Applied Mathematics and Contemporary Methods for Real-World Problems

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PREFACE

Mathematical modelling begins with assumptions that translate a real-world problem into a mathematical framework. Analysing the resulting equations helps us understand how a population grows, how a wave travels, or how the behaviour of a system can be inferred from measured data. Analytical methods reveal the structure of a model, while numerical computations help explore its consequences in practice.

Applied Mathematics and Contemporary Methods for Real-World Problems brings together chapters written in this spirit. Topics range from classical population models to nonlinear wave equations, and from iterative methods on time scales to data-driven modelling. Taken together, these chapters show how established mathematical ideas and contemporary methods can inform the study of diverse problems. A common concern runs through them: clarifying the assumptions underlying a model, assessing the reliability of its results, and recognising its limitations. Throughout the book, analytical results are complemented by numerical computations.

I hope this book will be useful to researchers in applied mathematics, graduate students, and readers from other fields with an interest in mathematical modelling. I sincerely thank the chapter authors for sharing their knowledge and expertise, and everyone who contributed to preparing this book for publication.

Dr. Öğr. Üyesi Muhammed HASDEMİR

1. BÖLÜM

ALGEBRAIC SOLITARY WAVES AND PERIODIC-AMPLITUDE TRAVELLING WAVES IN A Q-DEFORMED SCHRÖDINGER MODE

Mustafa EKİCİ[1]

1. Introduction

Mathematical modelling connects real-world wave problems with equations, measurable quantities and solution profiles. Nonlinear Schrödinger equations provide familiar examples in nonlinear fibre optics and the mean-field description of Bose–Einstein condensates (Agrawal, 2019; Dalfovo et al., 1999). Exact travelling waves help explain how model parameters affect a profile and provide reference solutions for checking numerical calculations.

A travelling wave preserves its amplitude as it moves. In a complex field, the phase must also satisfy the equation. This couples the amplitude, speed and frequency and makes phase reconstruction an essential part of the calculation. The quantity plotted as a density also matters: the squared amplitude and the conserved density need not coincide in a deformed model. These issues are particularly visible for waves with algebraic tails.

The classical nonlinear Schrödinger equation describes the competition between dispersion and a nonlinear response. Its solitary waves, conservation laws and focusing behaviour are discussed in detail (Sulem & Sulem, 1999), while broader exact-solution methods are presented in the literature (Ablowitz & Clarkson, 1991). Travelling-wave reductions are also useful when a model does not have a complete inverse-scattering description. They turn the field equation into ordinary differential equations whose parameters can be related directly to the height, width and phase of a wave.

Several analytical methods use this reduction to obtain explicit profiles. The rational (G′/G)-expansion method has been applied to the combined KdV–mKdV, reaction–diffusion and coupled Hirota–Satsuma KdV equations (Ekici & Ünal, 2022). The generalized Kudryashov method has also been used

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