An introduction to the Split Step Fourier Method using MATLAB

Pablo U. Suárez

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Abstract

The Split Step Fourier Method provides an excellent methodology for learning and teaching how to solve time dependent partial differential equations. This method is ubiquitously used in engineering and physics applications. In this article, we present the simplicity of this method by solving the Linear and Nonlinear Schrödinger Equation and with the aid of MATLAB, we demonstrate a straight forward implementation. Extension to other type of problems are also discussed with the corresponding codes. This article illustrates a very powerful numerical technique that can be implemented quite easily.
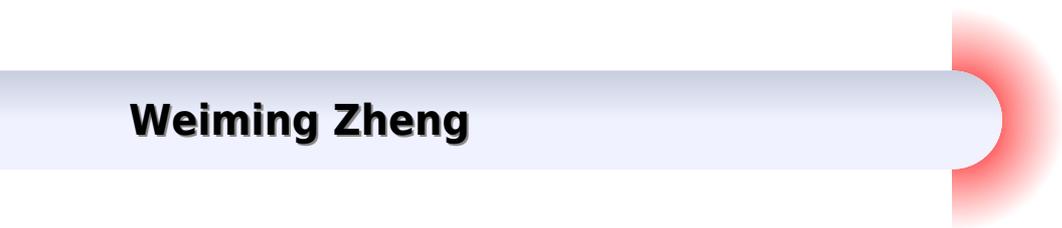
1 Introduction

The Split Step Fourier Method(SSFM) is a part of the the family of pseudo-spectral methods used to solve time dependent nonliner partial differential equation. The approach followed by SSFM follows the old age strategy of divide and conquer. The nonlinear PDE is divided into related sub-problems of the original equation. The method is easy to understand and with the use of MATLAB the implementation is straight forward.

In this article, we shall illustrate the implementation of the Fourier Split Method using MATLAB. We shall discuss the numerical solution of a variety of examples. We begin with the one dimesional linear Schrödinger Equation, the nonliner Schröinger equation, systems of the Schrodinger and the 2D Schrödinger equation. For a more detailed discussion on the origins and development of the method, the reader may wish to refer to books listed in

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Computational Photonics Marek S. Wartak,2013-01-10 A comprehensive manual on the efficient modeling and analysis of photonic devices for graduate students and researchers in engineering and physics **Nonlinear Dispersive Equations** Christian Klein,Jean-Claude Saut,2022-02-23 Nonlinear Dispersive Equations are partial differential equations that naturally arise in physical settings where dispersion dominates dissipation notably hydrodynamics nonlinear optics plasma physics and Bose Einstein condensates The topic has traditionally been approached in different ways from the perspective of modeling of physical phenomena to that of the theory of partial differential equations or as part of the theory of integrable systems This monograph offers a thorough introduction to the topic uniting the modeling PDE and integrable systems approaches for the first time in book form The presentation focuses on three universal families of physically relevant equations endowed with a completely integrable member the Benjamin Ono Davey Stewartson and Kadomtsev Petviashvili equations These asymptotic models are rigorously derived and qualitative properties such as soliton resolution are studied in detail in both integrable and non integrable models Numerical simulations are presented throughout to illustrate interesting phenomena By presenting and comparing results from different fields the book aims to stimulate scientific interactions and attract new students and researchers to the topic To facilitate this the chapters can be read largely independently of each other and the prerequisites have been limited to introductory courses in PDE theory **Applications of Photonic Technology [7B]** John C. Armitage,Roger A. Lessard,George A. Lampropoulos,2004 *Radio Wave Propagation and Parabolic Equation Modeling* Gokhan Apaydin,Levent Sevgi,2017-08-29 An important contribution to the literature that introduces powerful new methods for modeling and simulating radio wave propagation A thorough understanding of electromagnetic wave propagation is fundamental to the development of sophisticated communication and detection technologies The powerful numerical methods described in this book represent a major step forward in our ability to accurately model electromagnetic wave propagation in order to establish and maintain reliable communication links to detect targets in radar systems and to maintain robust mobile phone and broadcasting networks The first new book on guided wave propagation modeling and simulation to appear in

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Impact of the Physical Layer Impairments on Optical Fiber Communication Systems Helena Xuehong Chen Feng,2002 **Nonlinear Optics and Applications II** Mario Bertolotti,2007 Proceedings of SPIE present the original research papers presented at SPIE conferences and other high quality conferences in the broad ranging fields of optics and photonics These books provide prompt access to the latest innovations in research and technology in their respective fields Proceedings of SPIE are among the most cited references in patent literature *Tailoring of Ultrafast Frequency Conversion with Quasi-phase-matching Gratings* Gennady Imeshev,2000 **Split-step Fourier Method for Generalized Nonlinear Schrödinger Equation** Weiming Zheng,1994 Split Step Fourier Method Implemented in S-Function Constantino Monzó Cadena,2006 Index to Theses with Abstracts Accepted for Higher Degrees by the Universities of Great Britain and Ireland and the Council for National Academic Awards ,2004 Theses on any subject submitted by the academic libraries in the UK and Ireland Science Abstracts ,1995 **Split Step Fourier Method implemented in S-Function** Constantino Monzó Cadena,Oliver Gough,2006 **Methods of Applied Mathematics with a MATLAB Overview** Jon H. Davis,2003-11-03 Broadly organized around the applications of Fourier analysis Methods of Applied Mathematics with a MATLAB Overview covers both classical applications in partial differential equations and boundary value problems as well as the concepts and methods associated to the Laplace Fourier and discrete transforms Transform inversion problems are also examined along with the necessary background in complex variables A final chapter treats wavelets short time Fourier analysis and geometrically based transforms The computer program MATLAB is emphasized throughout and an introduction to MATLAB is provided in an appendix Rich in examples illustrations and exercises of varying difficulty this text can be used for a one or two semester course and is ideal for students in pure and applied mathematics physics and engineering Parallel Split-step Fourier Methods for the Nonlinear Schrödinger Equations Xiangming Xu,2001

Split-step Fourier Methods for Nonlinear Schrödinger Equations D. Pathria,J. L. Morris,1991 *Split-Step Fourier-Transform Analysis For Laser-Pulse Propagation in Particulate Media* W. G. Tam,Defence Research Establishment Valcartier,1982 **Spectral Methods in MATLAB** Lloyd N. Trefethen,2000-01-01 This is the only book on spectral methods built around MATLAB programs Along with finite differences and finite elements spectral methods are one of the three main technologies for solving partial differential equations on computers Since spectral methods involve significant linear algebra and graphics they are very suitable for the high level programming of MATLAB This hands on introduction is built around forty short and powerful MATLAB programs which the reader can download from the World Wide Web

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