Biomicroscopy I - Solutions Exercise Sheet 13

December 10, 2024

1 Detectors

A. **Nyquist criterion.** In order to define the maximum pixel size for given configuration we need to calculate the radius of magnified Airy disc:

$$r_{Airy}^{100x} = 1.22 \cdot \frac{\lambda}{2\text{NA}} \cdot M = 1.22 \cdot \frac{550 \text{ nm}}{2 \cdot 1.2} \cdot 100 \approx 28 \ \mu\text{m}.$$

By further applying Nyquist criterion we get that the maximum pixel size should be:

$$d_{max} = \frac{r_{Airy}^{100x}}{2} \approx 14 \ \mu\text{m}.$$

Consequently, we can define maximum allowed spatial frequency for a bandlimited image to be perfectly reconstructed with the given size of the pixel:

$$B = \frac{1}{2d_{max}} = \frac{1}{r_{Airy}^{100x}} \approx 0.036 \mu\text{m}^{-1}.$$

B. **Collection yield.** In order to define the total yield we need to calculate the fracture of the emitted power collected by the objective:

$$\frac{P_{col}}{P_{em}} = \frac{1}{4\pi} \int_0 \alpha_{max} \sin\theta d\theta \int_0^{2\pi} d\varphi = \frac{1}{2} \left(1 - \cos\alpha_{max}\right),$$

where α_{max} is defined by the numerical aperture of the utilized objective:

$$\alpha_{max} = \arcsin\left(\frac{\text{NA}}{n}\right),$$

which then results in the collection fracture $P_{col}/P_{em} \approx 24.6\%$.The total collection yield should be then calculated as:

$$\text{CY} = \frac{P_{col}}{P_{em}} \cdot T_{\text{optics}} \cdot \text{QE},$$

where we need to take the quantum efficiency of the given detector for the emission wavelength (since we calculate collection efficiency) QE = 40%. By substituting all the values we get the total collection yield as CY $\approx 2.95\%$.