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1 Purpose

Python (and the `matplotlib`, `numpy` libraries) is used to generate plots of wave interference and diffraction patterns to reinforce the results derived in lecture and viewed visually in Lab 5. The intensity pattern generated by N-slit interference, single-slit diffraction are shown, plotted using results derived in class. Additionally, the pattern generated by two finite-width slits (involving both interference and diffraction) is plotted, a result not derived in class.

2 Results

Python environment: Python 3.7.3, Anaconda, Inc. on Linux

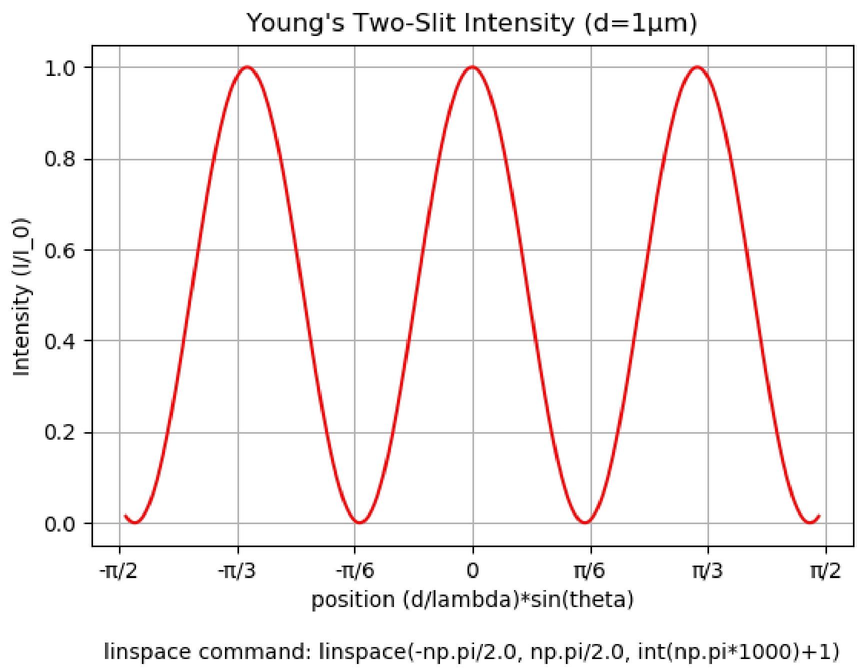

Figure 1: The intensity is clearly sinusoidally periodic w.r.t. δ, the phase difference.

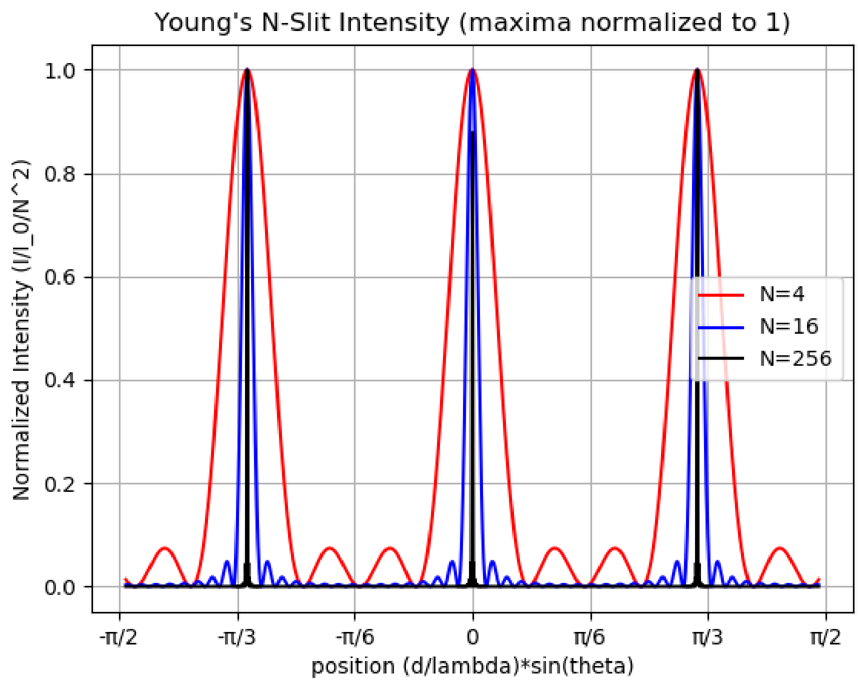

Figure 2: As before, the intensities are periodic w.r.t. δ, but there are proportionally more minor peaks w.r.t. N. Also, the overall intensity ratio I/I_0 is scaled proportional to N^2.

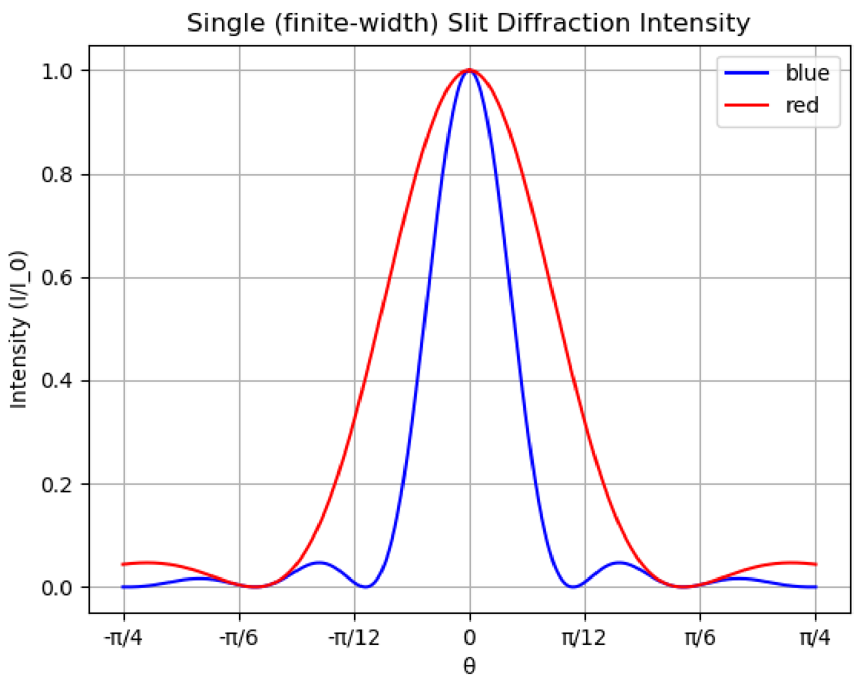

Figure 3: The two diffraction patterns for blue and red have the same overall shape, but the higher wavelength (red) produces a larger spread.

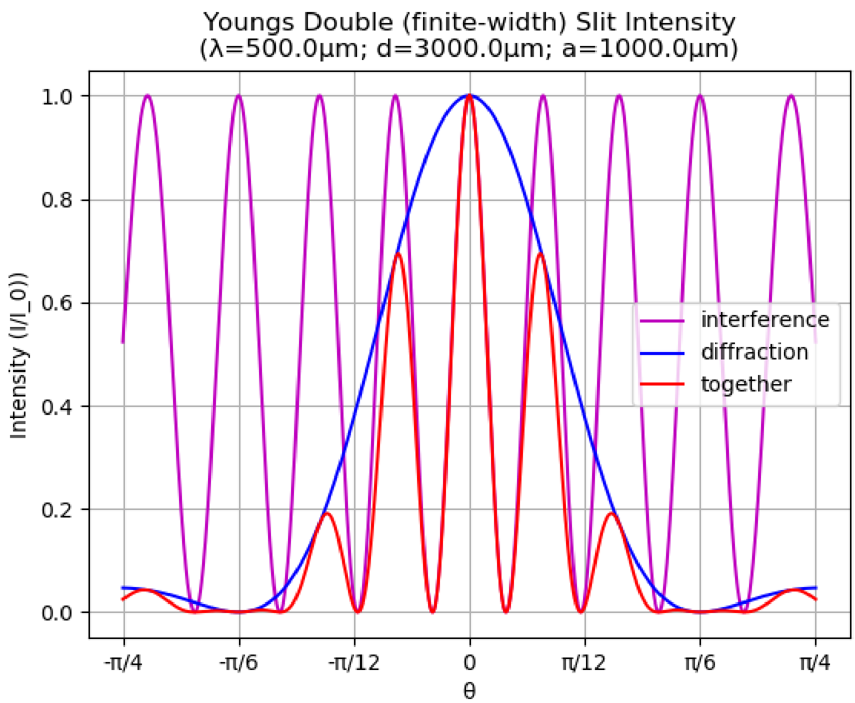

Figure 4: The interference pattern is modulated by the diffraction pattern of the finite-width slit. As explored in the Questions section, this modulation causes an unexpected peak at $m = 3$.

3 Conclusion

The plots produce the expected results. In particular, the two-slit intensity pattern shows the well-known periodic pattern with peaks of equal height (a uniform light-dark pattern, as observed in Lab 5). The N-slit intensity pattern shows peak maxima at the same locations, with peaks narrowing, number of small maxima increasing, and height of I/I_0 increasing (with large peak maxima at $I/I_0 = N^2$) as N increases. For the single finite-width slit, a higher wavelength produces a wider diffraction pattern, as expected. For two finite-width slits interfering and diffracting, we get an interference pattern with the same frequency as the thin-slit diffraction pattern, but with an intensity that is bounded above by the diffraction pattern of a single-wide slit. As discussed in (Section 4: Question), the interference pattern may have missing peaks near where the diffraction pattern has a minima.

4 Question

4.1 Why is the m=3 order missing in Figure 2?

Visually, it is clear that the thid peak lies under the minima for the diffraction curve. Since the interference/diffraction pattern caused by the two finite-width slits is the product of the interference and diffraction patterns, it is limited by the height of the height of the diffraction curve, which is 0 at $m = 3$ according to the following calculations.

$$\lambda = 500.0\mu\text{m}; d = 3000.0\mu\text{m}; a = 1000.0\mu\text{m}$$

Interference pattern height at $m = 3$:

$$\sin\theta = \frac{m\lambda}{d} \Rightarrow \sin\theta = \left(\frac{3 \cdot 500.0\mu\text{m}}{3000.0\mu\text{m}}\right) = 0.5000$$

$$(\theta = 0.5236\text{rad})$$

$$(I/I_0 = 1)$$

Diffraction pattern height at $\theta = \theta_3$.

$$I/I_0 = \left(\frac{\sin\frac{\pi a \sin\theta}{\lambda}}{\frac{\pi a \sin\theta}{\lambda}}\right)^2 = \left(\frac{\sin\frac{\pi(1000.0\mu\text{m})(0.5)}{500.0\mu\text{m}}}{\frac{\pi(1000.0\mu\text{m})(0.5)}{500.0\mu\text{m}}}\right)^2 = \left(\frac{\sin\pi}{\pi}\right)^2 = 0.0000$$

Combined pattern height at $\theta = \theta_3$.

$$\frac{I}{I_0} = 1 \cdot 0 = 0$$