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 $H^1_r(\mathbb{R}^N)$, where $b > 0$ and $p > 1$. We show the global existence and energy scattering in the intercritical regime, i.e., $p > \frac{N+4+2b}{N}$ and $p < \frac{N+2+2b}{N-2}$ 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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I. INTRODUCTION

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

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

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

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

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. 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 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 $K(x) = K(\varepsilon|x|)$ with $K \in C^4(\mathbb{R}^N) \cap L^\infty(\mathbb{R}^N)$, $\varepsilon > 0$ small, and $p \geq 1 + \frac{4}{N}$. Recently, the Cauchy problem

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Lawrence Sklar

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    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   <u>Nonlinear Dynamics of the Lithosphere and Earthquake Prediction</u> Vladimir Keilis-Borok,Alexandre A. Soloviev,2013-03-14 The vulnerability of our civilization to earthquakes is rapidly growing rais ing 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 ma jor 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 pro vide 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 inte gration 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   *Regular and Chaotic Motions in Dynamic Systems* A. S. Wightman,2013-06-29 The fifth International School Mathematical Physics was held at the Ettore Majorana Centro della Culture Scientifica Erice Sicily 2 to 14 July 1983 The present volume collects lecture notes on the session which was devoted to Regular and Chaotic Motions in Dynamlcal Systems The School was a NATO Advanced Study Institute sponsored by the Italian Ministry of Public Education the Italian Ministry of Scientific and

Technological Research and the Regional Sicilian Government Many of the fundamental problems of this subject go back to Poincare and have been recognized in recent years as being of basic importance in a variety of physical contexts stability of orbits in accelerators and in plasma and galactic dynamics occurrence of chaotic motions in the excitations of solids etc This period of intense interest on the part of physicists followed nearly a half a century of neglect in which research in the subject was almost entirely carried out by mathematicians It is an in dication of the difficulty of some of the problems involved that even after a century we do not have anything like a satisfactory solution   **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 de voted 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 Astronomy and Astrophysics Abstracts aims to present a comprehensive documentation of literature in all fields of astronomy and astrophysics Every effort will be made to ensure that the averagetime interval between the date of receipt of the original literature and publication ofthe abstracts will not exceed eight months This time interval is near to that achieved by monthly abstracting journals com pared to which our system of accumulating abstracts for about six months offers the advantage of greater convenience for the user Volume 17 contains literature published in 1976 and received before August 15 1976 some older literature which was received late and which is not recorded in earlier volumes is also included We acknowledge with thanks contributions to this volume by Dr J Bouska who surveyed journals and publications in the Czech languageand supplied us with abstracts in English and by the Common wealth Scientific and Industrial Research Organization C S I R O Sydney for providing titles and abstracts of papers on radio astronomy We want to acknowledge valuable contributions to this vol ume by Zentralstelle fur Atomkernenergie Dokumentation Leopoldshafen which supported our ab stracting service by sending us retrospective literature searches   *Navier-Stokes Predictions of Dynamic Stability Derivatives* James DeSpirito,Sidra I. Silton,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

Meteorological Fluid Dynamics Radyadour K. Zeytounian,2008-10-09 The author considers meteorology as a part of fluid dynamics He tries to derive the properties of atmospheric flows from a rational analysis of the Navier Stokes equations at the same time analyzing various types of initial and boundary problems This approach to simulate nature by models from fluid dynamics will be of interest to both scientists and students of physics and theoretical meteorology   Topics In Theoretical Physics - Proceedings Of The Second Pacific Winter For Theoretical Physics Yongmin Cho,1997-04-01 Recently exciting new notions have been emerging in theoretical physics The quantum nature of gravitation revealed in the physics of black holes exotic excitations obeying fractional statistics and integrable structure such as Yangian symmetry in low dimensional models are some of the subjects presented in this volume The spectrum of the talks at the School reflected in the proceedings is a wide one ranging from the phenomenology of particle physics to that of condensed matter physics to topics of a mathematical nature This is an indication that there is a robust interplay of ideas from diverse disciplines of theoretical physics in the Asia Pacific region   *Applied Symbolic Dynamics And Chaos* Bailin Hao,Wei-mou Zheng,1998-07-04 Latest Edition Applied Symbolic Dynamics and Chaos 2nd Edition 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   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

ChaosReview 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 <u>Dynamic Meteorology</u> S. Panchev,2012-12-06 1 ABOUT THE DISCIPLINE DYNAMIC METEOROLOGY The name dynamic meteorology is traditional for designating a university course as well as the scientific branch of meteorology as a whole While there is no need to abandon this name it needs contemporary treatment and specifications in its definition A synonym for it could be dynamics more precisely hydrodynamics or fluid dynamics of the atmosphere It suggests the relationship of this discipline to general hydrodynamics and applied mathematics and its pronounced theoretical nature Besides the atmosphere however our planet has another liquid envelope the hydrosphere world s ocean which also concerns ocean dynamics and therefore it is necessary to define from a unified standpoint the subject and aims of the disciplines dealing with the dynamics of the processes which take place in both fluid spheres Such a unified standpoint offers the so called geophysical fluid dynamics During the past few years this description is encountered quite often in scientific literature concerning the Earth as a planet Obviously a scientific branch or a science is created whose subject is our planet and the investigation methods are borrowed from classical fluid dynamics and applied mathematics including the most recent numerical methods As can be seen from its very suitable name it is the dynamics of quite definite geophysical fluids atmosphere ocean and even the liquid inside of the Earth and not of some abstract often perfect flUids as in classical hydrodynamics **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 *Physics and Chance* Lawrence Sklar,1993 Lawrence Sklar offers a comprehensive non technical introduction to statistical mechanics and attempts to understand its foundational elements **Theoretical Approaches to Biological Control** Bradford A. Hawkins,Howard V. Cornell,2008-10-14 Biological control is the suppression of pest populations using predators parasitoids and pathogens Historically biological control has largely been on a trial and error basis and has failed more often than it has succeeded However by developing theories based upon fundamental population principles and the biological characteristics of the pest and agent we can gain a much better understanding of when and how to use biological control This book gathers together recent theoretical developments and provides a balanced guide to the important issues that need to be considered in applying ecological theory to biological control It will be a source of productive and stimulating thought for all those interested in pest management theoretical

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