

# Coupled Wave Theory of Distributed Feedback Lasers

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This repository applies the calculations of Kogelnik and Shank in J. Appl. Phys. 43, 2327 (1972) [1] to a few use cases. The calculations have been validated by replotting the graphs from [1].

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[1] H. Kogelnik and C. V. Shank, Coupled Wave Theory of Distributed Feedback Lasers. Journal of Applied Physics, 43 (1972) 2327–2335. <https://doi.org/10.1063/1.1661499>.

## COUPLED-WAVE THEORY OF DISTRIBUTED FEEDBACK LASERS

This page comprises simulations from the manuscript H. Kogelnik and C. V. Shank, *Coupled-Wave Theory of Distributed Feedback Lasers*. Journal of Applied Physics, **43** (1972) 2327–2335. doi:10.1063/1.1661499

We compare the different simulations in the paper with our code.

### 1.1 Dispersion diagram for index modulation for various gain to coupling parameter ratios

Fig. 1.1 calculates the dispersion diagram for index modulation for various gain ( $\alpha_o$ ) to coupling ( $\kappa$ ) parameter ratios. In case of index modulation we have that  $\kappa = \pi n_1 / \lambda_o$ . We observe that the calculated result fits the result from [1], as can be seen in Fig. 1.2.

### 1.2 Dispersion diagram for gain modulation for various gain to coupling parameter ratios

Fig. 1.3 calculates the dispersion diagram for index modulation for various gain ( $\alpha_o$ ) to coupling ( $\kappa$ ) parameter ratios. In case of index modulation we have that  $\kappa = \frac{1}{2}j\alpha_1$ . We observe that the calculated result fits Fig. 1.4.

### 1.3 Mode spectrum for index coupling

### 1.4 Mode spectrum for gain coupling

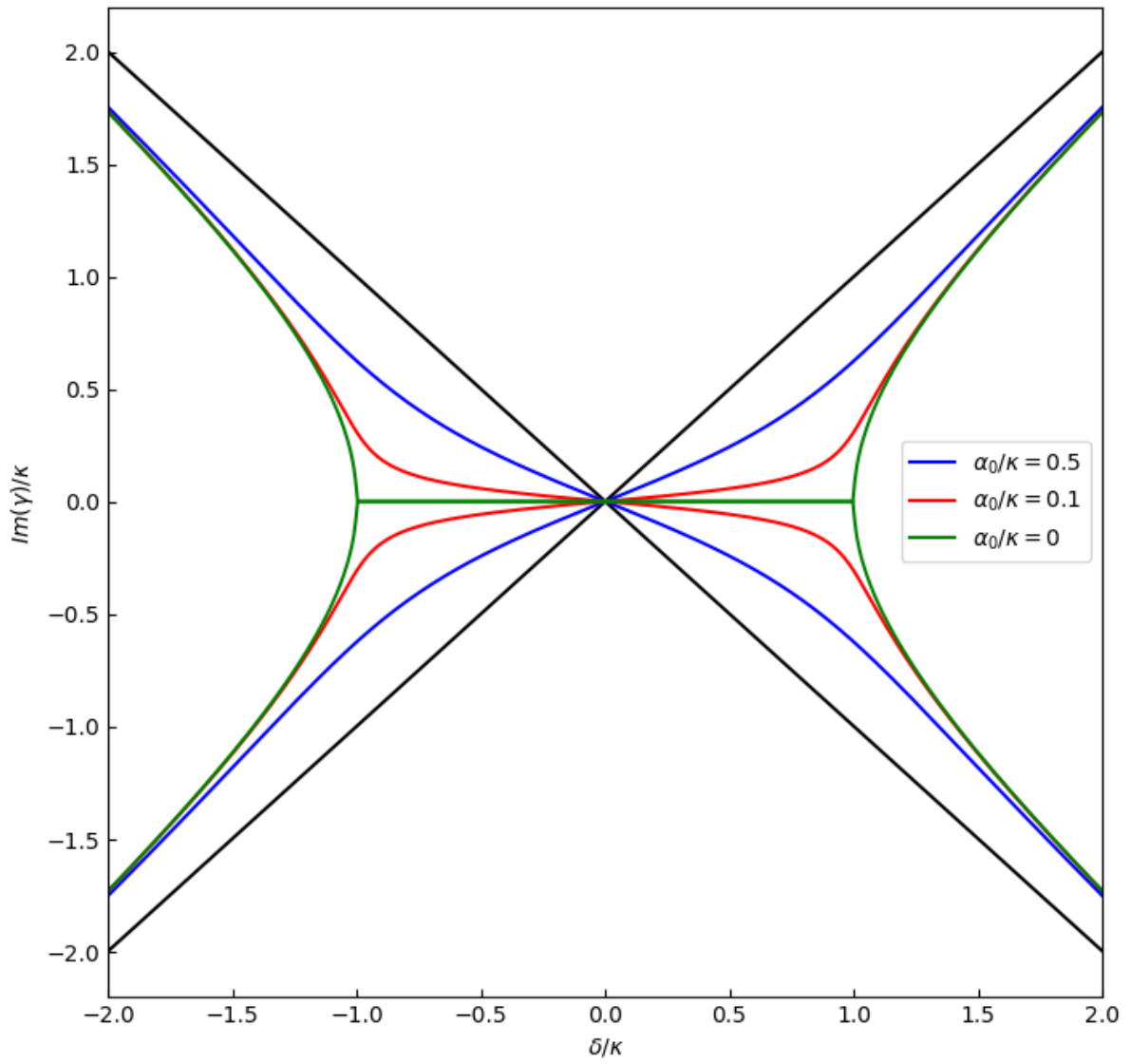


Fig. 1.1: Calculated dispersion diagram for index modulation for various gain to coupling parameter ratios

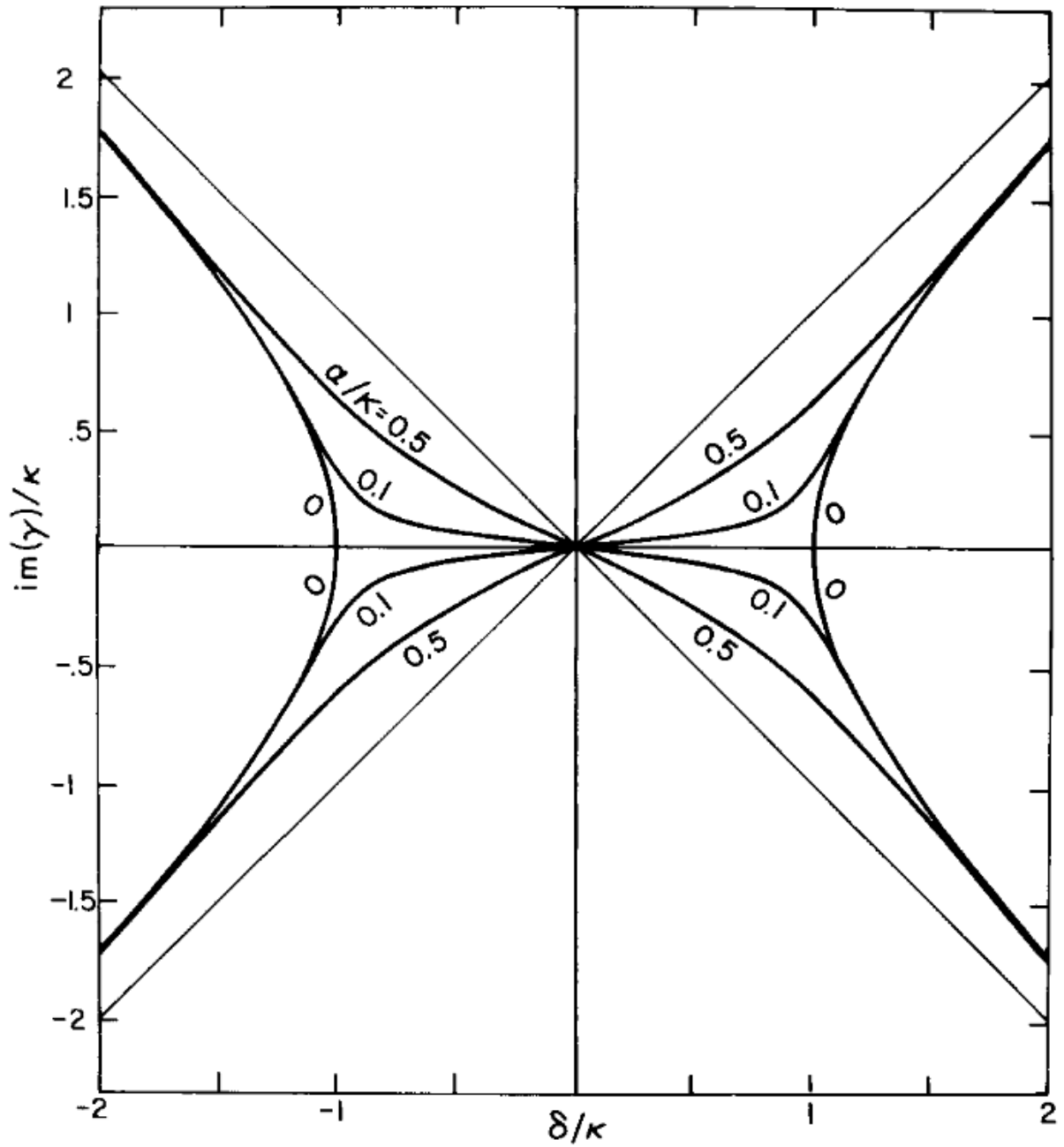


Fig. 1.2: Dispersion diagram for index modulation for various gain to coupling parameter ratios

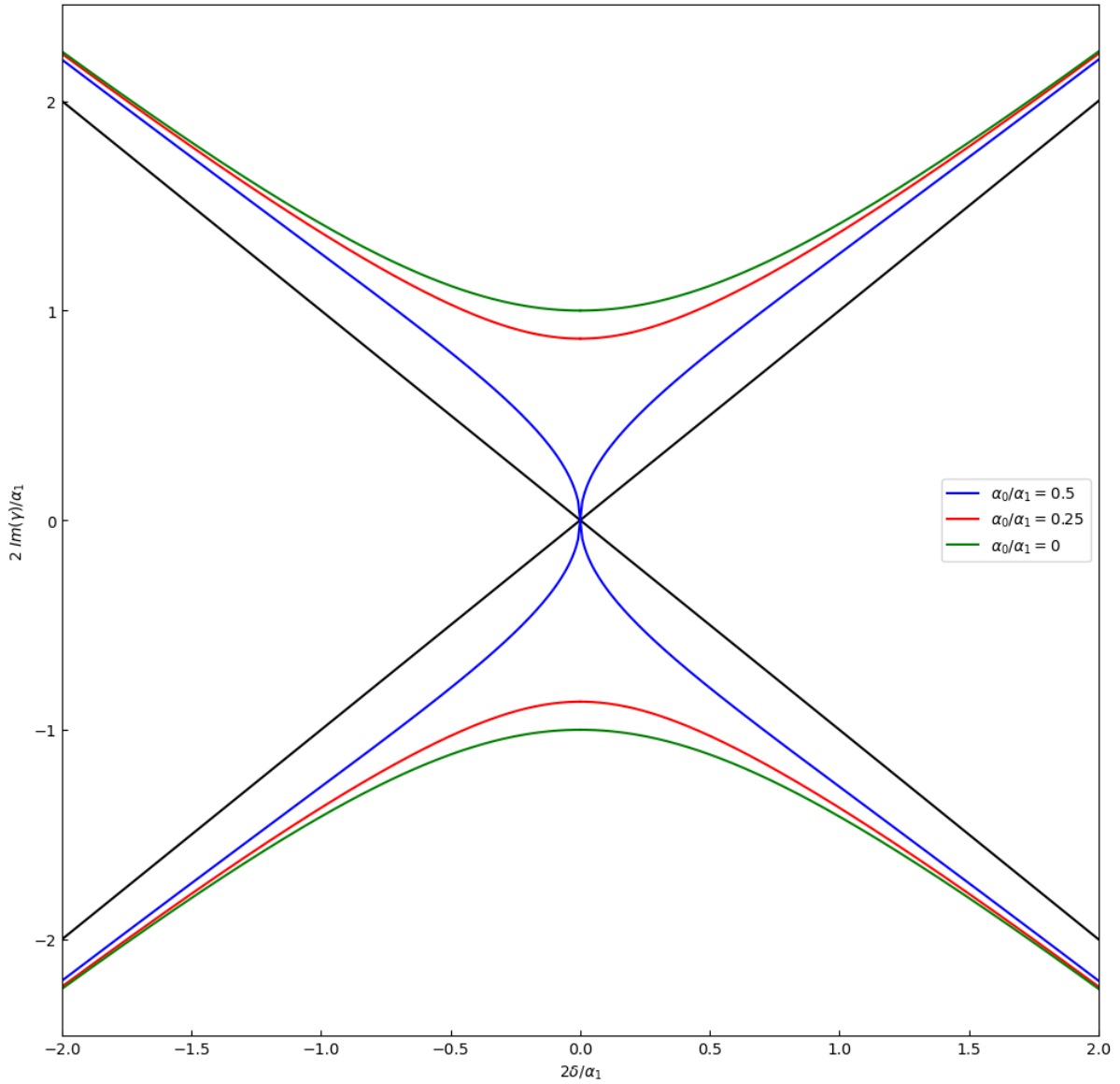


Fig. 1.3: Calculated dispersion diagram for gain modulation for various gain to coupling parameter ratios

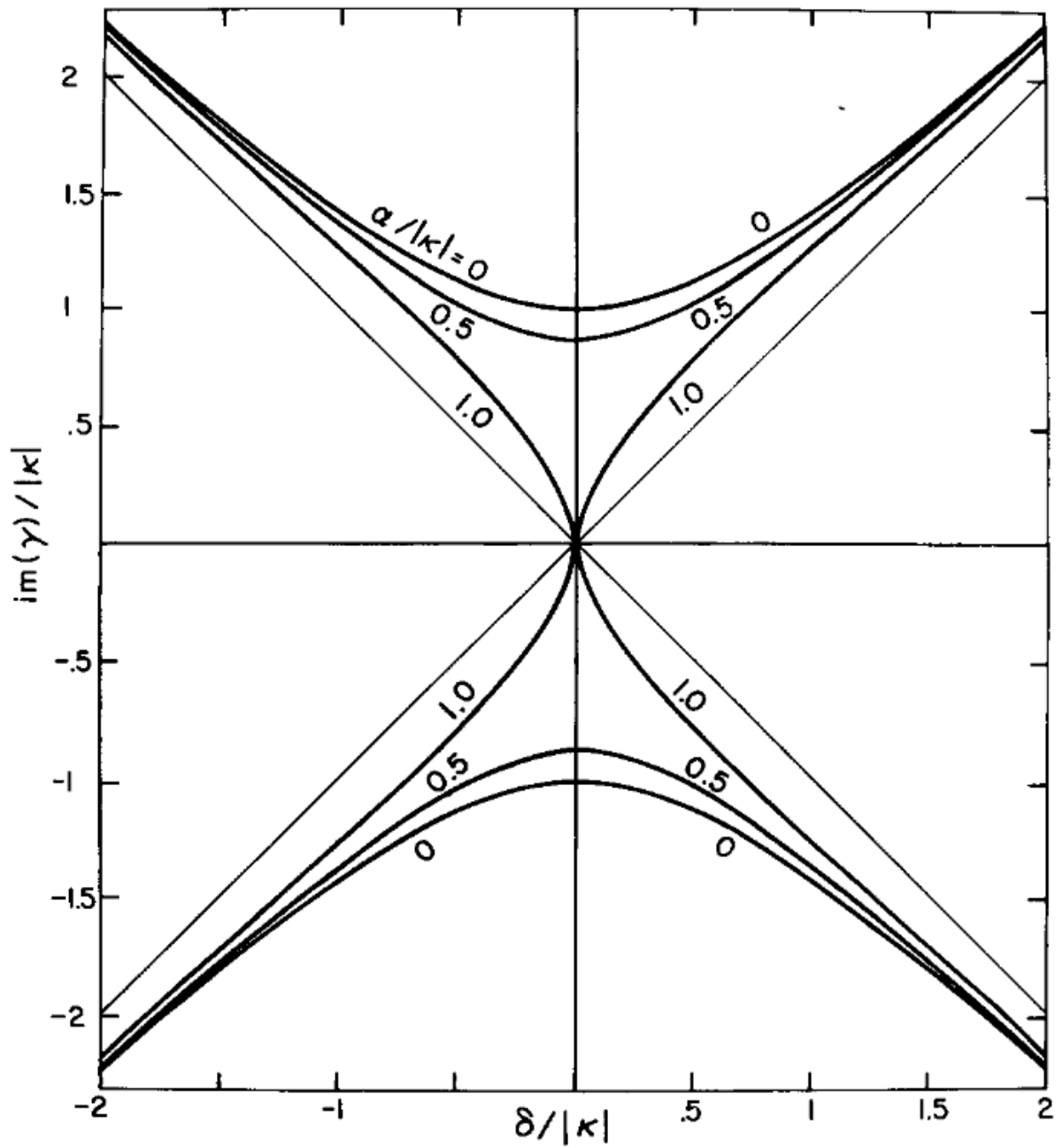


Fig. 1.4: Dispersion diagram for gain modulation for various gain to coupling parameter ratios



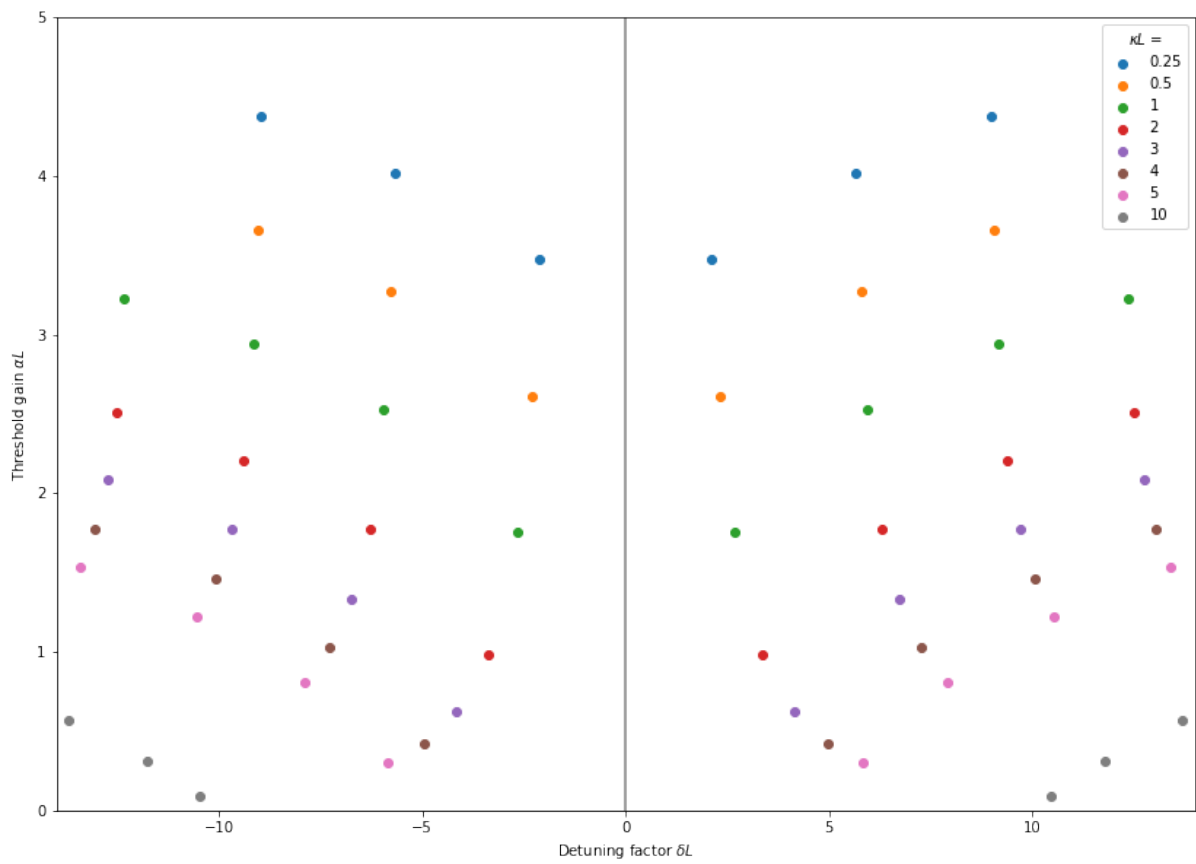


Fig. 1.5: Calculated gain required for threshold vs frequency deviation from the Bragg condition for index modulation

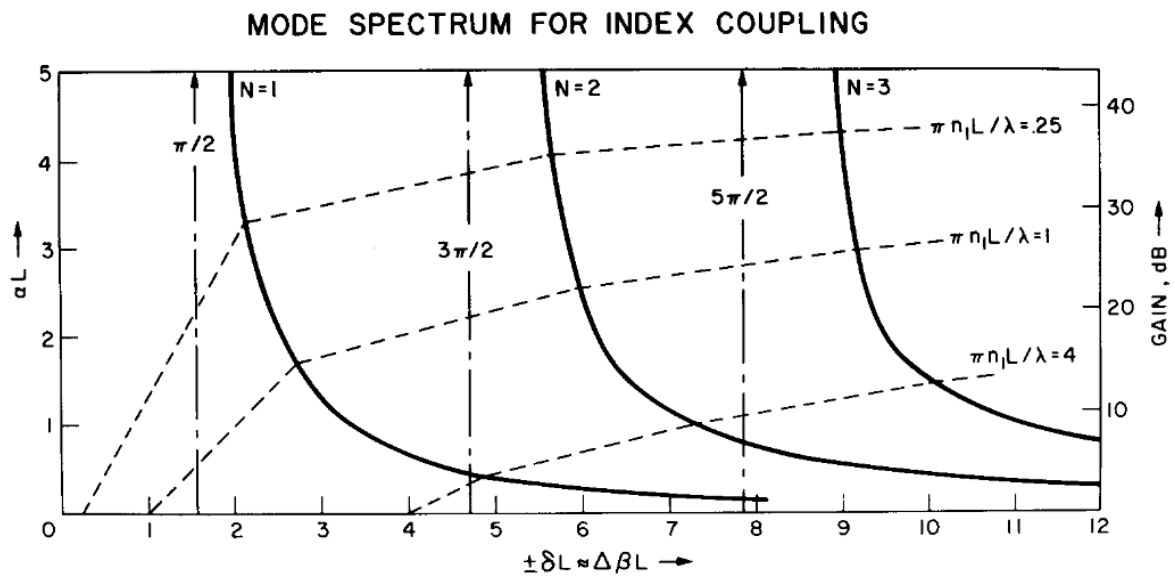


Fig. 1.6: Plot of the gain required for threshold vs frequency deviation from the Bragg condition for an index modulation. Only half of the spectrum is shown because of symmetry.

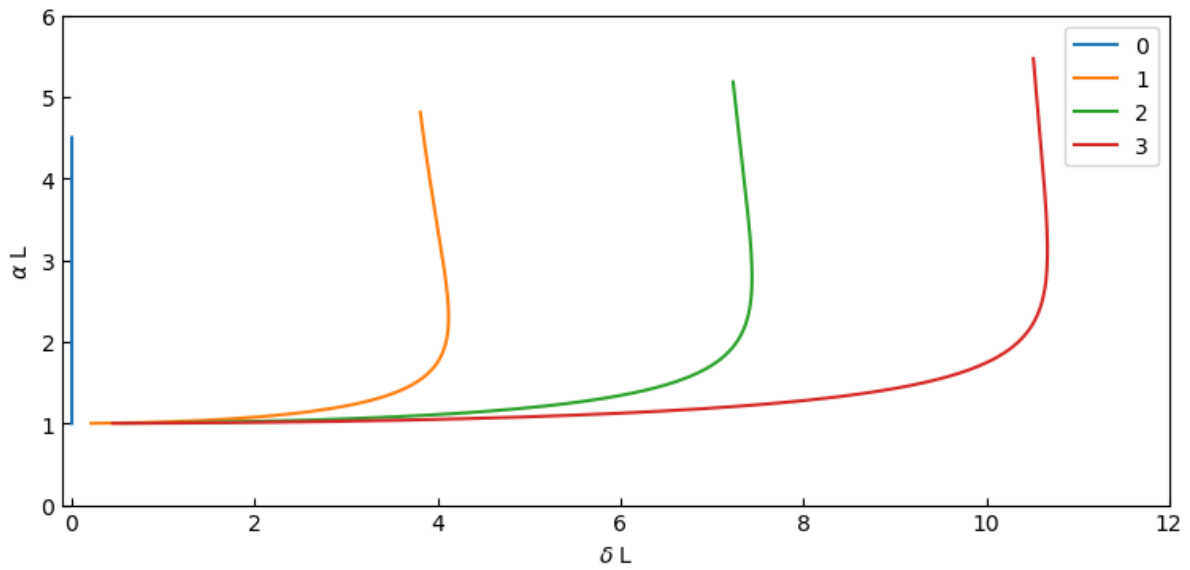


Fig. 1.7: Calculated DC gain required for threshold vs frequency deviation from the Bragg condition for gain modulation

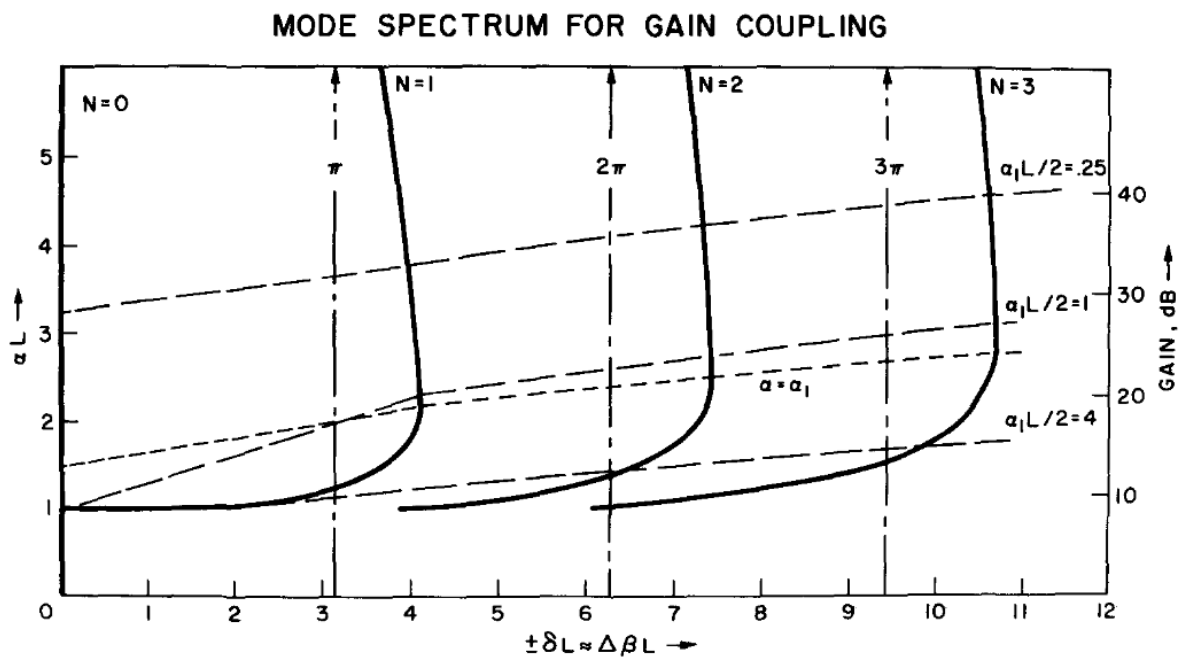


Fig. 1.8: Plot of the DC gain required for threshold vs frequency deviation from the Bragg condition for gain modulation. Only half of the spectrum is shown because of symmetry.

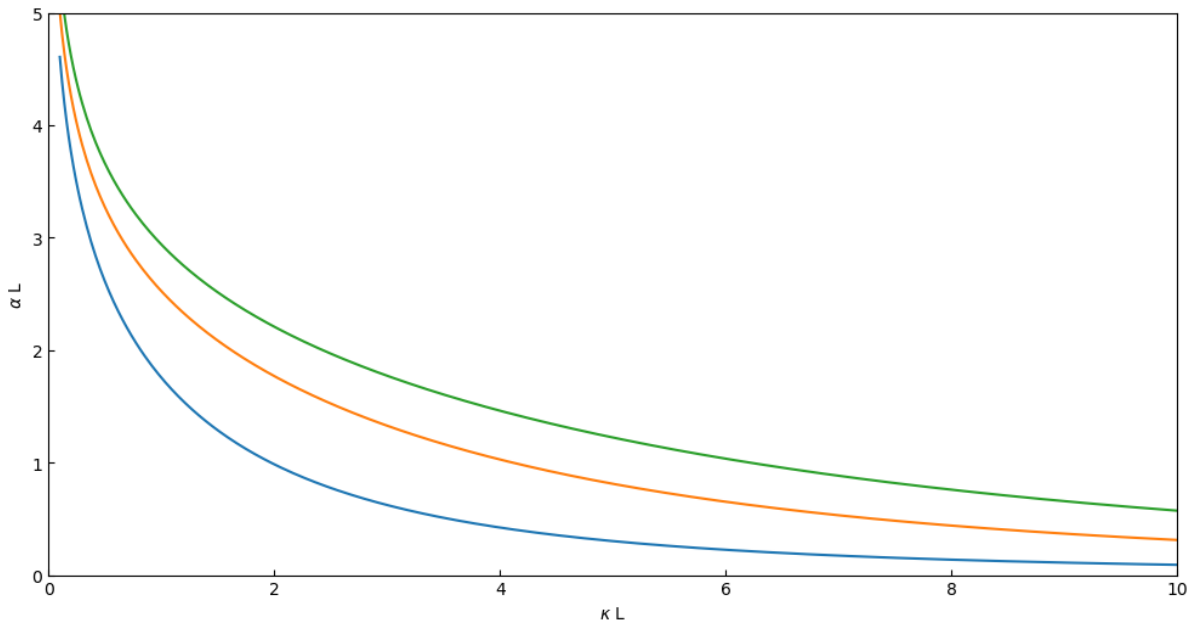


Fig. 1.9: Calculated gain at threshold vs coupling strength for various modes

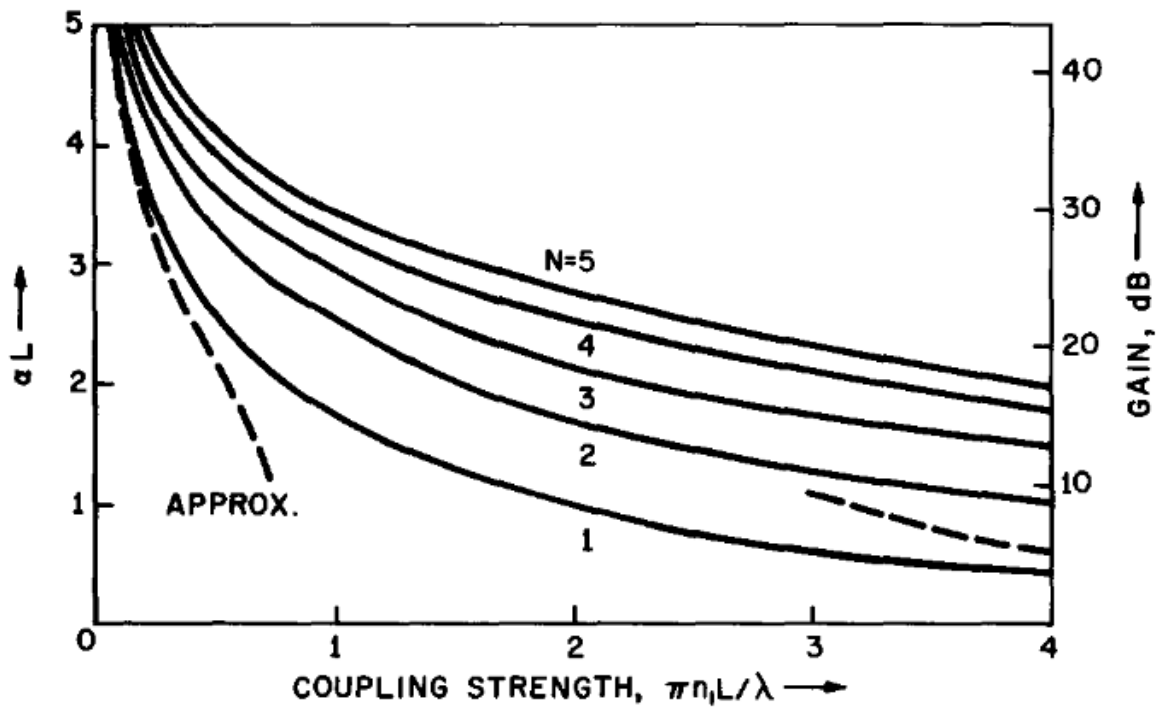


Fig. 1.10: Plot of the gain at threshold vs coupling strength for various modes. The mode number  $N$  refers to a set of modes placed symmetrically about the Bragg frequency.

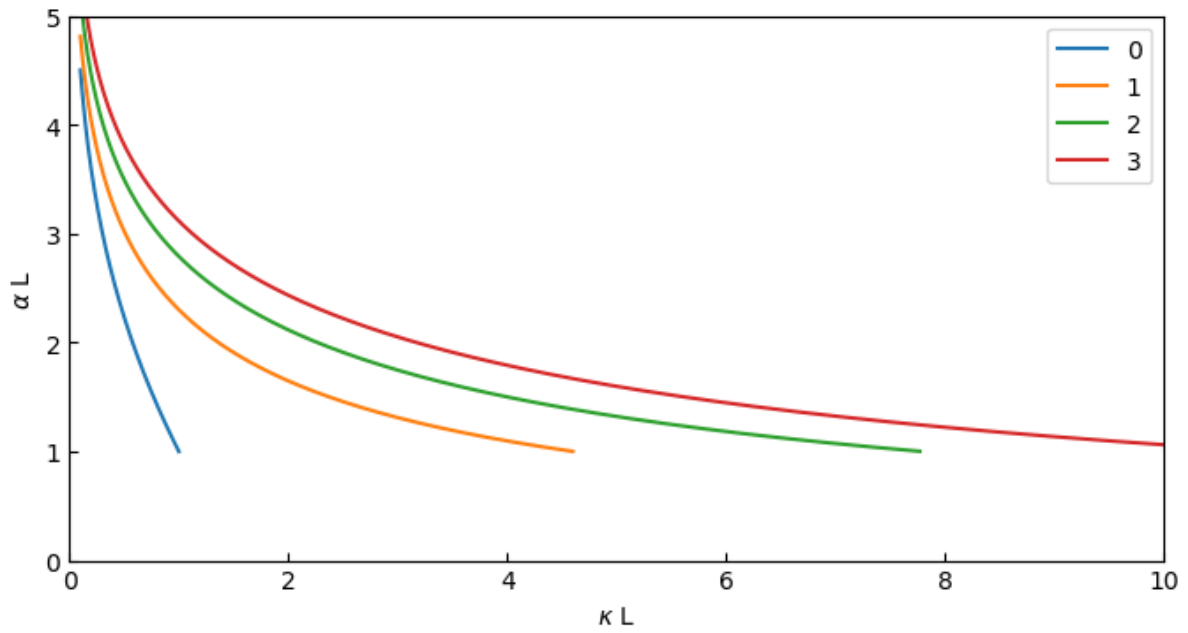


Fig. 1.11: Calculated gain at threshold vs coupling strength for various modes

### THRESHOLD FOR GAIN COUPLING

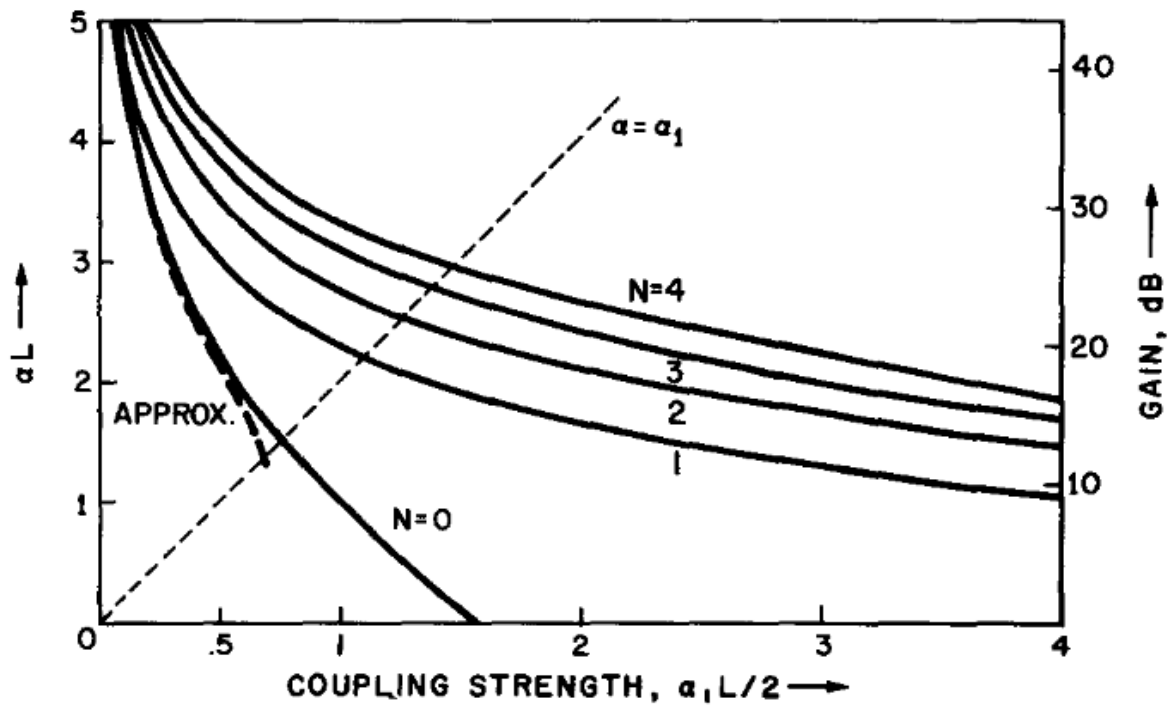


Fig. 1.12: Plot of the gain at threshold vs coupling strength for various modes. The  $N=0$  mode corresponds to a mode at the Bragg frequency. The numbers  $N>0$  correspond to a set of modes symmetrically placed about the Bragg frequency.

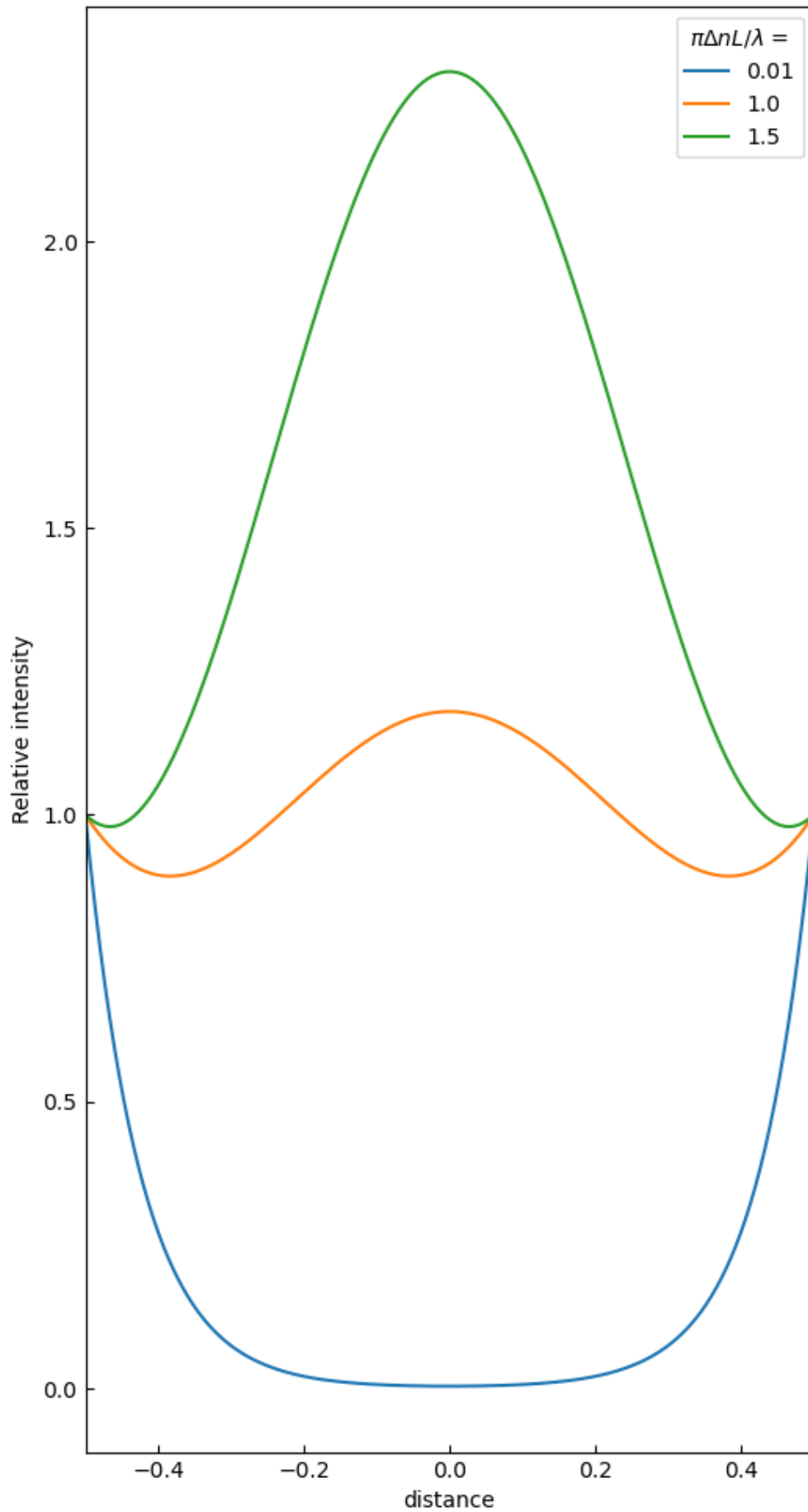


Fig. 1.13: Calculated gain at threshold vs coupling strength for various modes

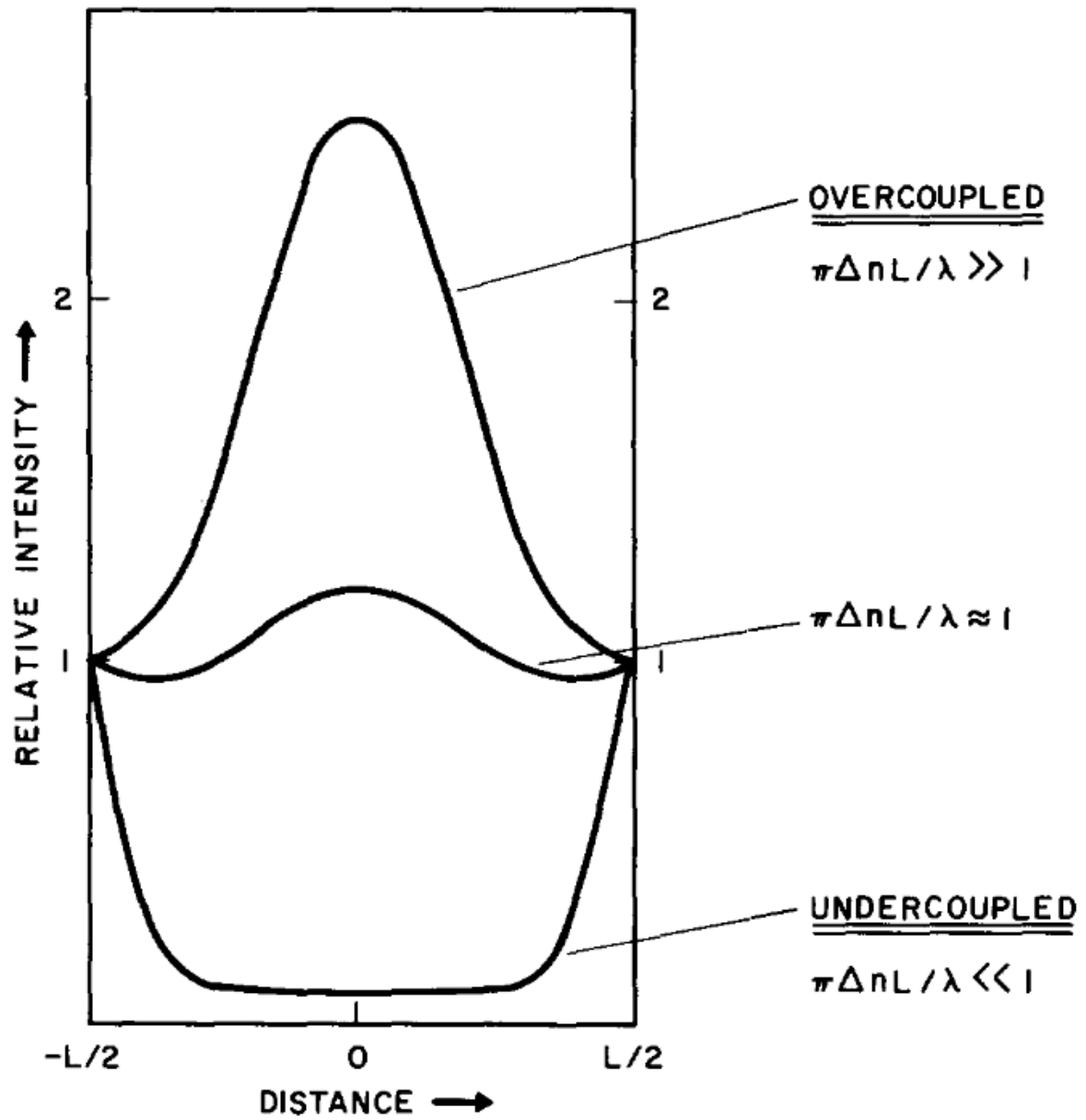


Fig. 1.14: Plot of the spatial intensity distribution of the lowest order modes at various coupling levels.

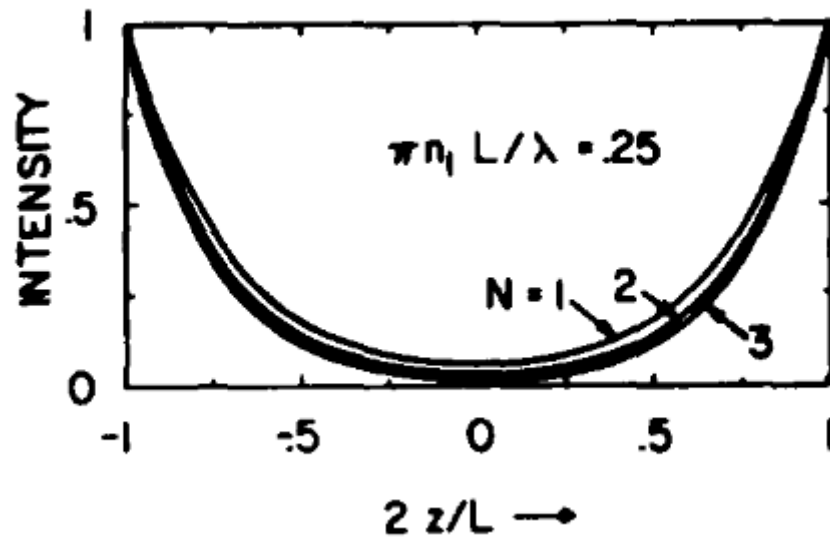


Fig. 1.15: Plot of the spatial intensity distribution for the first three modes at  $\pi n_1 L / \lambda = 0.25$ .

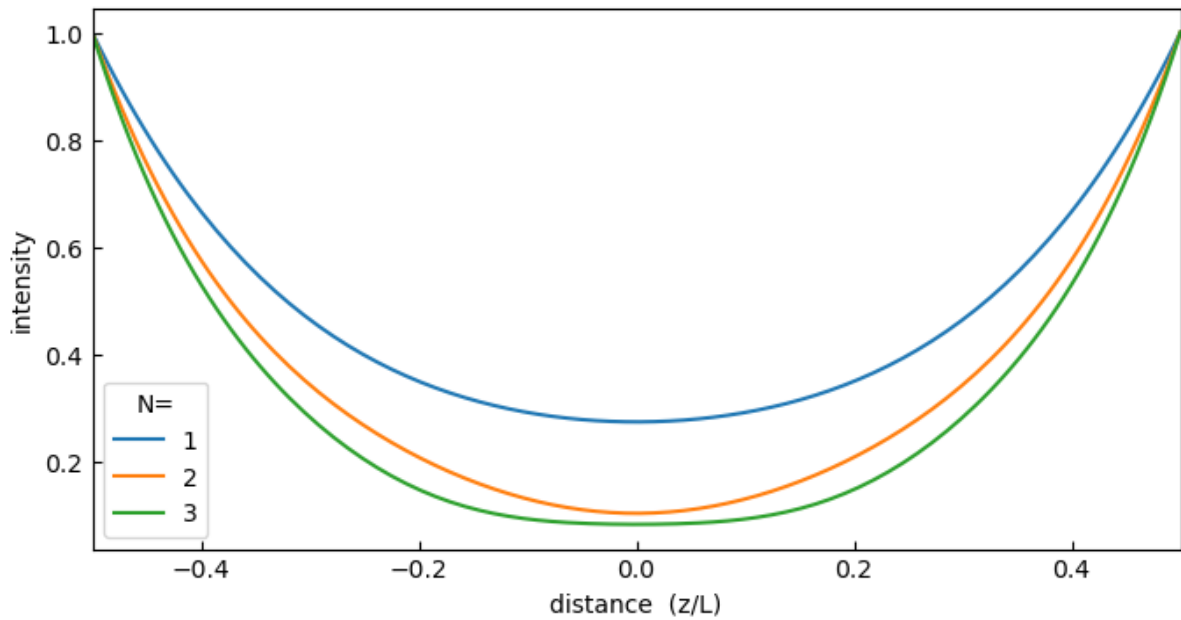


Fig. 1.16: Calculated spatial intensity distribution for the first three modes

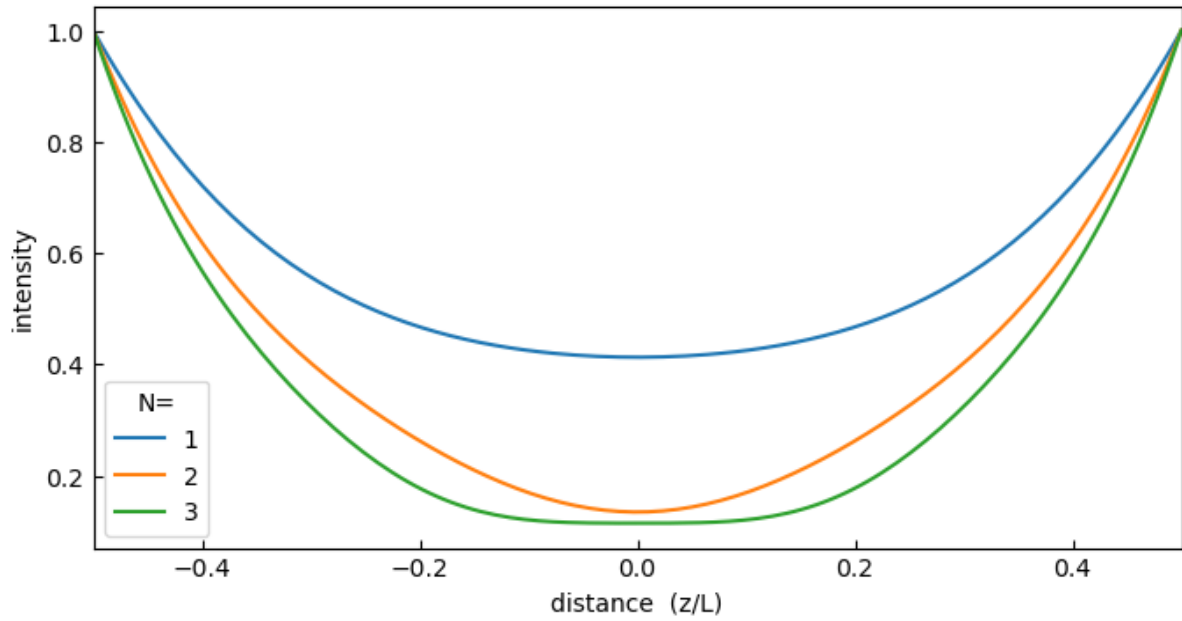


Fig. 1.17: Calculated spatial intensity distribution for the first three modes

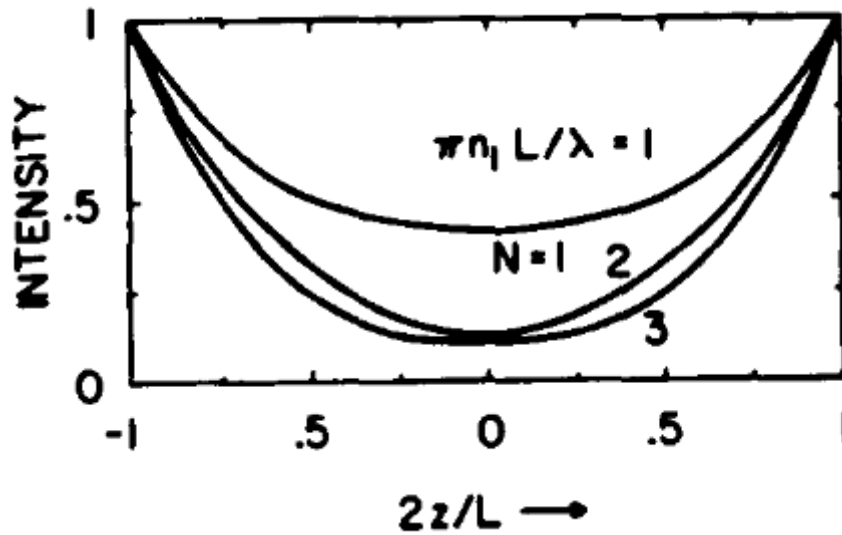


Fig. 1.18: Plot of the spatial intensity distribution for the first three modes at  $\pi n_1 L / \lambda = 1$ .



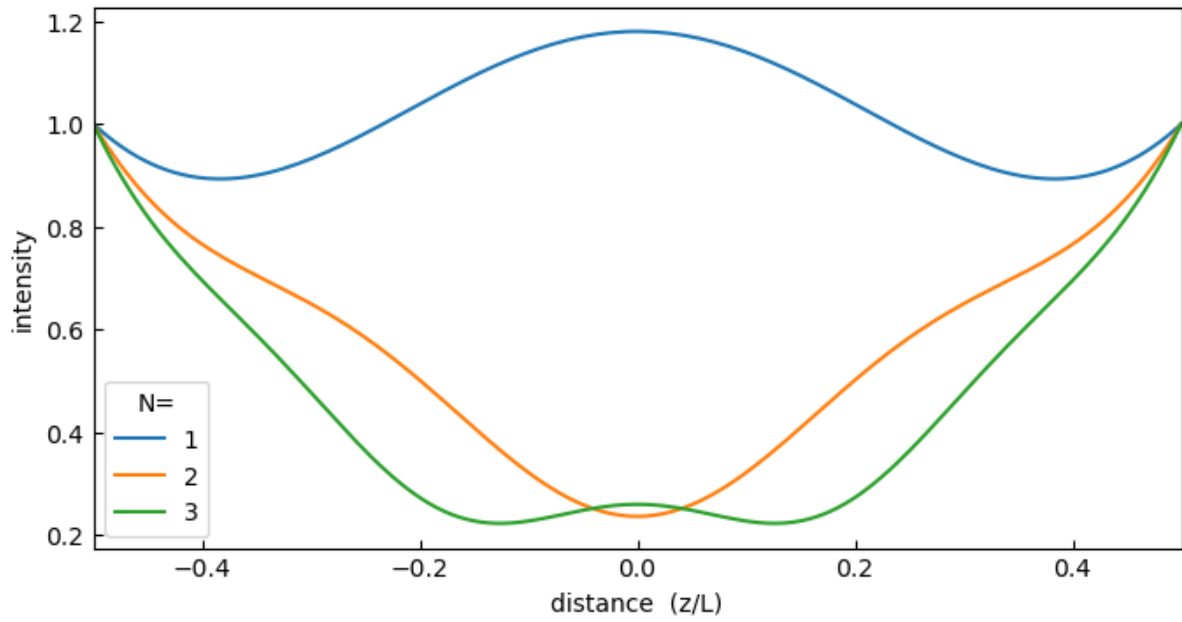
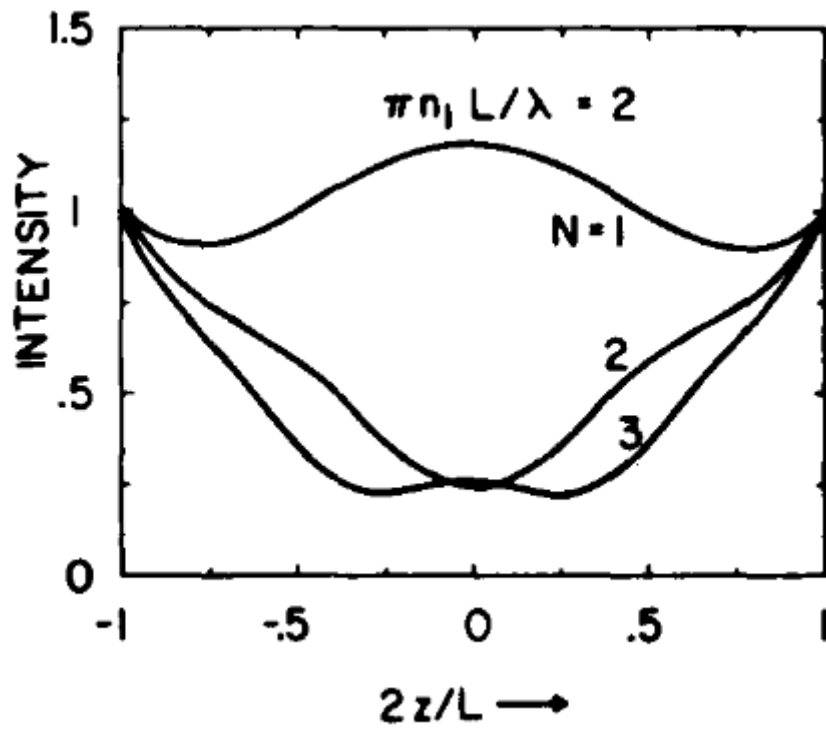


Fig. 1.19: Calculated spatial intensity distribution for the first three modes


 Fig. 1.20: Plot of the spatial intensity distribution for the first three modes at  $\pi n_i L / \lambda = 2$ .

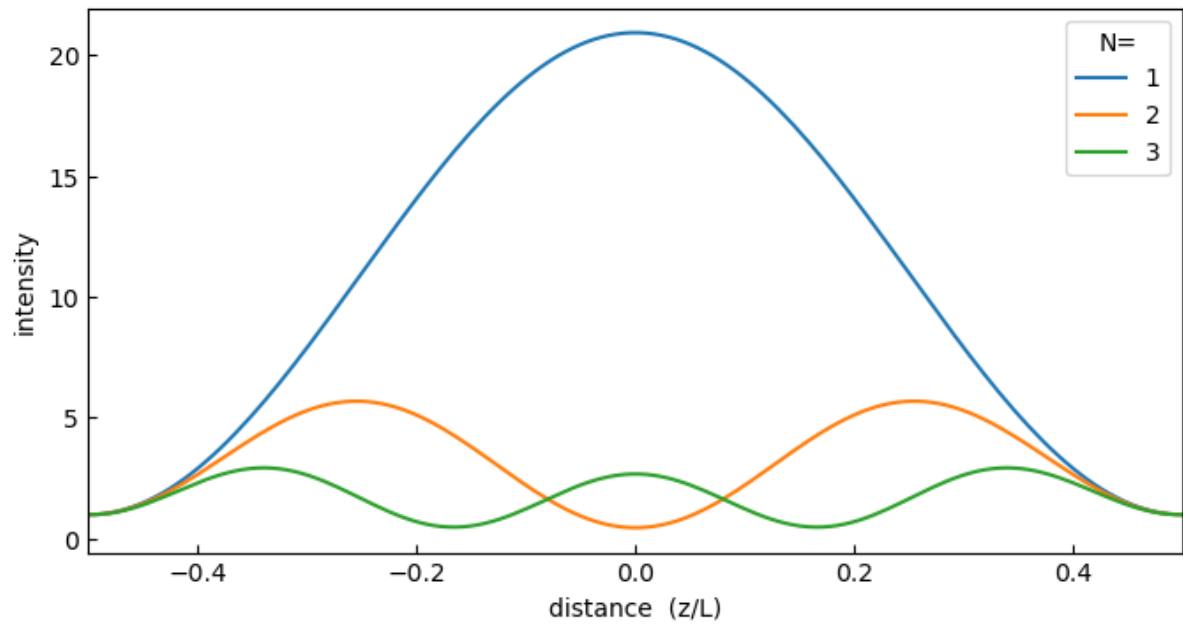


Fig. 1.21: Calculated spatial intensity distribution for the first three modes

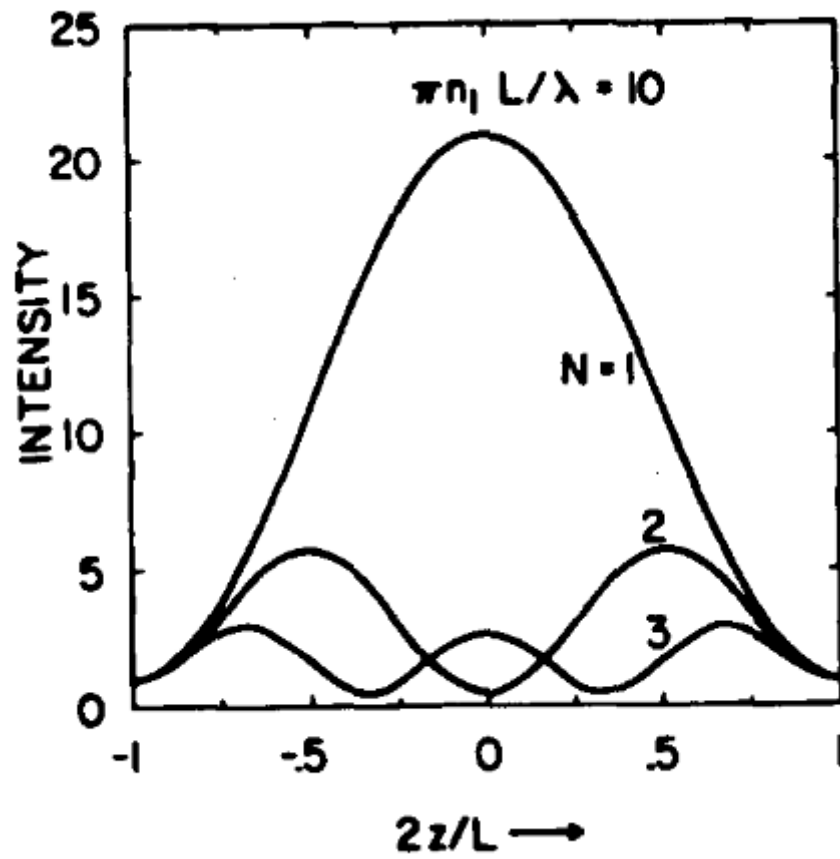


Fig. 1.22: Plot of the spatial intensity distribution for the first three modes at  $\pi n_i L / \lambda = 10$ .

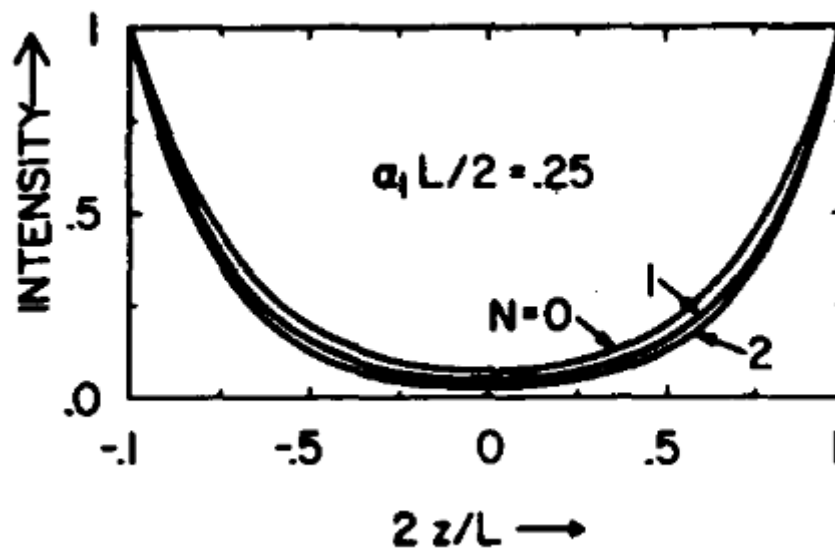


Fig. 1.23: Plot of the spatial intensity distribution for the first three modes at  $\alpha L / 2 = 0.25$ .

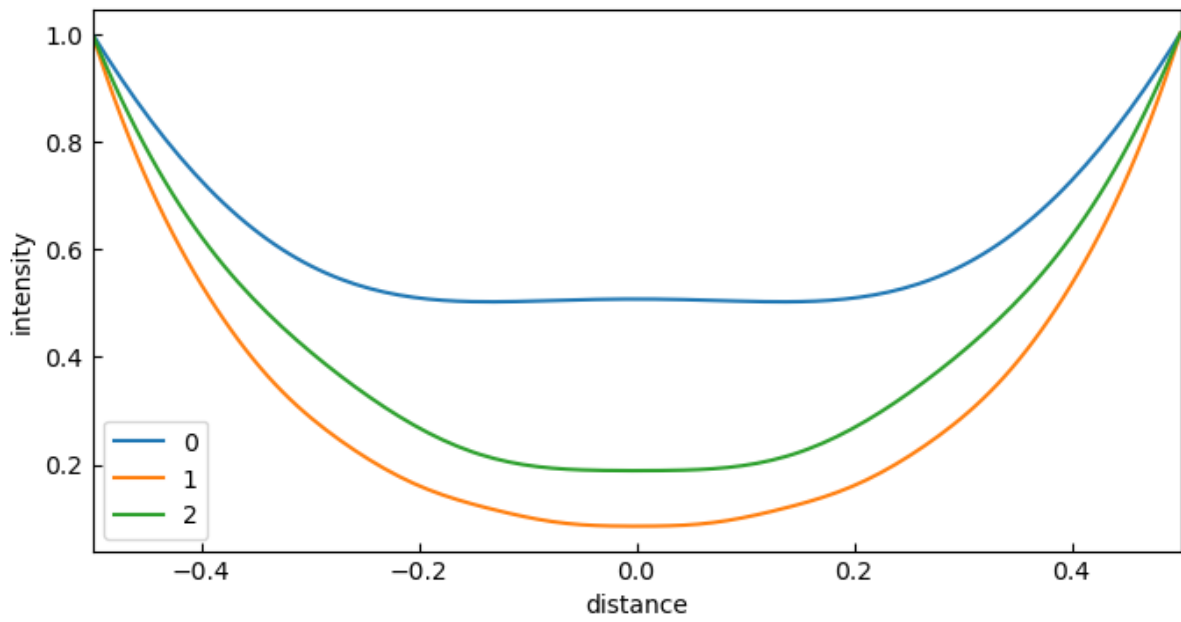


Fig. 1.24: Calculated spatial intensity distribution for the first three modes at  $L/2 = 1$

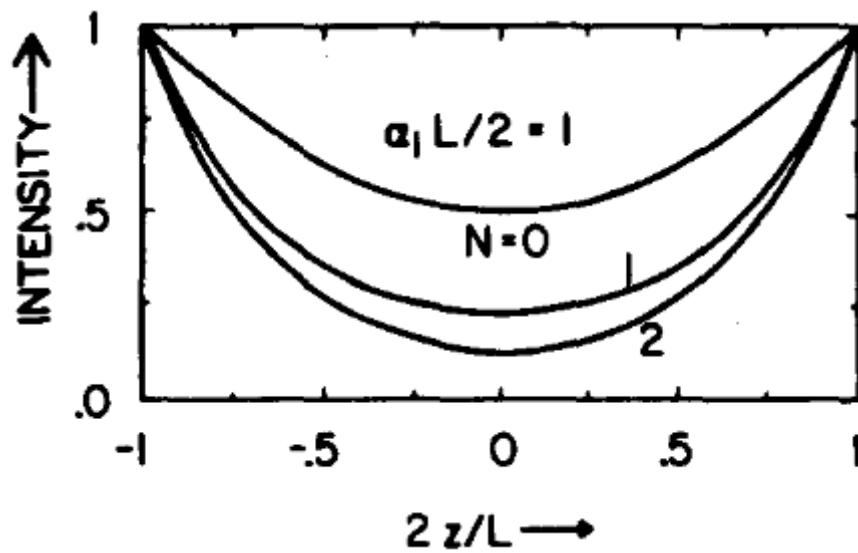


Fig. 1.25: Plot of the spatial intensity distribution for the first three modes at  $\alpha L/2 = 1$ .

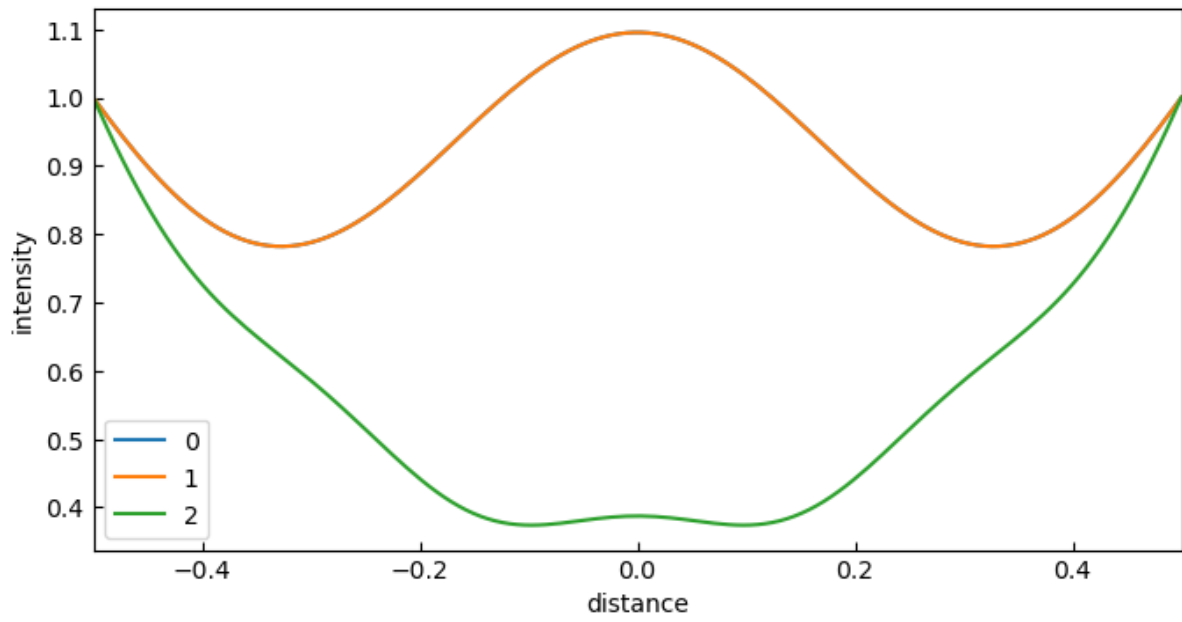


Fig. 1.26: Calculated spatial intensity distribution for the first three modes at  $L/2 = 2$

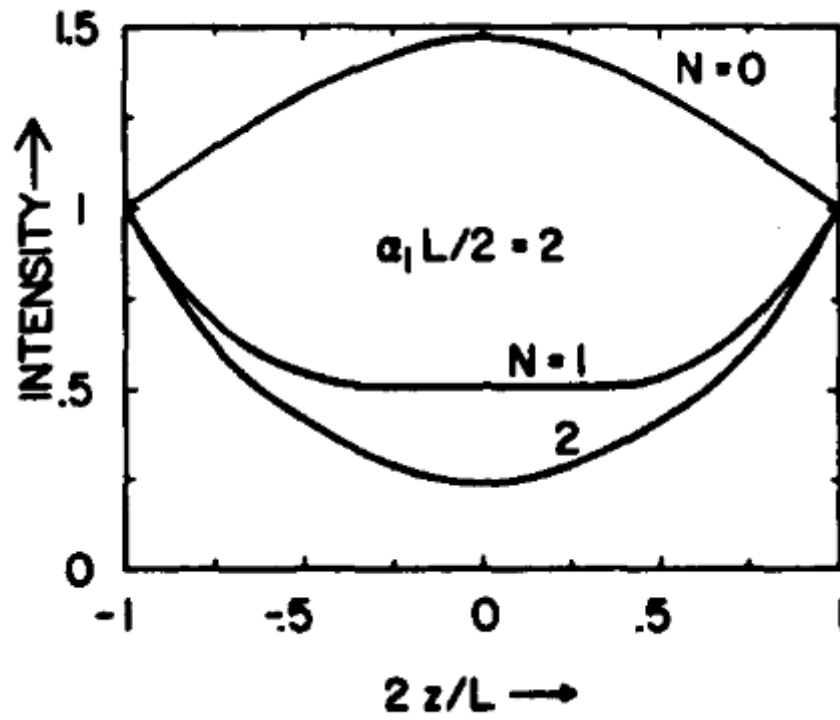


Fig. 1.27: Plot of the spatial intensity distribution for the first three modes at  $\alpha L/2 = 2$ .

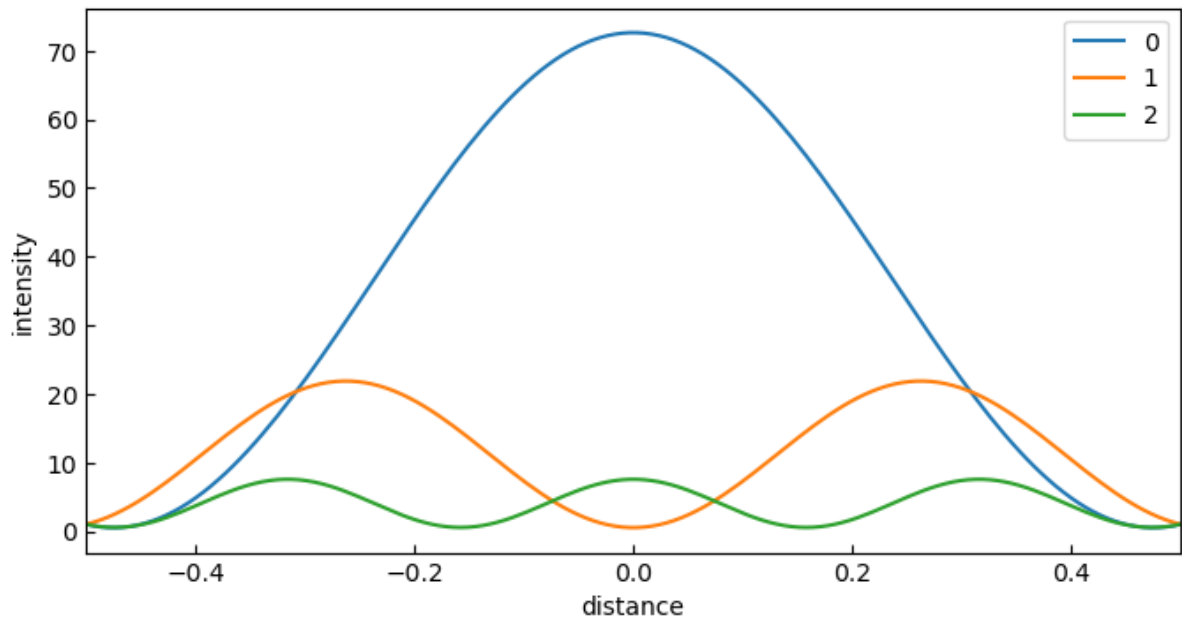


Fig. 1.28: Calculated spatial intensity distribution for the first three modes at  $L/2 = 10$

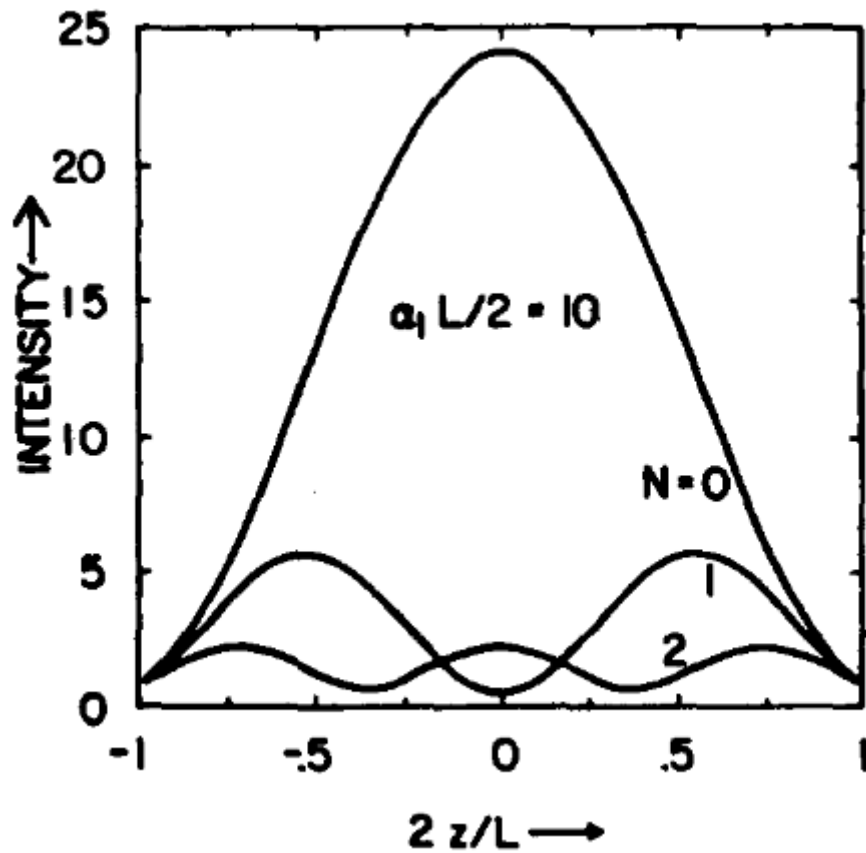


Fig. 1.29: Plot of the spatial intensity distribution for the first three modes at  $\alpha L/2 = 10$ .

## UV-NANOIMPRINTED DISTRIBUTED-FEEDBACK PEROVSKITE LASING

This chapter comprises simulations from the manuscript:

Iakov Goldberg, Nirav Annavarapu, Simon Leitner, Karim Elkhoully, Fei Han, Tibor Kuna, Weiming Qiu, Cedric Rolin, Jan Genoe, Robert Gehlhaar and Paul Heremans, “*Multimode Lasing in All-Solution-Processed UV-Nanoimprinted Distributed Feedback MAPbI<sub>3</sub> Perovskite Waveguides*”, submitted manuscript

The calculation of the modes is done in accordance to [1].

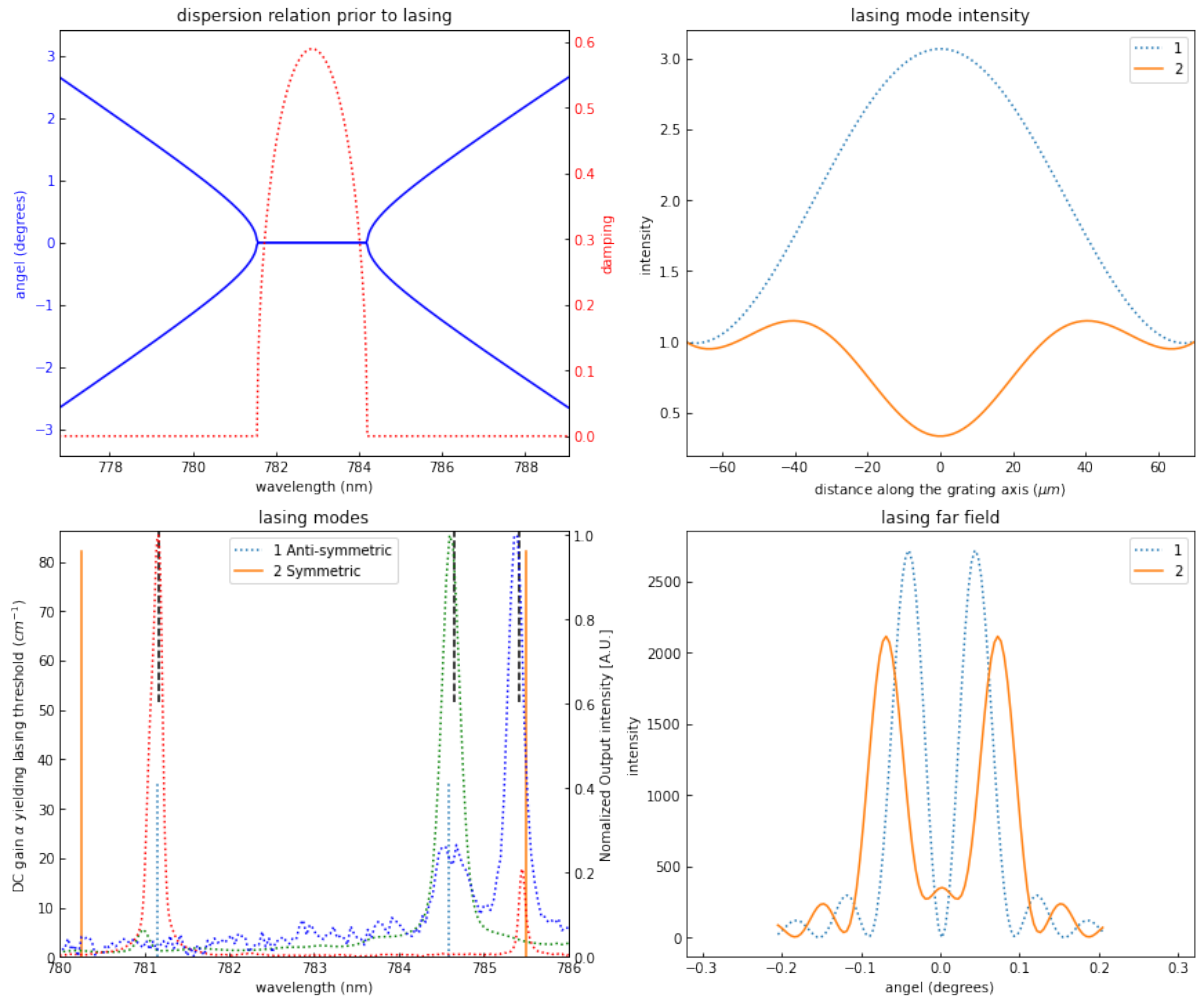


Fig. 2.1: Upper left: calculated dispersion relation prior to lasing, Upper right: intensity of the lasing mode in the near field, lower left: required DC gain for the lasing threshold, the dotted lines show the measured lasing lines at 3 different locations, lower right: far field lasing intensity as a function of the angle





**REFERENCES**

## BIBLIOGRAPHY

- [1] H. Kogelnik and C. V. Shank. Coupled-Wave Theory of Distributed Feedback Lasers. *Journal of Applied Physics*, 43(5):2327–2335, May 1972. doi:[10.1063/1.1661499](https://doi.org/10.1063/1.1661499).