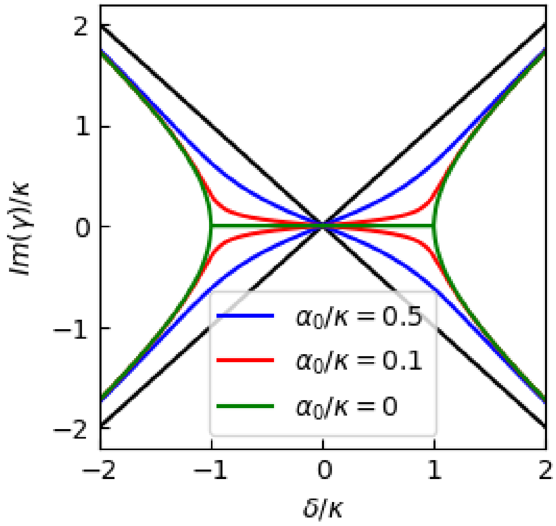

Coupled Wave Theory of Distributed Feedback Lasers

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Mar 23, 2023

CONTENTS

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.

CHAPTER

ONE

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 (α_o) to coupling (κ) 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 (α_o) to coupling (κ) 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

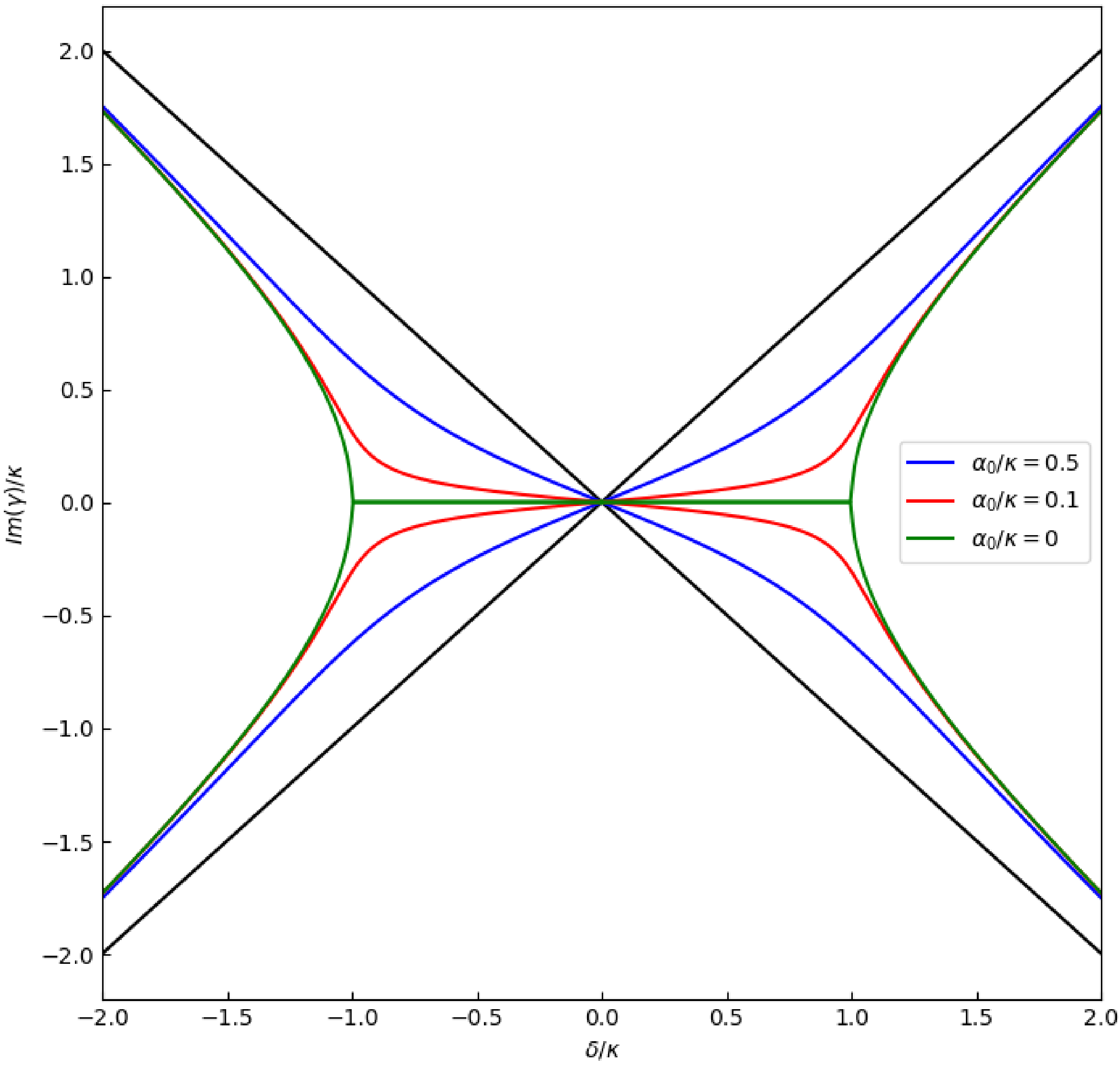

Fig. 1.1: Calculated dispersion diagram for index modulation for various gain to coupling parameter ratios

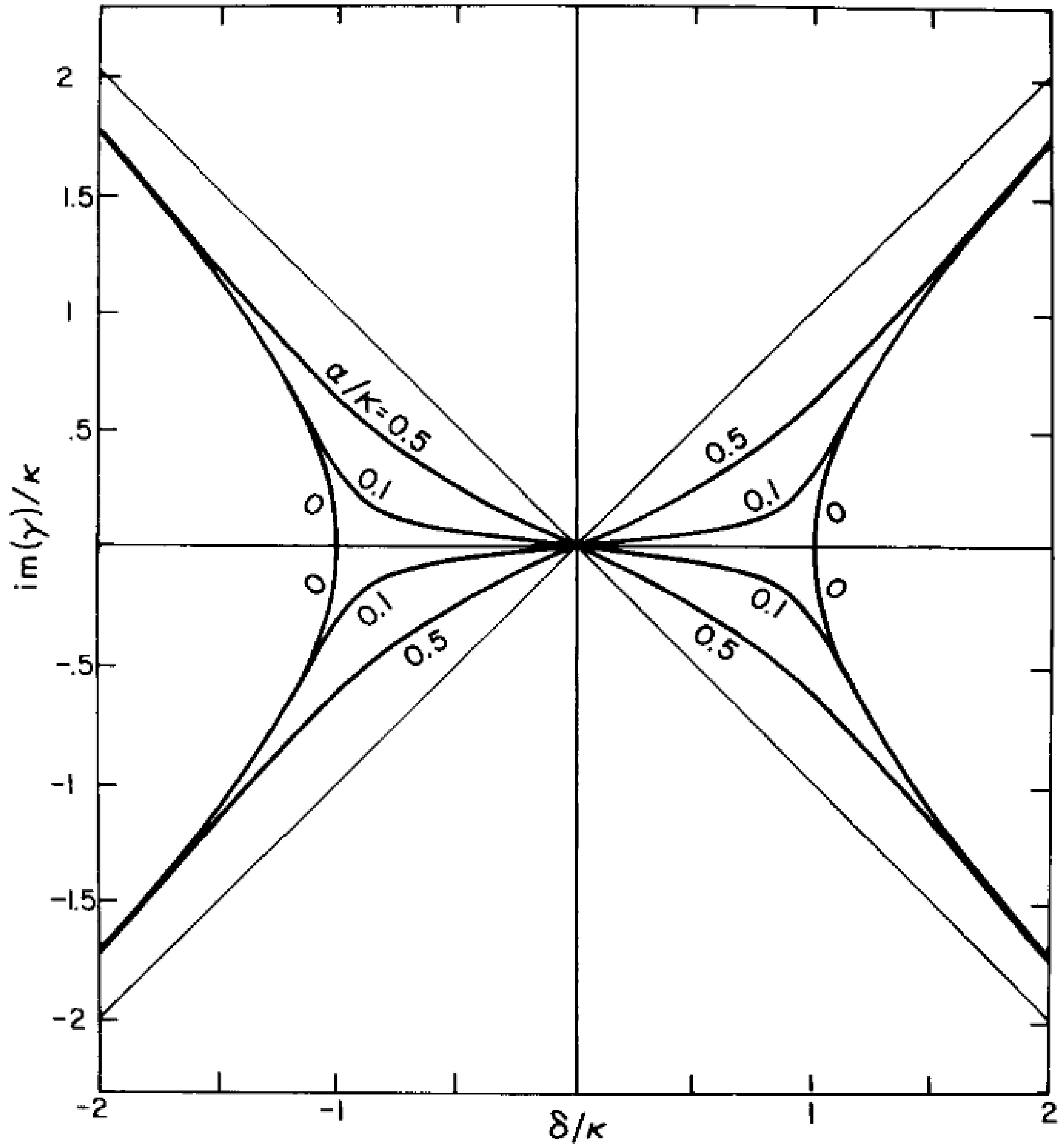

Fig. 1.2: Dispersion diagram for index modulation for various gain to coupling parameter ratios

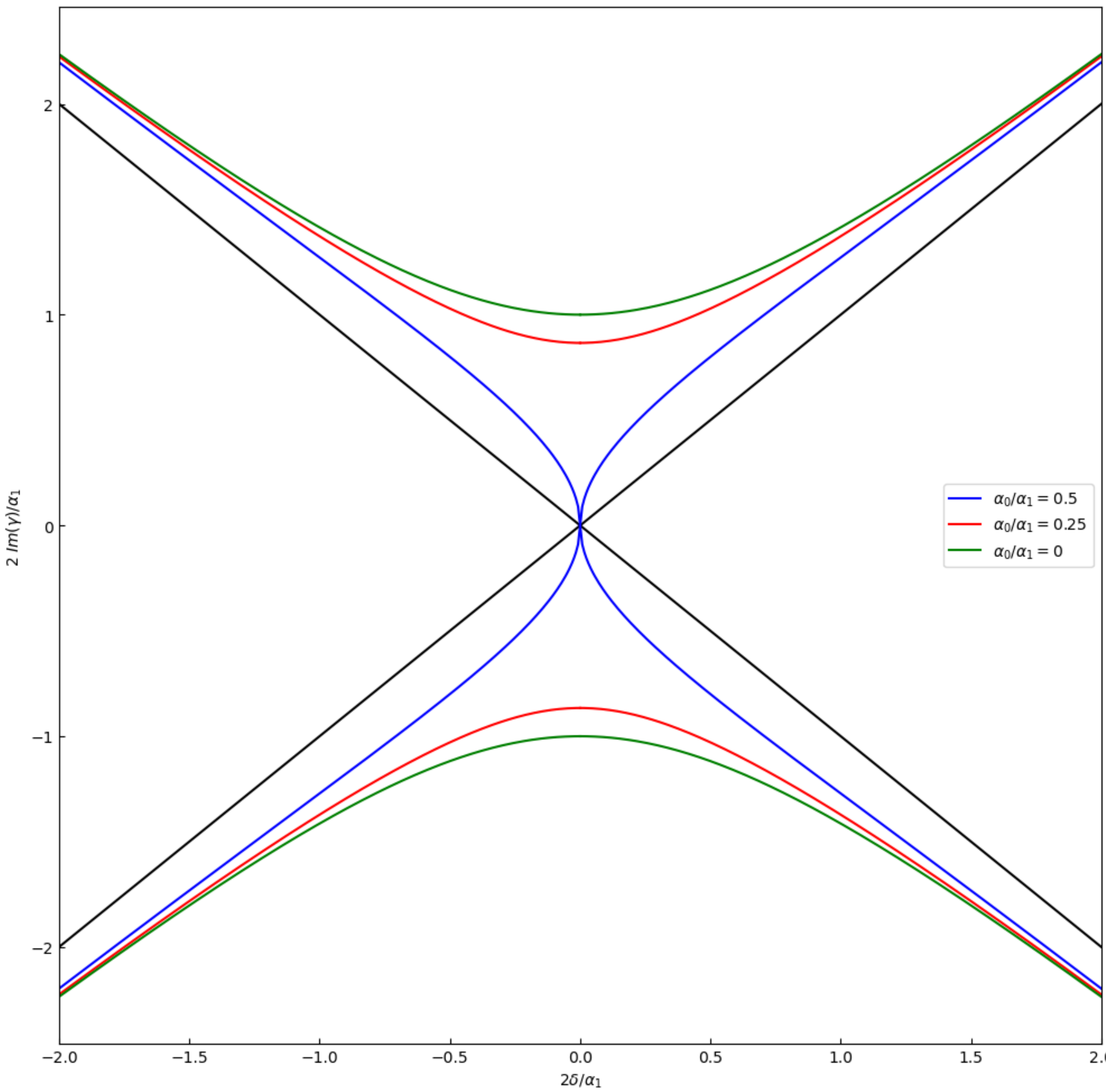

Fig. 1.3: Calculated dispersion diagram for gain modulation for various gain to coupling parameter ratios

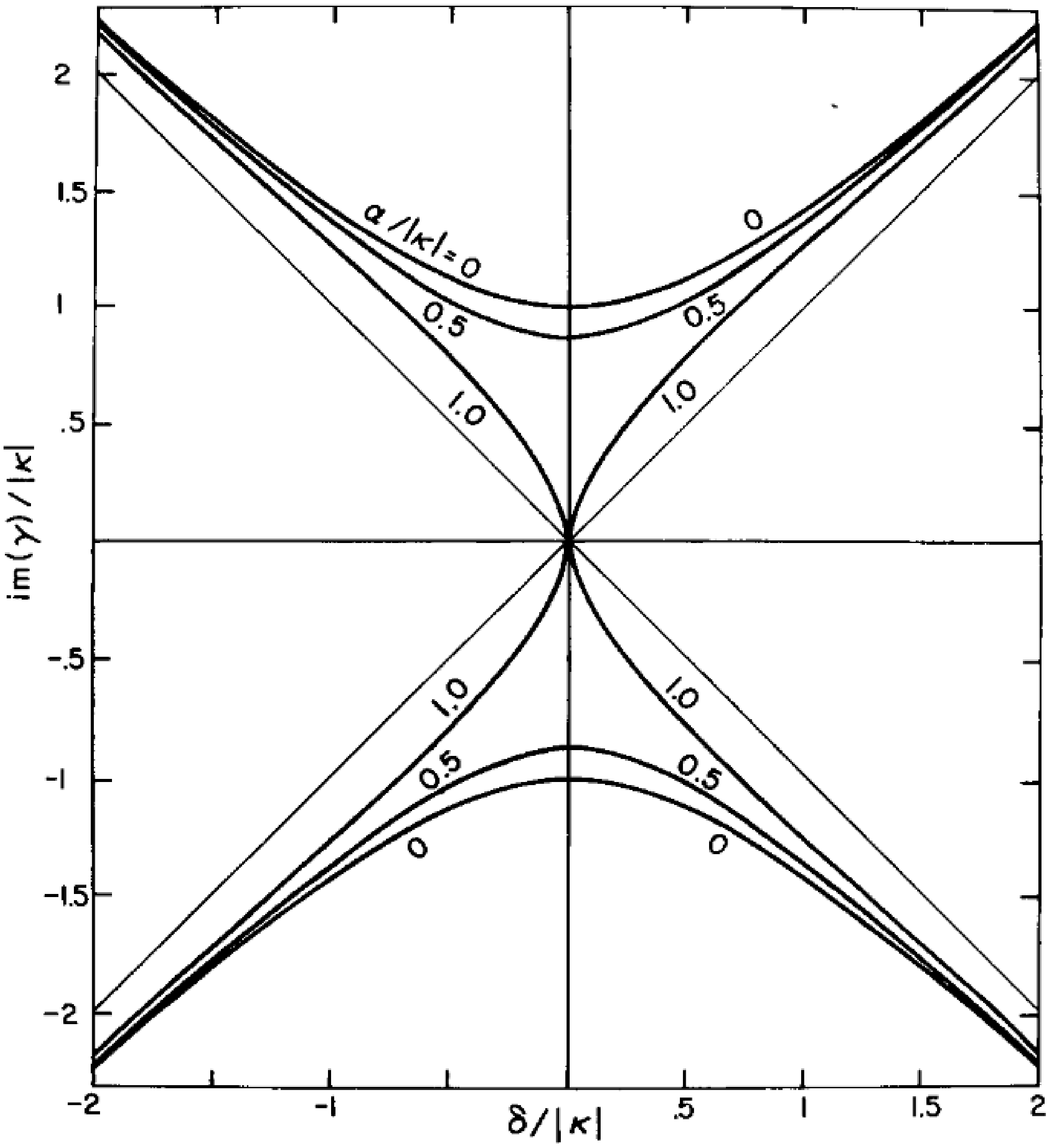

Fig. 1.4: Dispersion diagram for gain modulation for various gain to coupling parameter ratios

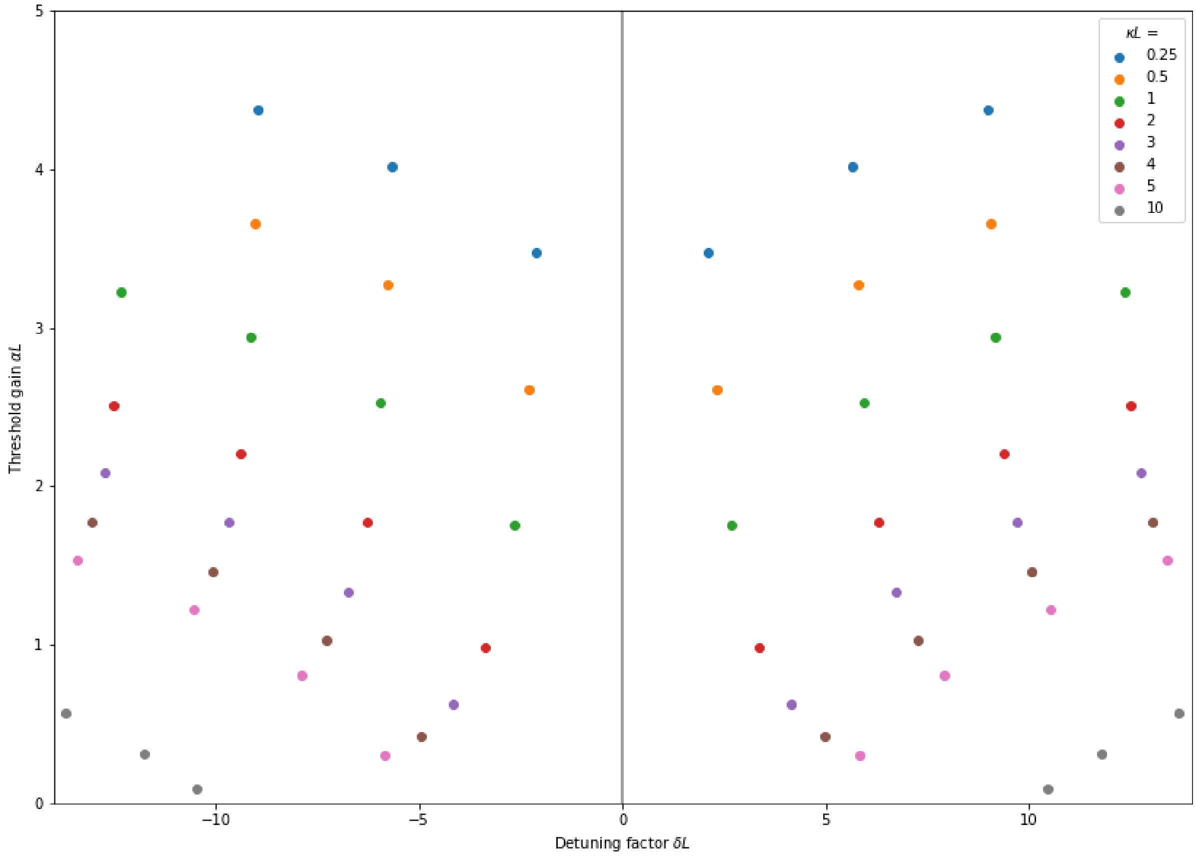

Fig. 1.5: Calculated gain required for threshold vs frequency deviation from the Bragg condition for index modulation

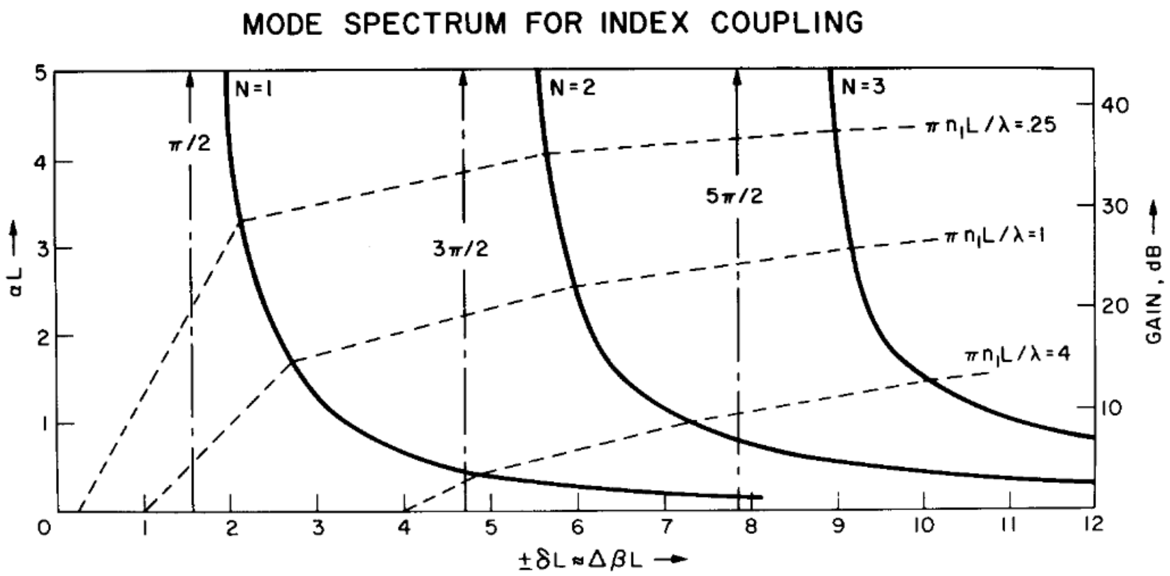

Fig. 1.6: Plot of the gain required for threshold vs frequency deviation from the Bragg condition for an index modulation. Only half of the spectrum is shown because of symmetry.

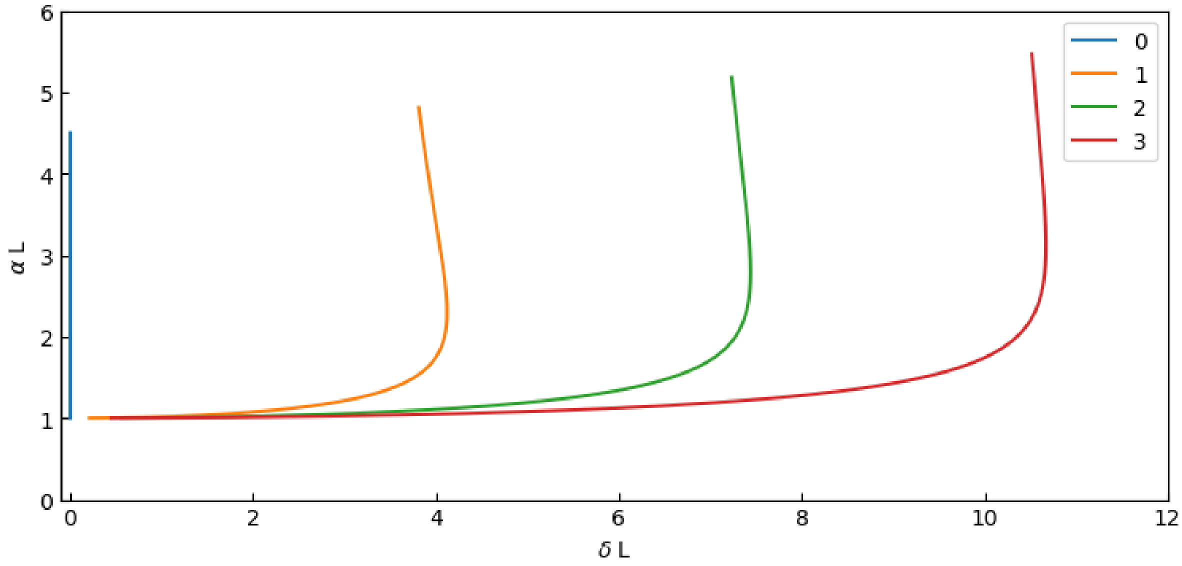

Fig. 1.7: Calculated DC gain required for threshold vs frequency deviation from the Bragg condition for gain modulation

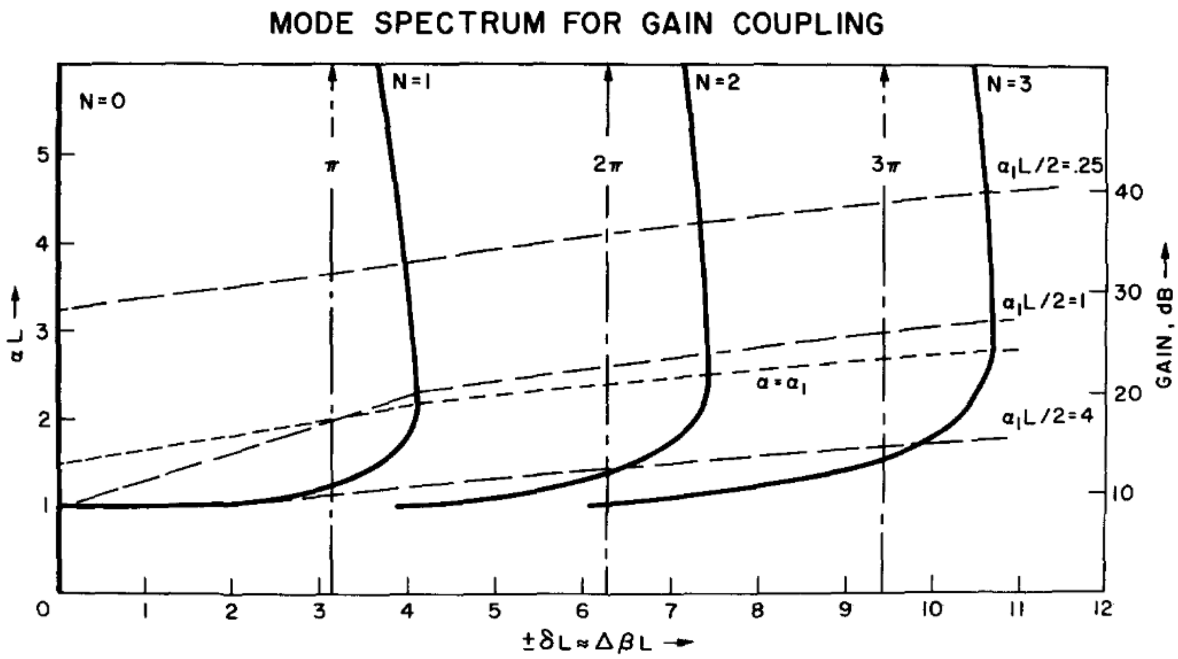

Fig. 1.8: Plot of the DC gain required for threshold vs frequency deviation from the Bragg condition for gain modulation. Only half of the spectrum is shown because of symmetry.

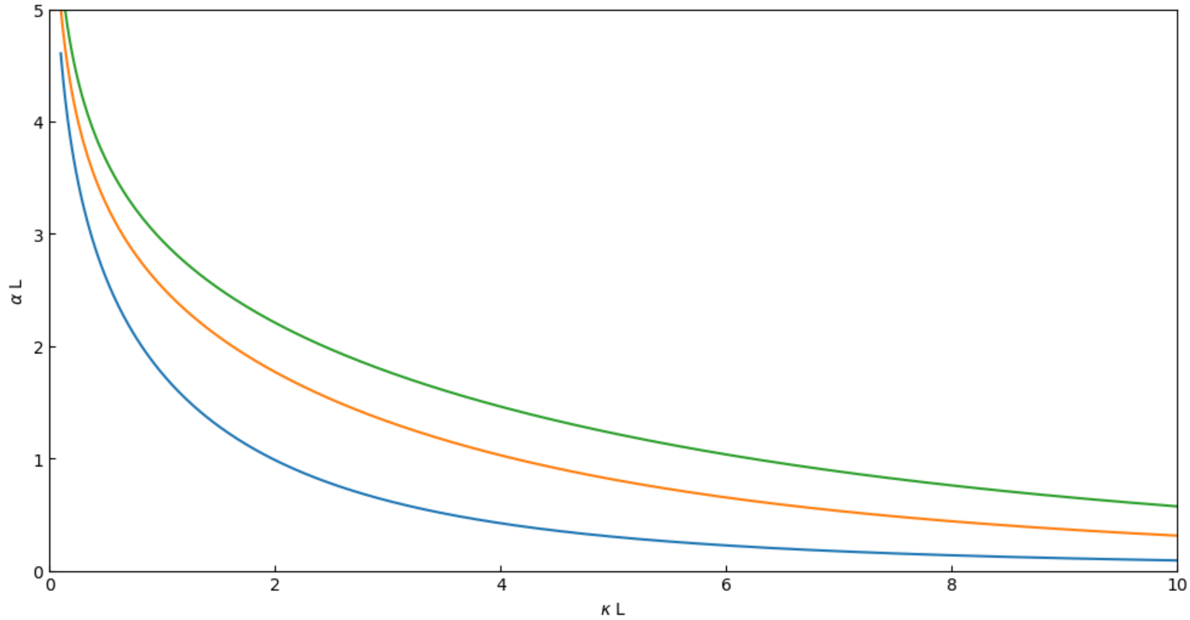

Fig. 1.9: Calculated gain at threshold vs coupling strength for various modes

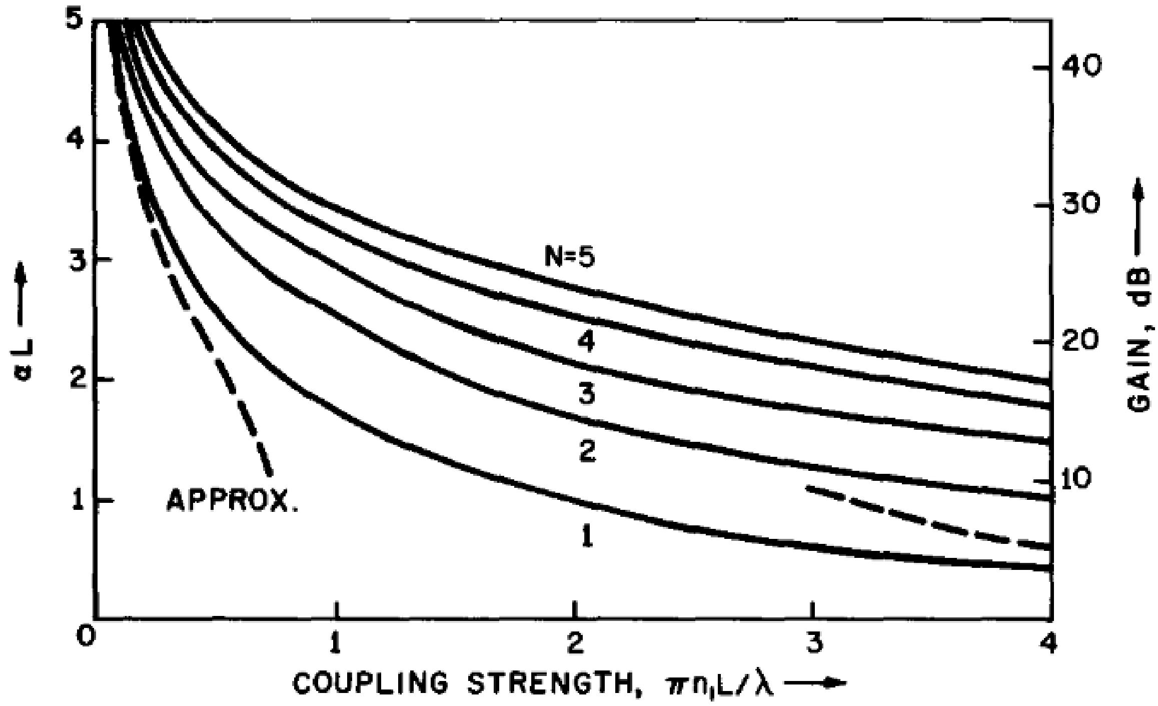

Fig. 1.10: Plot of the gain at threshold vs coupling strength for various modes. The mode number N refers to a set of modes placed symmetrically about the Bragg frequency.

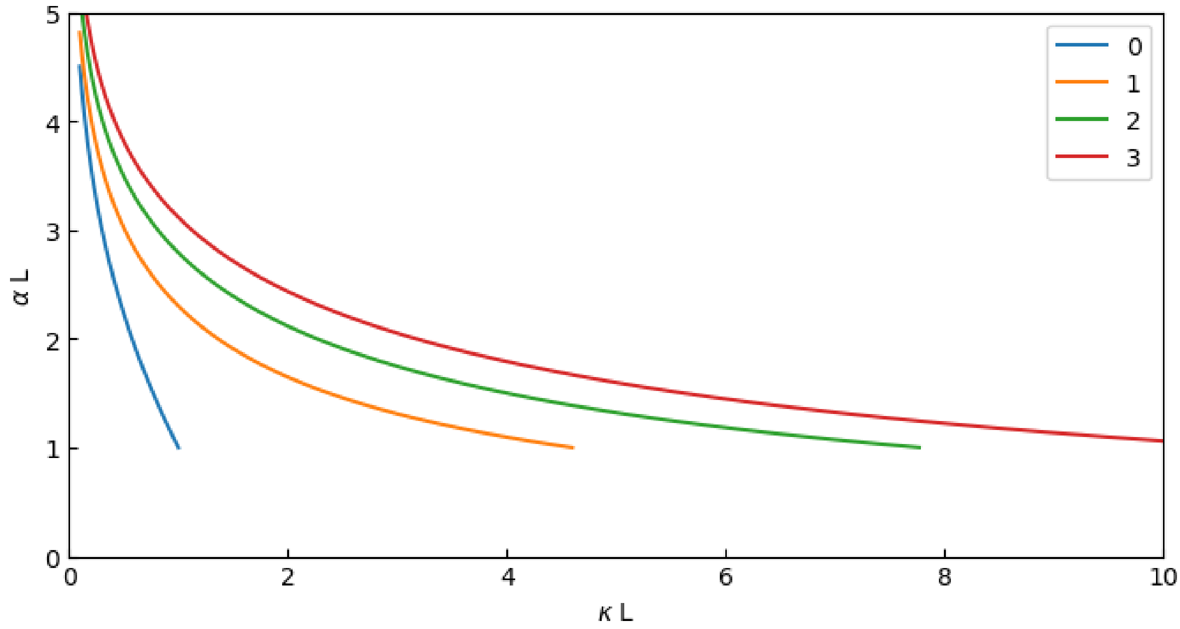

Fig. 1.11: Calculated gain at threshold vs coupling strength for various modes

THRESHOLD FOR GAIN COUPLING

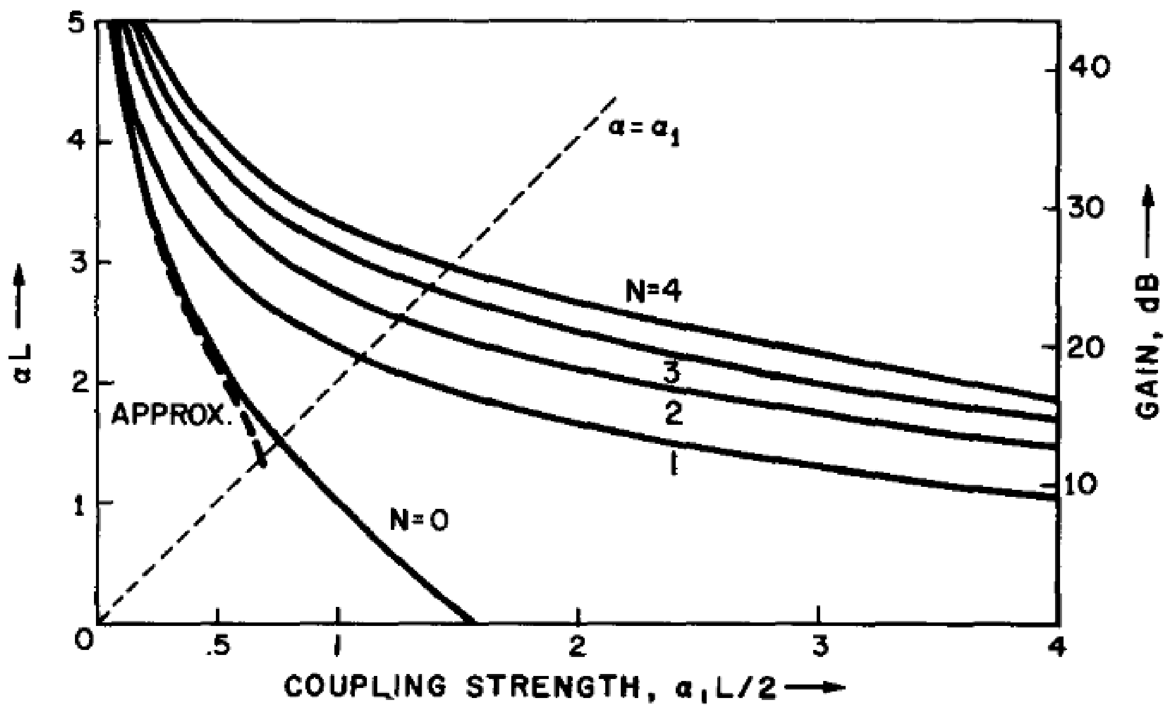

Fig. 1.12: Plot of the gain at threshold vs coupling strength for various modes. The N=O mode corresponds to a mode at the Bragg frequency. The numbers N>O correspond to a set of modes symmetrically placed about the Bragg frequency.

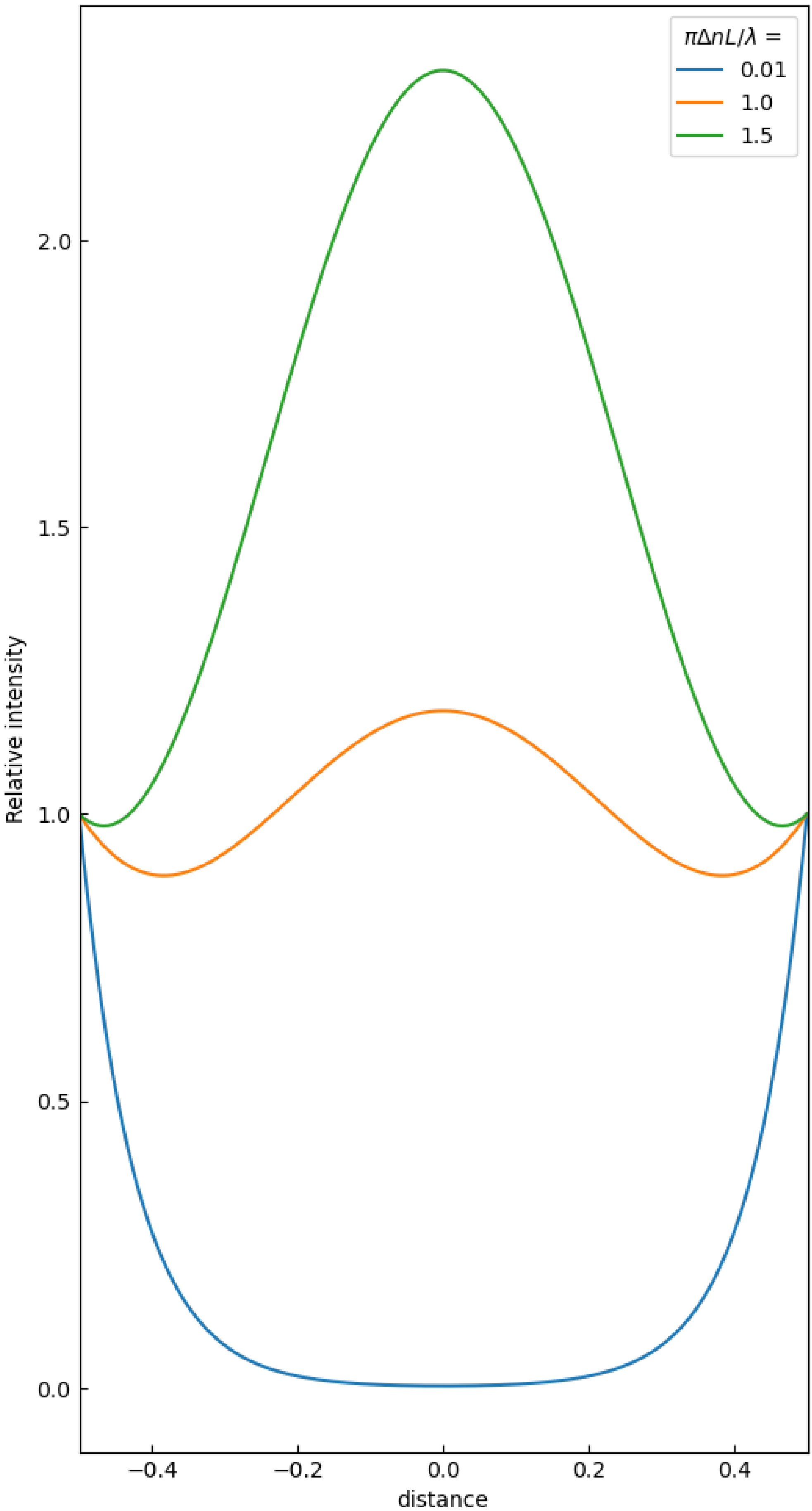

Fig. 1.13: Calculated gain at threshold vs coupling strength for various modes

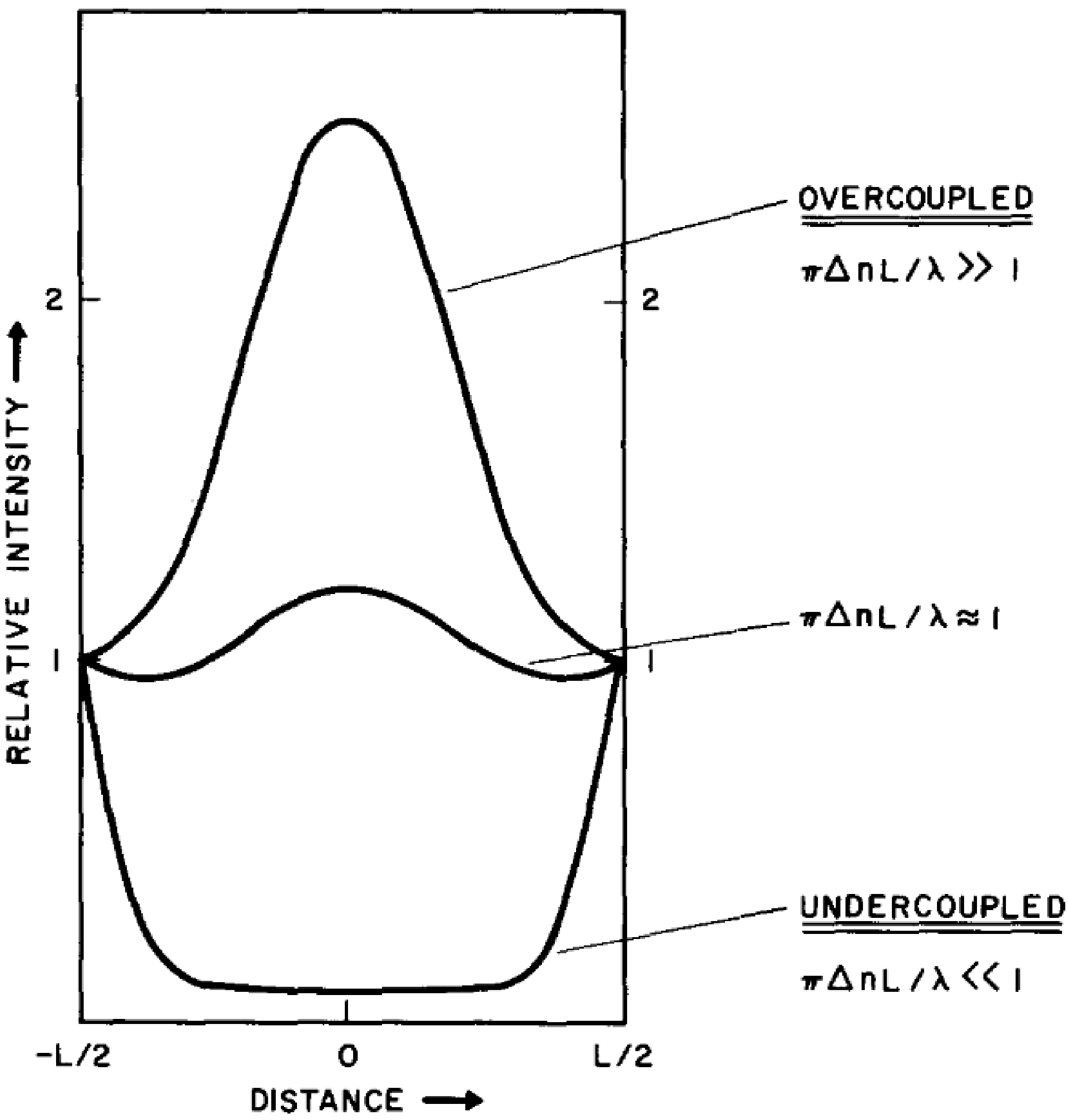

Fig. 1.14: Plot of the spatial intensity distribution of the lowest order modes at various coupling levels.

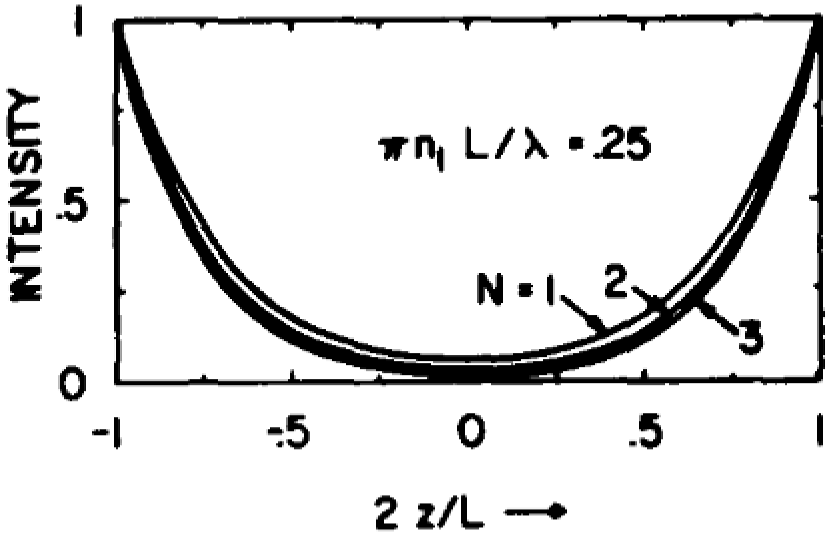

Fig. 1.15: Plot of the spatial intensity distribution for the first three modes at $\pi n_i L/\lambda = 0.25$.

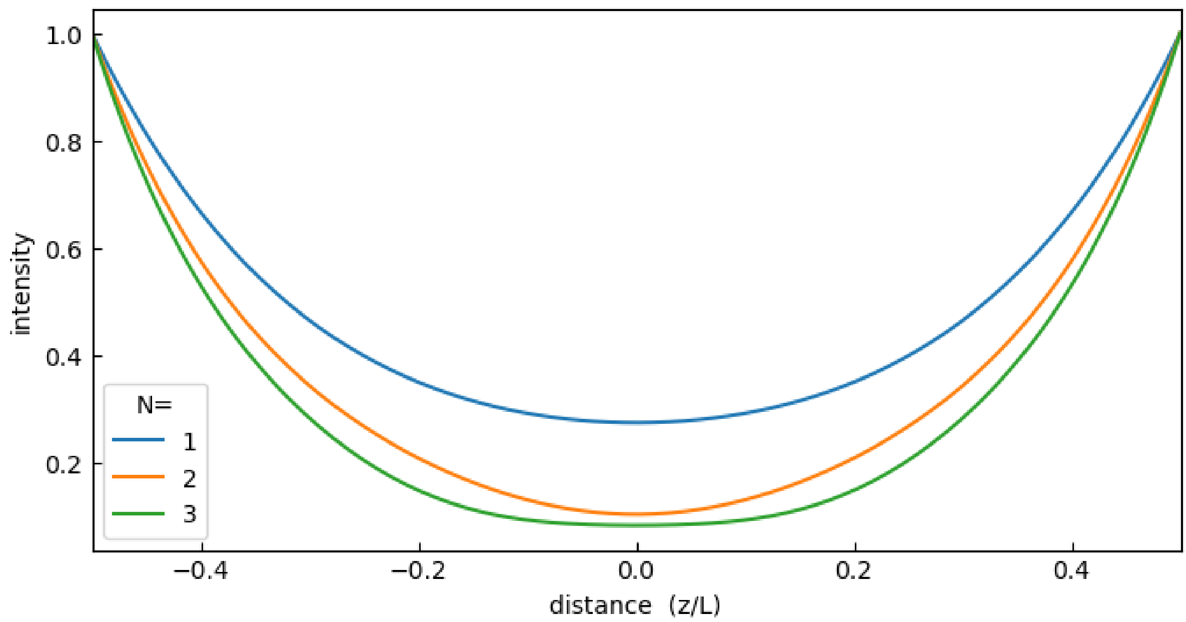

Fig. 1.16: Calculated spatial intensity distribution for the first three modes

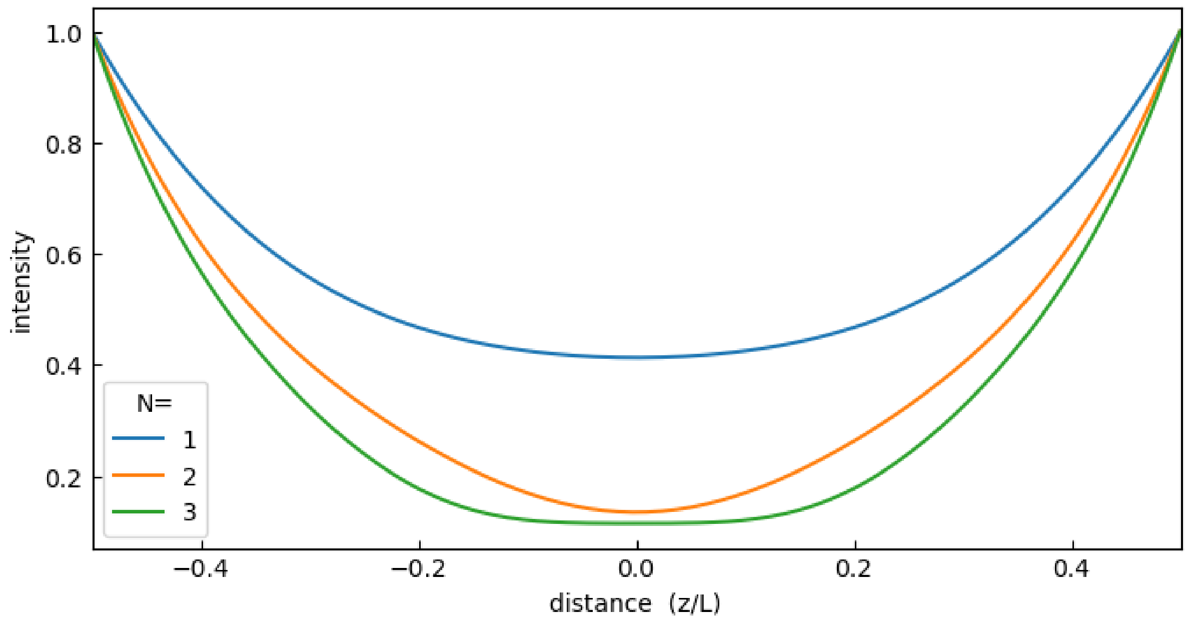

Fig. 1.17: Calculated spatial intensity distribution for the first three modes

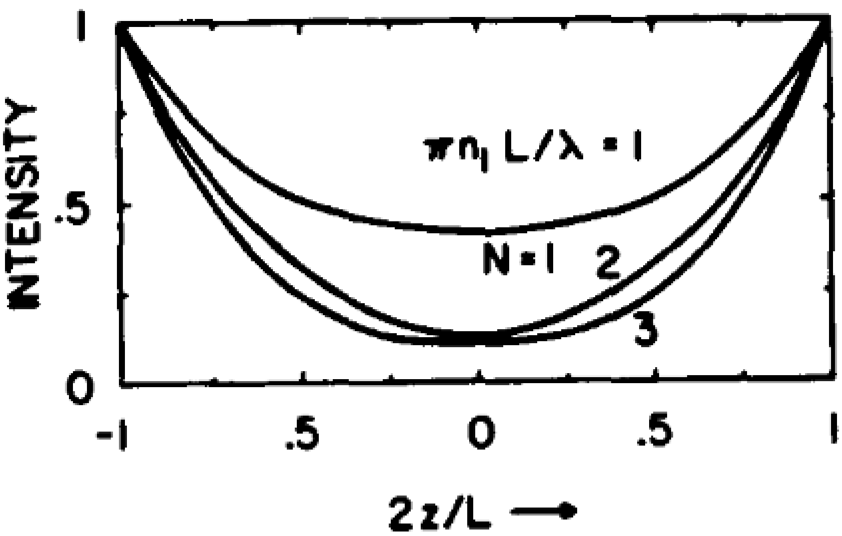

Fig. 1.18: Plot of the spatial intensity distribution for the first three modes at $\pi n_i L/\lambda = 1$.

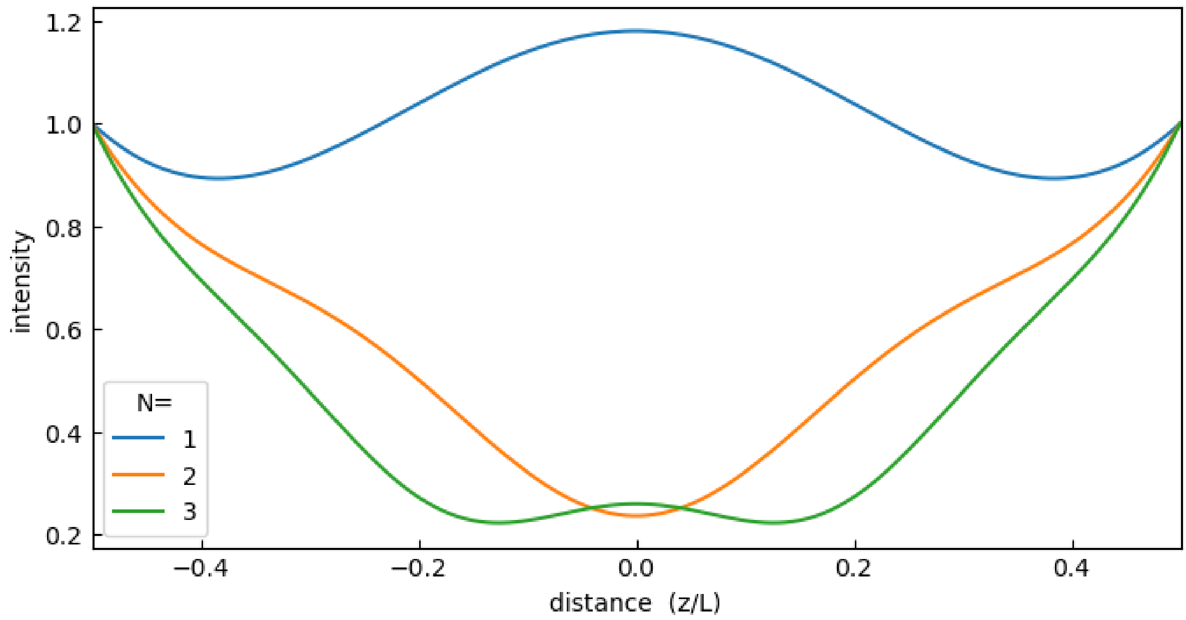

Fig. 1.19: Calculated spatial intensity distribution for the first three modes

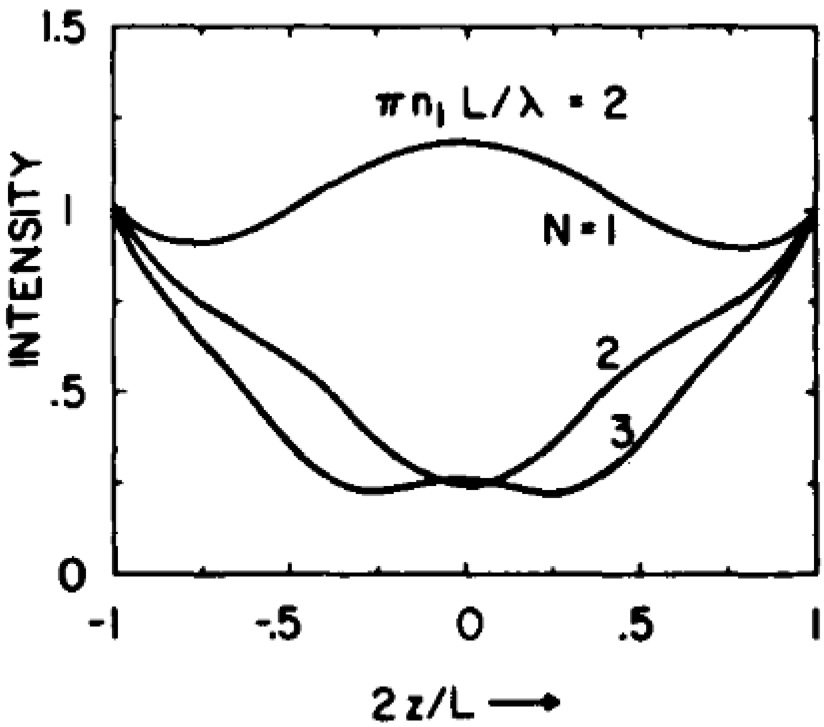

Fig. 1.20: Plot of the spatial intensity distribution for the first three modes at $\pi n_i L/\lambda = 2$.

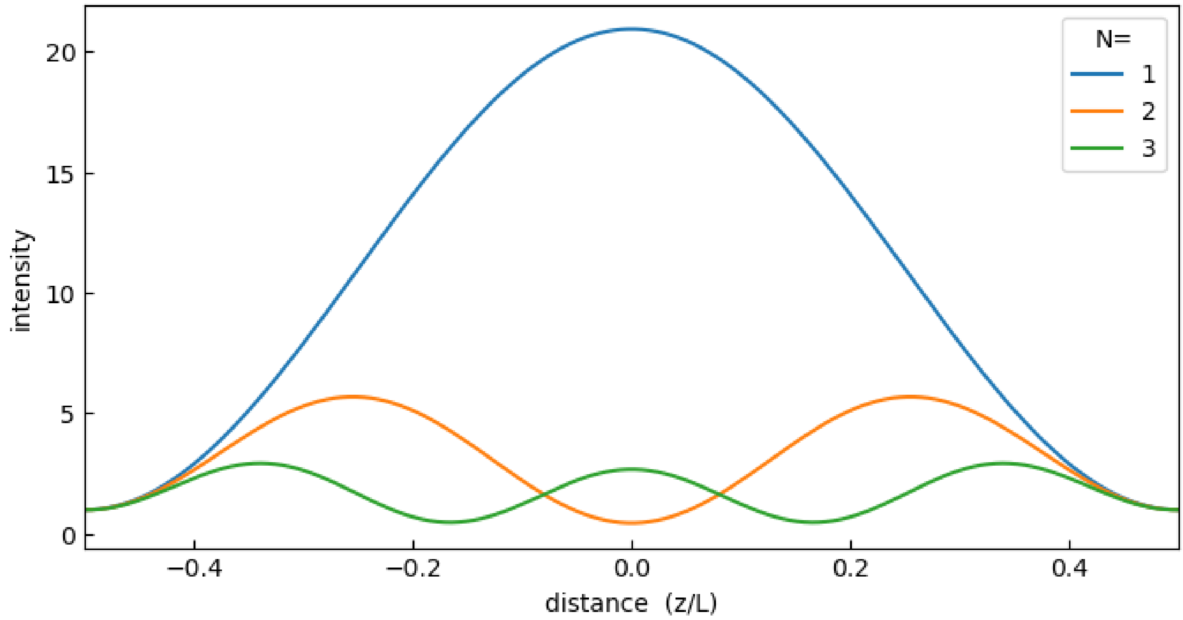

Fig. 1.21: Calculated spatial intensity distribution for the first three modes

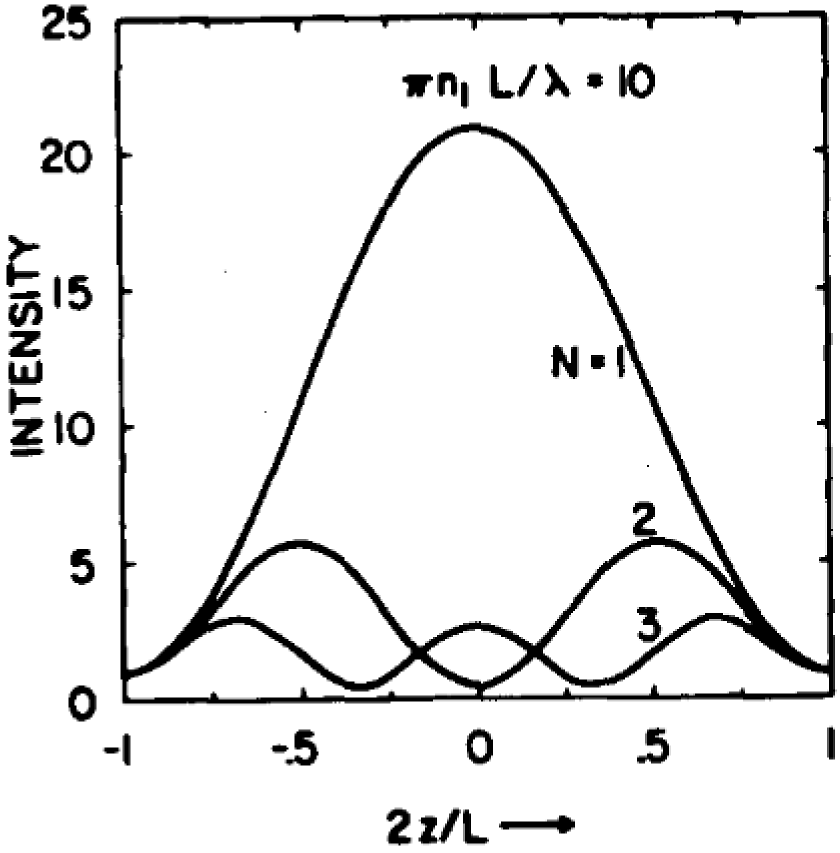

Fig. 1.22: Plot of the spatial intensity distribution for the first three modes at $\pi n_i L/\lambda = 10$.

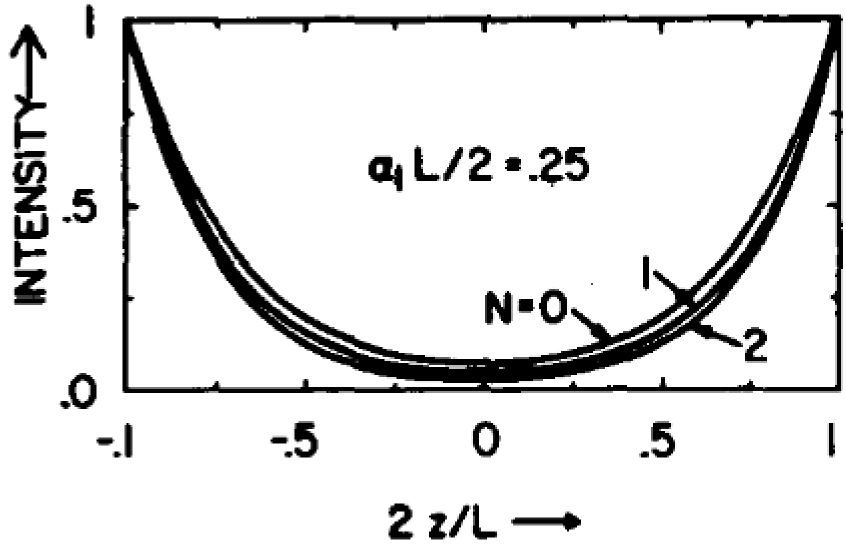

Fig. 1.23: Plot of the spatial intensity distribution for the first three modes at $\alpha L/2 = 0.25$.

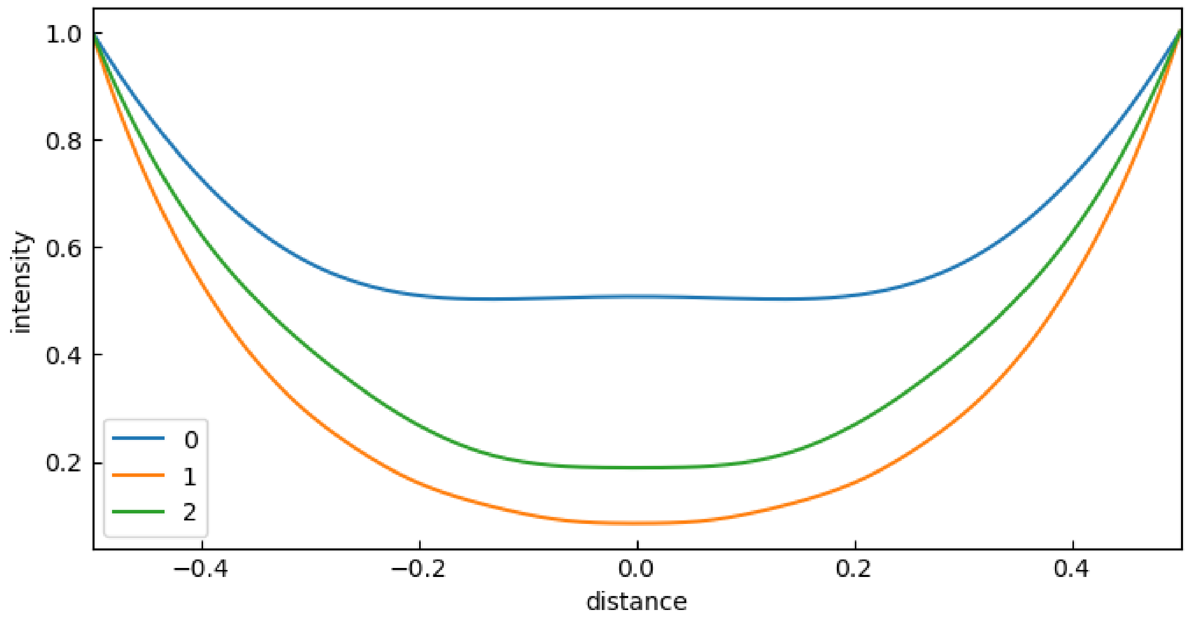

Fig. 1.24: Calculated spatial intensity distribution for the first three modes at L / 2 =1

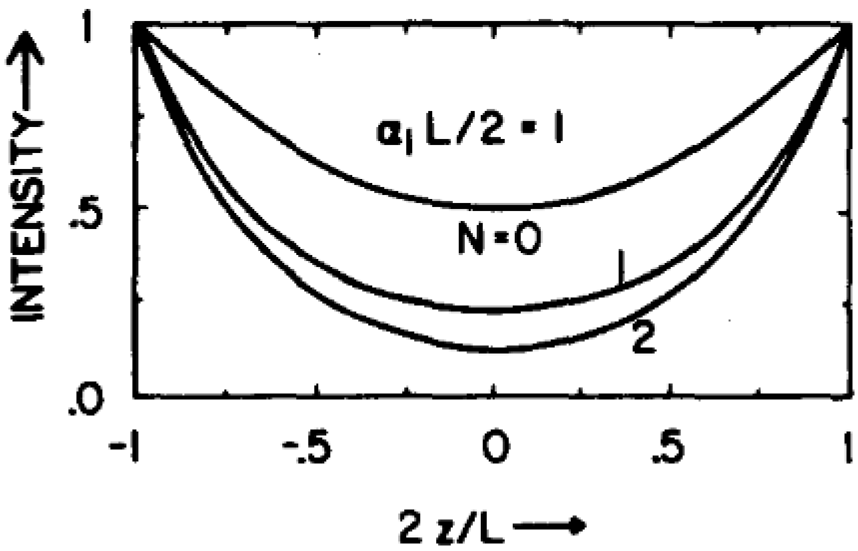

Fig. 1.25: Plot of the spatial intensity distribution for the first three modes at $\alpha L/2 = 1$.

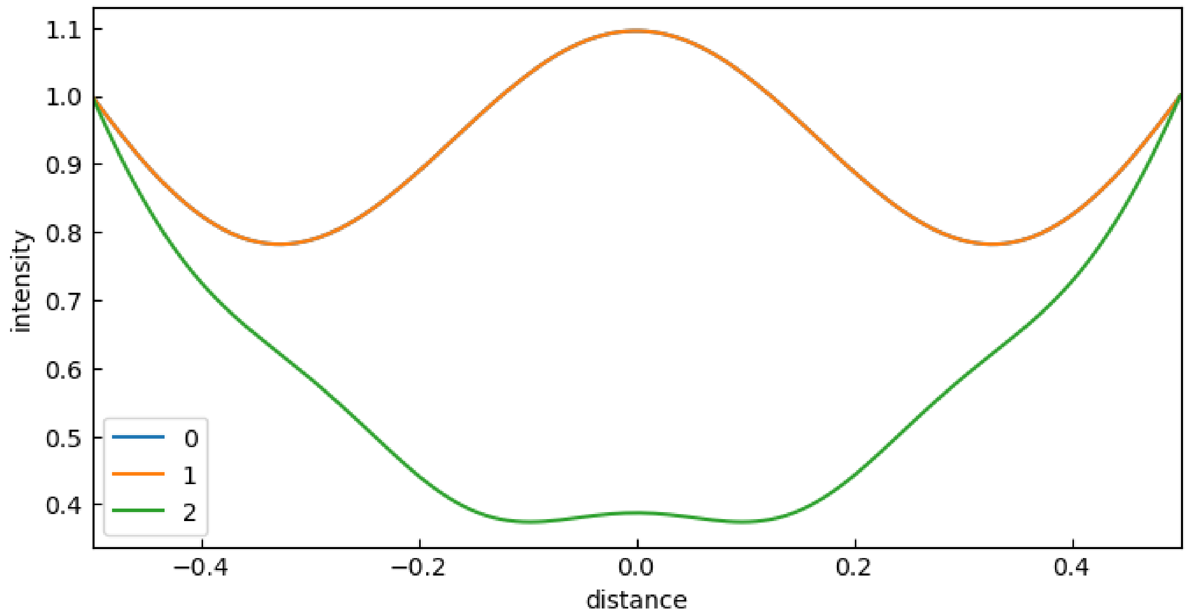

Fig. 1.26: Calculated spatial intensity distribution for the first three modes at L / 2 =2

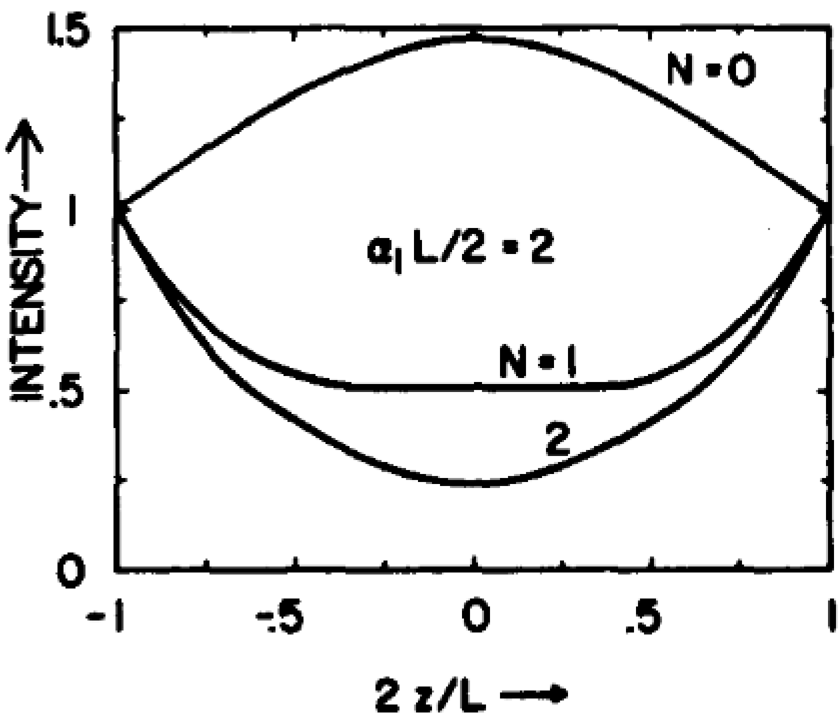

Fig. 1.27: Plot of the spatial intensity distribution for the first three modes at $\alpha L/2 = 2$.

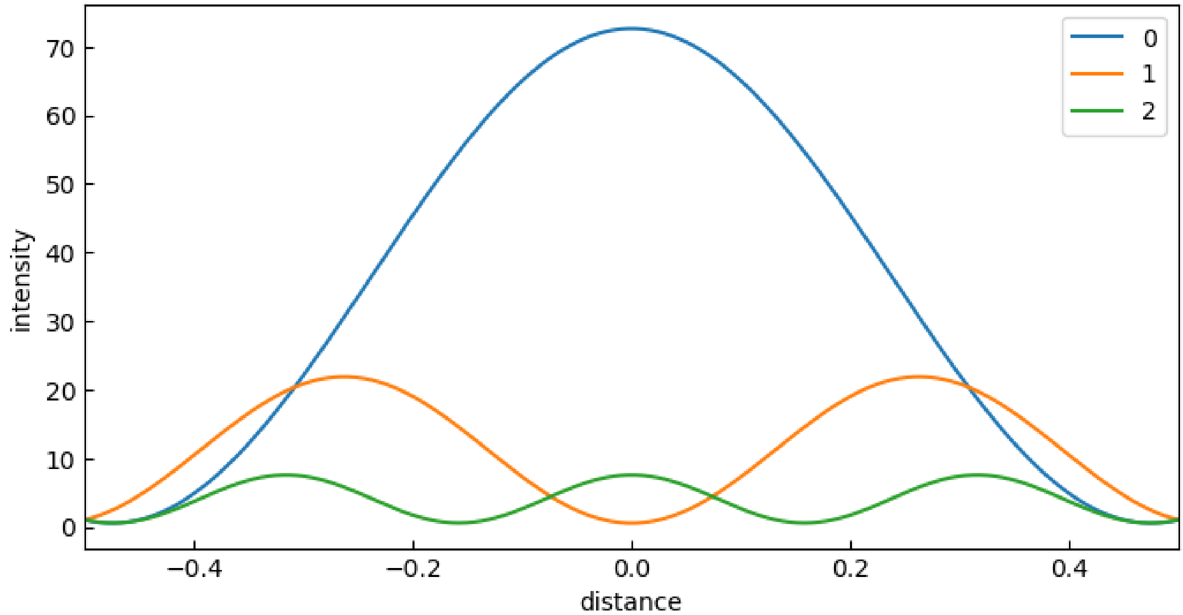

Fig. 1.28: Calculated spatial intensity distribution for the first three modes at L / 2 =10

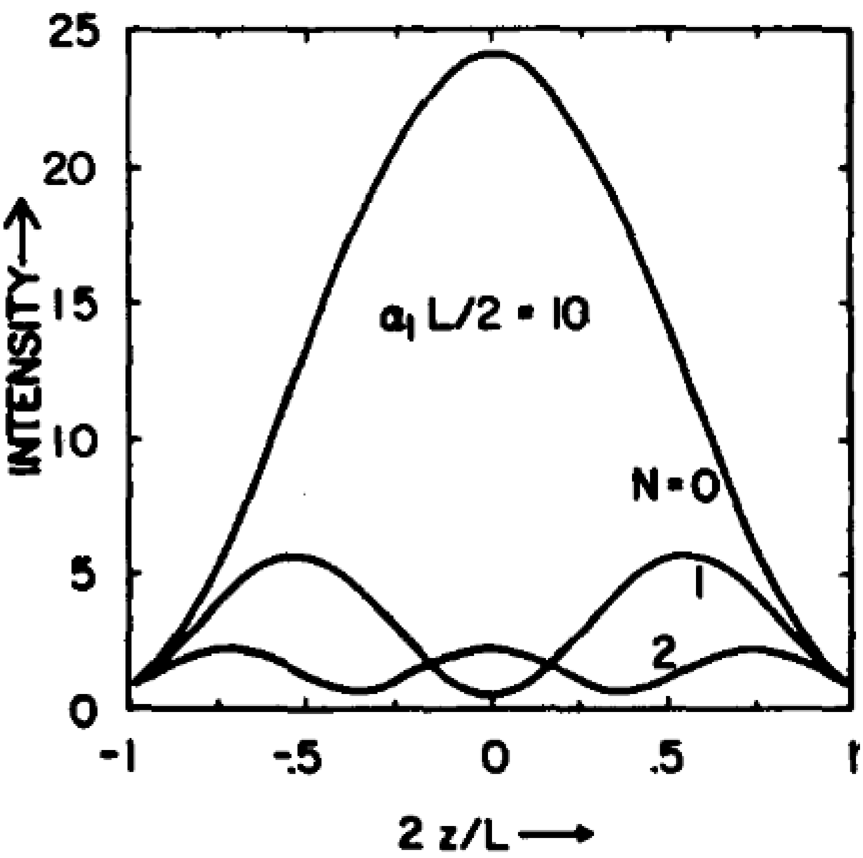

Fig. 1.29: Plot of the spatial intensity distribution for the first three modes at $\alpha L/2 = 10$.

CHAPTER

TWO

UV-NANOIMPRINTED DISTRIBUTED-FEEDBACK PEROVSKITE LASING

This chapter comprises simulations from the manuscript:

Iakov Goldberg, Nirav Annavarapu, Simon Leitner, Karim Elkhouly, 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 $MAPbI_3$ Perovskite Waveguides"*, submitted manuscript

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

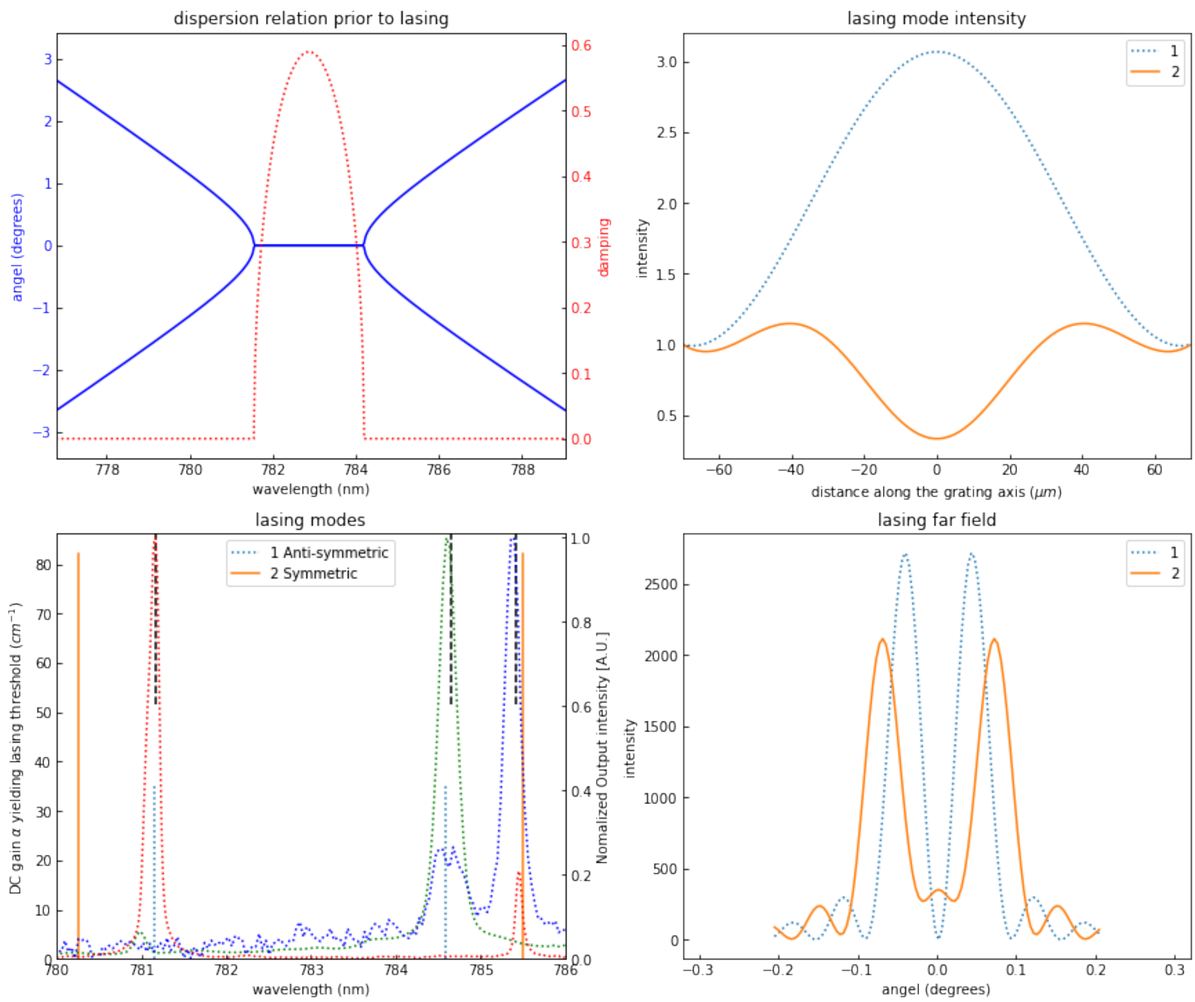

Fig. 2.1: Upper left: calculated dispersion relation prior to lasing, Upper right: intensity of the lasing mode in the near field, lower left: required DC gain for the lasing threshold, the dotted lines show the measured lasing lines at 3 different locations, lower right: far field lasing intensity as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

CHAPTER

THREE

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.