

# Long time dynamics and blow-up for the focusing inhomogeneous nonlinear Schrödinger equation with spatially growing nonlinearity

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## ABSTRACT

We investigate the Cauchy problem for the focusing inhomogeneous nonlinear Schrödinger equation  $i\partial_t u + \Delta u = -|x|^b |u|^{p-1} u$  in the radial Sobolev space  $H^1_b(\mathbb{R}^N)$ , where  $b > 0$  and  $p > 1$ . We show the global existence and energy scattering in the intercritical regime, i.e.,  $p > \frac{N+1+2b}{N-2}$  and  $p < \frac{N+1+2b}{N-2}$  if  $N \geq 3$ . We also obtain blowing-up solutions for the mass-critical and mass-supercritical nonlinearities. The main difficulty, coming from the spatial growing nonlinearity, is overcome by refined Gagliardo–Nirenberg-type inequalities. Our proofs are based on improved Gagliardo–Nirenberg inequalities, the Morawetz–Sobolev approach of Dodson and Murphy [Proc. Am. Math. Soc. **145**(11), 4859–4867 (2017)], radial Sobolev embeddings, and localized virial estimates.

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## 1. INTRODUCTION

In this paper, we consider the Cauchy problem for the following focusing inhomogeneous nonlinear Schrödinger equation:

$$i\partial_t u + \Delta u = -|x|^b |u|^{p-1} u, \quad (t, x) \in \mathbb{R}_+ \times \mathbb{R}^N, \quad (1.1)$$

where  $b > 0$  and  $p > 1$ . Equation (1.1) is a special case of a more general inhomogeneous nonlinear Schrödinger equation given by

$$i\partial_t u + \Delta u = K(x) |u|^{p-1} u, \quad (1.2)$$

which arises in various physical contexts such as the propagation of a laser beam and plasma waves. Here,  $u$  is the electric field in laser optics and  $K$  is proportional to the electric density.<sup>1,2</sup> For  $p = 3$ , Eq. (1.1) can be viewed as a model of dilute Bose–Einstein condensate when the two-body interactions of the condensate are considered.

The Cauchy problem for (1.2) was first investigated by Merle<sup>3</sup> who proves the existence of blow-up solutions in the mass-critical regime and under some assumptions on  $K$  including in particular  $k_1 \leq K(x) \leq k_2$  with  $k_1, k_2$  being positive constants. Later on, the stability of standing waves was studied in Refs. 7 and 8 for  $K(x) = K(|x|)$  with  $K \in C^2(\mathbb{R}^N) \cap L^\infty(\mathbb{R}^N)$ ,  $\epsilon > 0$  small, and  $p \geq 1 + \frac{2}{N}$ . Recently, the Cauchy problem

# Long Time Prediction In Dynamics

**Shouting Gao, Lingkun Ran, Xiaofan Li**



## **Long Time Prediction In Dynamics:**

**Long-Time Predictions in Dynamics** V.G. Szebehely, B.D. Tapley, 2012-12-06 Proceedings of the NATO Advanced Study Institute Cortina D Ampezzo Italy August 3 16 1975      Vibro-impact Dynamics Albert C. J. Luo, Yu Guo, 2013-01-25 Presents a systematic view of vibro impact dynamics based on the nonlinear dynamics analysis Comprehensive understanding of any vibro impact system is critically impeded by the lack of analytical tools viable for properly characterizing grazing bifurcation The authors establish vibro impact dynamics as a subset of the theory of discontinuous systems thus enabling all vibro impact systems to be explored and characterized for applications Vibro impact Dynamics presents an original theoretical way of analyzing the behavior of vibro impact dynamics that can be extended to discontinuous dynamics All topics are logically integrated to allow for vibro impact dynamics the central theme to be presented It provides a unified treatment on the topic with a sound theoretical base that is applicable to both continuous and discrete systems Vibro impact Dynamics Presents mapping dynamics to determine bifurcation and chaos in vibro impact systems Offers two simple vibro impact systems with comprehensive physical interpretation of complex motions Uses the theory for discontinuous dynamical systems on time varying domains to investigate the Fermi oscillator Essential reading for graduate students university professors researchers and scientists in mechanical engineering      Nonlinear Dynamics of the Lithosphere and Earthquake Prediction Vladimir Keilis-Borok, Alexandre A. Soloviev, 2013-03-14 The vulnerability of our civilization to earthquakes is rapidly growing raising earthquakes to the ranks of major threats faced by humankind Earth quake prediction is necessary to reduce that threat by undertaking disaster preparedness measures This is one of the critically urgent problems whose solution requires fundamental research At the same time prediction is a major tool of basic science a source of heuristic constraints and the final test of theories This volume summarizes the state of the art in earthquake prediction Its following aspects are considered Existing prediction algorithms and the quality of predictions they provide Application of such predictions for damage reduction given their current accuracy so far limited Fundamental understanding of the lithosphere gained in earthquake prediction research Emerging possibilities for major improvements of earthquake prediction methods Potential implications for predicting other disasters besides earthquakes Methodologies At the heart of the research described here is the integration of three methodologies phenomenological analysis of observations universal models of complex systems such as those considered in statistical physics and nonlinear dynamics and Earth specific models of tectonic fault networks In addition the theory of optimal control is used to link earthquake prediction with earthquake preparedness      **Literature 1976, Part 1** S. Böhme, U. Esser, W. Fricke, U. Güntzel-Lingner, I. Heinrich, F. Henn, D. Krahn, L. D. Schmadel, H. Scholl, G. Zech, 2013-11-11 Astronomy and Astrophysics Abstracts which has appeared in semi annual volumes since 1969 is devoted to the recording summarizing and indexing of astronomical publications throughout the world It is prepared under the auspices of the International Astronomical Union according to a resolution adopted at the 14th General Assembly in 1970

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Deep Learning in Multi-step Prediction of Chaotic Dynamics Matteo Sangiorgio, Fabio Dercole, Giorgio Guariso, 2022-02-14 The book represents the first attempt to systematically deal with the use of deep neural networks to forecast chaotic time series Differently from most of the current literature it implements a multi step approach i.e. the forecast of an entire interval of future values This is relevant for many applications such as model predictive control that requires predicting the values for the whole receding horizon Going progressively from deterministic models with different degrees of complexity and chaoticity to noisy systems and then to real world cases the book compares the performances of various neural network architectures feed forward and recurrent It also introduces an innovative and powerful approach for training recurrent structures specific for sequence to sequence tasks The book also presents one of the first attempts in the context of environmental time series forecasting of applying transfer learning techniques such as domain adaptation

Nonlinear Dynamics, Chaotic and Complex Systems Eryk Infeld, R. Zelazny, A. Galkowski, 1997-06-19 The physics and mathematics of nonlinear dynamics chaotic and complex systems constitute some of the most fascinating developments of late twentieth century science It turns out that chaotic behaviour can be understood and even utilized to a far greater degree than had been suspected Surprisingly universal constants have been discovered The implications have changed our understanding of important phenomena in physics biology chemistry economics medicine and numerous other fields of human endeavor In this book two dozen scientists and mathematicians who were deeply involved in the nonlinear revolution cover most of the basic aspects of the field

Navier-Stokes Predictions of Dynamic Stability Derivatives James DeSpirito, Sidra I. Sifton, Paul Weinacht, 2008 The prediction of the dynamic stability derivatives roll damping Magnus and pitch damping moments were evaluated for three spin stabilized projectiles using steady state computational fluid dynamic CFD calculations Roll damping CFD predictions were found to be very good across the Mach number range investigated Magnus moment predictions were very good in the supersonic flight regime however the accuracy varied in the subsonic and

transonic flight regime The best Magnus moment prediction in the subsonic flight regime was for the square base projectile that did not exhibit highly nonlinear Magnus moments A primary contribution of this report is the demonstration that the pitch damping moment can be adequately predicted via steady state methods rather than resorting to unsteady techniques The predicted pitch damping moment compared very well to experimental data for the three projectiles investigated For one configuration the pitch damping moment was predicted by several CFD codes two different steady state methods and a time accurate planar pitching motion method All methods compared very well to each other and to the experimental data

*Hamiltonian Dynamical Systems* R.S MacKay,J.D Meiss,2020-08-18 Classical mechanics is a subject that is teeming with life However most of the interesting results are scattered around in the specialist literature which means that potential readers may be somewhat discouraged by the effort required to obtain them Addressing this situation *Hamiltonian Dynamical Systems* includes some of the most significant papers in Hamiltonian dynamics published during the last 60 years The book covers bifurcation of periodic orbits the break up of invariant tori chaotic behavior in hyperbolic systems and the intricacies of real systems that contain coexisting order and chaos It begins with an introductory survey of the subjects to help readers appreciate the underlying themes that unite an apparently diverse collection of articles The book concludes with a selection of papers on applications including in celestial mechanics plasma physics chemistry accelerator physics fluid mechanics and solid state mechanics and contains an extensive bibliography The book provides a worthy introduction to the subject for anyone with an undergraduate background in physics or mathematics and an indispensable reference work for researchers and graduate students interested in any aspect of classical mechanics *Nonlinear Dynamics And Chaos: Proceedings Of The Fourth Physics Summer School* Robert L Dewar,B I Henry,1992-01-24 Articles in this collection discuss basic concepts and modern developments in the field Suitable for both theorists and experimentalists *The Basis of Atmospheric Mesoscale Dynamics and a Dynamical Method of Predicting Rainstorms* Shouting Gao,Lingkun Ran,Xiaofan Li,2021-07-28 This book serves to deepen the theoretical understanding of mesoscale dynamics and makes its basic concepts clear reflecting new research results It emphasizes important theories that have not been given enough attention in recent years such as generalized potential temperature and the moist potential vorticity theory of non uniform saturated moist atmospheres By integrating theory with practice the book also introduces the forecast method of rainstorms and other disastrous weathers using dynamic factors This book can be used as a point of reference for operational forecasters researchers and graduate and undergraduate students whose research interests are atmospheric sciences and ocean and water sciences It will also be of interest to scholars who study geological disasters such as multiphase flow mountains debris flows and landslides as well as geological seismologists *Variational Methods in Geosciences* Y.K. Sasaki,2012-12-02 The last few decades have seen a spectacular growth in the use of variational methods one of the most classic and elegant methods in physical and mathematical sciences as powerful tools of optimization and numerical analysis The tremendous

accumulation of information on the use of variational methods in the area of the geosciences which includes meteorology oceanography hydrology geophysics and seismology indicated the need for the first symposium on Variational Methods in Geosciences to be organized and held in Norman on October 15 17 1985 The value of this symposium was enhanced by the number of stimulating and informative papers presented **Nonlinear Dynamics In Human Behavior** William Sulis, A Combs, 1996-09-20 This book represents a selection of papers presented at the Fourth Annual Conference of the Society for Chaos Theory in Psychology and the Life Sciences held at Johns Hopkins University in Baltimore June 24 27 1995 The book reflects the Society as a whole consisting of applications of nonlinear methodology in psychophysics neurophysiology business and social science as well as applications of the nonlinear paradigm to issues arising in psychotherapy and the study of creativity Unique are contributions on the use of Boolean networks in the study of psychosis and quality of life Review articles on the appropriate use of time series methods in psychology and psychophysics provide a valuable reference

Predictive Maintenance in Dynamic Systems Edwin Lughofer, Moamar Sayed-Mouchaweh, 2019-02-28 This book provides a complete picture of several decision support tools for predictive maintenance These include embedding early anomaly fault detection diagnosis and reasoning remaining useful life prediction fault prognostics quality prediction and self reaction as well as optimization control and self healing techniques It shows recent applications of these techniques within various types of industrial production utilities equipment plants smart devices etc systems addressing several challenges in Industry 4.0 and different tasks dealing with Big Data Streams Internet of Things specific infrastructures and tools high system dynamics and non stationary environments Applications discussed include production and manufacturing systems renewable energy production and management maritime systems power plants and turbines conditioning systems compressor valves induction motors flight simulators railway infrastructures mobile robots cyber security and Internet of Things The contributors go beyond state of the art by placing a specific focus on dynamic systems where it is of utmost importance to update system and maintenance models on the fly to maintain their predictive power **Applied Symbolic Dynamics And Chaos (Second Edition)** Hao Bailin, Zheng Wei-mou, 2018-05-11 Symbolic dynamics is a coarse grained description of dynamics It has been a long studied chapter of the mathematical theory of dynamical systems but its abstract formulation has kept many practitioners of physical sciences and engineering from appreciating its simplicity beauty and power At the same time symbolic dynamics provides almost the only rigorous way to understand global systematics of periodic and especially chaotic motion in dynamical systems In a sense everyone who enters the field of chaotic dynamics should begin with the study of symbolic dynamics However this has not been an easy task for non mathematicians On one hand the method of symbolic dynamics has been developed to such an extent that it may well become a practical tool in studying chaotic dynamics both on computers and in laboratories On the other hand most of the existing literature on symbolic dynamics is mathematics oriented This book is an attempt at partially filling up this apparent gap by emphasizing the applied aspects of symbolic

dynamics without mathematical rigor Contents Preface to the Second Edition Preface to the First Edition Introduction Symbolic Dynamics of Unimodal Maps Maps with Multiple Critical Points Symbolic Dynamics of Circle Maps Symbolic Dynamics of Two Dimensional Maps Application to Ordinary Differential Equations Counting the Number of Periodic Orbits Symbolic Dynamics and Grammatical Complexity Symbolic Dynamics and Knot Theory Appendix References Index Readership Researchers and students interested in chaotic dynamics Keywords Symbolic Dynamics Chaos Review Key Features No previous knowledge of dynamical systems theory is required in order to read this book The revisions concern mainly the application to ordinary differential equations via constructing two dimensional symbolic dynamics of the corresponding Poincare maps

**Nonlinear Dynamics** Nail N. Akhmediev, Rowena Ball, 2003 This book is an inspirational introduction to modern research directions and scholarship in nonlinear dynamics and will also be a valuable reference for researchers in the field With the scholarly level aimed at the beginning graduate student the book will have broad appeal to those with an undergraduate background in mathematical or physical sciences In addition to pedagogical and new material each chapter reviews the current state of the area and discusses classic and open problems in engaging surprisingly non technical ways The contributors are Brian Davies bifurcations in maps Nalini Joshi integrable systems and asymptotics Alan Newell wave turbulence and pattern formation Mark Ablowitz nonlinear waves Carl Weiss spatial solitons Cathy Holmes Hamiltonian systems Tony Roberts dissipative fluid mechanics Jorgen Frederiksen two dimensional turbulence and Mike Lieberman Fermi acceleration **Applied Symbolic Dynamics and Chaos** Bai-lin Hao, Wei-Mou Zheng, 1998 Symbolic dynamics is a coarse grained description of dynamics It provides a rigorous way to understand the global systematics of periodic and chaotic motion in a system In the last decade it has been applied to nonlinear systems described by one and two dimensional maps as well as by ordinary differential equations This book will help practitioners in nonlinear science and engineering to master that powerful tool **Dynamics of Plate Tectonics and Mantle Convection** Joao C.

Duarte, 2023-02-10 Dynamics of Plate Tectonics and Mantle Convection written by specialists in the field gathers state of the art perspectives on the dynamics of plate tectonics and mantle convection Plate tectonics is a unifying theory of solid Earth sciences In its initial form it was a kinematic theory that described how the planet's surface is fragmented into several rigid lithospheric plates that move in relation to each other over the less viscous asthenosphere Plate tectonics soon evolved to describe the forces that drive and resist plate movements The Earth sciences community is now developing a new perspective that looks at plate tectonics and mantle convection as part of a single system Why does our planet have plate tectonics and how does it work How does mantle convection drive the supercontinent cycle How have tectono convective modes evolved over the Earth's history How did they shape the planet and impact life Do other planets have mantle convection and tectonics These are some of the fascinating questions explored in this book This book started with a challenge from the editor to the authors to provide perspectives from their vantage point and open the curtain to the endeavors and

stories behind the science Provides diverse perspectives from different experts around the world in plate tectonics and geodynamics Includes the most up to date knowledge on plate tectonics and mantle convection Sets the scene for the developments and challenges likely to be faced by researchers in the future of geodynamics Knowledge Management, Organizational Intelligence And Learning, And Complexity - Volume I L. Douglas Kiel, 2009-08-25 Knowledge Management Organizational Intelligence and Learning and Complexity is the component of Encyclopedia of Technology Information and Systems Management Resources in the global Encyclopedia of Life Support Systems EOLSS which is an integrated compendium of twenty one Encyclopedias The Theme on Knowledge Management Organizational Intelligence and Learning and Complexity in the Encyclopedia of Technology Information and Systems Management Resources provides the latest scientific insights into the evolution of complexity in both the natural and social realms Emerging perspectives from the fields of knowledge management computer based simulation and the organizational sciences are presented as tools for understanding and supporting this evolving complexity and the earth's life support systems These three volumes are aimed at the following a wide spectrum of audiences from the merely curious to those seeking in depth knowledge University and College students Educators Professional practitioners Research personnel and Policy analysts managers and decision makers and NGOs **Machinery, Materials Science and Engineering Applications** Fei Lei, Qiang Xu, Guangde Zhang, 2017-03-31 This conference proceeding contains papers presented at the 6th International Conference on Machinery Materials Science and Engineering Applications MMSE 2016 held 28-30 October 2016 in Wuhan China The conference proceeding contributions cover a large number of topics both theoretical and applied including Material science Electrical Engineering and Automation Control Electronic Engineering Applied Mechanics Mechanical Engineering Aerospace Science and Technology Computer Science and Information technology and other related engineering topics MMSE provides a perfect platform for scientists and engineering researchers to exchange ideas build cooperative relationships and discuss the latest scientific achievements MMSE will be of interest for academics and professionals working in a wide range of industrial governmental and academic sectors including Material Science Electrical and Electronic Engineering Information Technology and Telecommunications Civil Engineering Energy Production Manufacturing Mechanical Engineering Nuclear Engineering Transportation and Aerospace Science and Technology **The Dynamical Behaviour of our Planetary System** Rudolf Dvorak, Jacques Henrard, 2012-12-06 It is now a well established tradition that every four years at the end of winter a group of celestial mechanicians from all over the world gather at the Alpen gasthof Peter Rosegger in the Styrian Alps Ramsau Austria This time the colloquium was held from March 17 to March 23 1996 and was devoted to the Dynamical Behaviour of our Planetary System The papers covered a large range of questions of current interest theoretical questions resonances universal properties non integrability transport and questions about numerical tools symplectic maps indicators of chaos were particularly well represented the never ending problem of the sculpting of the asteroid belt was also quite



popular You will find in the following pages a pot pourri of what we listen to you will miss of course the diversity of accents with which the tunes were delivered from China from Japan from Brazil from the United States of America and from all over Europe East and West Let us not forget that the comet 199682 Hyakutake came to visit us many an evening was spent on the deck of the Alpengasthof contemplating this celestial visitor who liked to play hide and seek behind the spruce trees

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