BULL. AUSTRAL. MATH. SOC.
VOL. 16 (1977), 313-314.

78A50, 92A99

Crosstalk between optical waveguides with applications to visual photoreceptors

Peter McIntyre

The greater part of this thesis is concerned with an analysis of the interaction of the electromagnetic fields of neighbouring dielectric waveguides, using the method of coupled-mode theory. Such an interaction leads to an exchange of power or crosstalk between neighbouring waveguides. The concept of crosstalk and some of the necessary definitions are introduced in Chapter 1.

Chapter 2 provides a general introduction to coupled-mode theory, its validity, approximations and solutions of the coupled-mode equations. The relationship with the normal-mode approach is examined.

In Chapter 3 we derive a set of degenerate modes for a dielectric waveguide of circular cross-section and use these modes to determine the power transfer between two or more neighbouring waveguides. The validity of the degenerate modes and of coupled-mode theory as applied to waveguides of circular cross-section is also examined.

The theory of Chapter 3 is extended in Chapters 4 to 6 to determine the crosstalk in several waveguide systems of practical interest. In Chapter 4 we calculate the crosstalk in systems which are not invariant in the longitudinal (z) direction. Two examples analysed in detail are tapered and non-parallel waveguides. Crosstalk between multimode waveguides in which many bound modes can propagate, is investigated in Chapter 5. A comparison of mode and ray theories for multimode waveguides is used to examine some of the difficulties associated with the two theories. Chapter 6 is devoted to crosstalk between absorbing waveguides. We show

Received 26 November 1976. Thesis submitted to the Australian National University, January 1976. Degree approved, November 1976. Supervisor: Professor Allan W. Snyder.

how loss can be included in the coupled-mode theory of crosstalk and determine the power absorbed by each of the waveguides.

In Chapter 7 we use the theory developed in Chapters 3, 4, and 6 to analyse crosstalk between visual photoreceptors, in particular between the rhabdomeres of the dipteran rhabdom. A discussion of modes on photoreceptors and of the implications for and limitations on the operation and evolution of visual systems due to crosstalk is also given.

In Chapter 8 we use coupled-mode theory to examine the propagation of light in a twisted, birefringent, dichroic medium. A simple theory is developed to determine the polarisation properties and absorption of light passing through a slowly twisting medium. The theory is then applied to twisted photoreceptors which have been observed in ants and bees. We determine the effect of the twisting on the absorption properties (polarisation and absolute sensitivities) of the photoreceptors and on the measurement of their birefringence.

https://doi.org/10.1017/S0004972700023364 Published online by Cambridge University Press