

# Inverse scattering designs of mode-selective waveguide couplers

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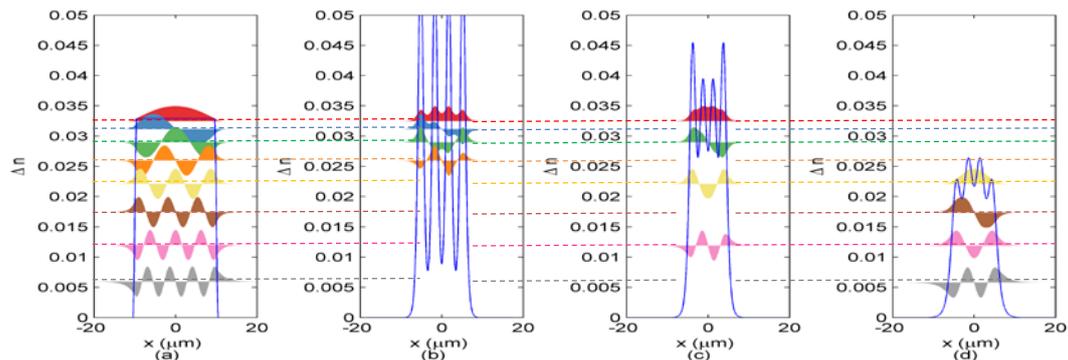
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We describe the design of arbitrary mode-selective waveguide couplers through application of the Darboux transform of inverse scattering theory. We demonstrate that contrary to recent SUSY designs, it is not necessary to use complex refractive index profiles to achieve this.

## Introduction

We have previously discussed the design of multimode waveguides with prescribed mode effective indices through the use of the Darboux transformation [1] of inverse scattering in the context of group velocity equalization [2]. In this work, we discuss the design of waveguides suitable for building mode-selective waveguide couplers (MSC) for mode-division muxing/demuxing. We design appropriate trunk/partner waveguide pairs with phase matched propagation constants. The strength of this technique is the ability to phase-match any arbitrary combination of modes using real refractive index (RI) profiles. This is contrary to recently published works, involving supersymmetric (SUSY) transformations [3], which utilize complex RIs, involving gain and loss, and can mux/demux *only one mode* at a time.

## Results



**Fig. 1.** RI profile of (a) multimode step-index trunk waveguide, and partner waveguides for (b) four lowest-order, (c) four alternate-order and (d) four highest-order modes @  $\lambda=1.55\mu\text{m}$ ,  $n_{\text{cladding}}=1.444$

Fig. 1 shows an example of a multimode step-index trunk waveguide (a) and the corresponding partner waveguides matching the four lowest-order (b), alternate-order (c), or four highest-order (d) modes, obtained by the use of the inverse scattering algorithm based on Darboux transformations. Such trunk/partner waveguide designs can be coupled optically and provide a scalable and potentially versatile method of mode discrimination and/or multiplexing technology in an era of ever-increasing demand upon high-capacity optical communication systems. Coupler designs will be presented at the conference.

## References

- [1] D. W. Mills and L. S. Tamil, "Synthesis of Guided Wave Optical Interconnects," *IEEE J. Quantum Electron.*, vol. 29, no. 11, pp. 2825–2834, 1993.
- [2] A. R. May and M. N. Zervas, "Group velocity equalisation in multimode waveguides using inverse scattering designs," in *Sixth International Conference on Optical, Optoelectronic and Photonic Materials and Applications (ICOOPMA '14)*, 2014.
- [3] M. Heinrich, M.-A. Miri, S. Stützer, R. El-Ganainy, S. Nolte, A. Szameit, and D. N. Christodoulides, "Supersymmetric mode converters," *Nat. Commun.*, vol. 5, p. 3698, 2014.