}{n_o} \right)^3 \left[\frac{2J_2(\tilde{r}_d)}{\tilde{r}_d} \right],$$

$$\tilde{r}_d = \frac{2\pi \text{NA} r_d}{M\lambda}, \quad \text{NA} = n_o \sin \theta_{\max}, \quad M = \frac{n_o}{n_b} \frac{f_t}{f_o}.$$

Paraxial spatio-angular PSF and OTF



Scalar optics transfer functions—Mertz, Goodman



Electromagnetic optics transfer functions

