

Renormalization and transition to chaos in area preserving nontwist maps

D. del-Castillo-Negrete^{*}, J.M. Greene[†], P.J. Morrison

Department of Physics and Institute for Fusion Studies, The University of Texas at Austin, Austin, TX 78712, USA

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Abstract

The problem of transition to chaos, i.e. the destruction of invariant circles or KAM (Kolmogorov–Arnold–Moser) curves, in area preserving nontwist maps is studied within the renormalization group framework. Nontwist maps are maps for which the twist condition is violated along a curve known as the shearless curve. In renormalization language this problem is that of finding and studying the fixed points of the renormalization group operator \mathcal{R} that acts on the space of maps. A simple period-two fixed point of \mathcal{R} , whose basin of attraction contains the nontwist maps for which the shearless curve exists, is found. Also, a critical period-12 fixed point of \mathcal{R} , with two unstable eigenvalues, is found. The basin of attraction of this critical fixed point contains the nontwist maps for which the shearless curve is at the threshold of destruction. This basin defines a new universality class for the transition to chaos in area preserving maps.

1. Introduction

A fundamental problem of Hamiltonian dynamics is to understand the behavior of an integrable Hamiltonian system when subject to perturbation. In terms of the action–angle variables (J, θ) of the integrable system, the Hamiltonian for the perturbed system in the case of one degree-of-freedom can be written as

$$H = H_0(J) + H_1(J, \theta, t), \quad (1)$$

where H_0 is the Hamiltonian of the integrable system and the perturbation is represented by H_1 . Since the pioneering work of Poincaré, it has been known that the dynamics for Hamiltonians of this form is far from trivial. Typically, the phase space consists of a complicated mixture of integrable (confined to invariant tori) and nonintegrable (chaotic) trajectories. Thus, the problem of the transition to chaos is to determine which trajectories of H_0 remain integrable and which become chaotic under the effect of H_1 .

^{*} Corresponding author. Present address: Scripps Institution of Oceanography 0230, University of California at San Diego, La Jolla, CA 92093-0230, USA. E-mail: diego@fwlty.ucsd.edu.

[†] Present address: General Atomics Inc., San Diego, CA 92186-9784, USA.

Renormalization In Areapreserving Maps

R. S. MacKay



Renormalization In Areapreserving Maps:

Renormalisation in Area-preserving Maps R. S. MacKay, 1993 This book is adapted and revised from the author's seminal PhD thesis in which two forms of asymptotically universal structure were presented and explained for area preserving maps Area preserving maps are the discrete time analogue of two degree of freedom Hamiltonian systems How they work and much of their dynamics are described in this book The asymptotically universal structure is found on small scales in phase space and long time scales The key to understanding it is renormalisation that is looking at a system on successively smaller phase space and longer time scales Having presented this idea the author briefly surveys the use of the idea of renormalisation in physics The renormalisation picture is then presented as the key to understanding the transition from regular to chaotic motion in area preserving maps Although written ten years ago the subject matter continues to interest many today This updated version will be useful to both researchers and students *Renormalisation in Area Preserving Maps* Robert Sinclair Mackay, 1986 [Holomorphic Dynamics and Renormalization](#) Mikhail Lyubich, Michael Yampolsky, Schwarzian derivatives and cylinder maps by A Bonifant and J Milnor Holomorphic dynamics Symbolic dynamics and self similar groups by V Nekrashevych Are there critical points on the boundaries of mother hedgehogs by D K Childers Finiteness for degenerate polynomials by L DeMarco Cantor webs in the parameter and dynamical planes of rational maps by R L Devaney Simple proofs of uniformization theorems by A A Glutsyuk The Yoccoz combinatorial analytic invariant by C L Petersen and P Roesch Bifurcation loci of exponential maps and quadratic polynomials Local connectivity triviality of fibers and density of hyperbolicity by L Rempe and D Schleicher Rational and transcendental Newton maps by J Ruckert Newton's method as a dynamical system Efficient root finding of polynomials and the Riemann zeta function by D Schleicher The external boundary of M_2 by V Timorin Renormalization Renormalization of vector fields by H Koch Renormalization of arbitrary weak noises for one dimensional critical dynamical systems Summary of results and numerical explorations by O Diaz Espinosa and R de la Llave KAM for the nonlinear Schrodinger equation A short presentation by H L Eliasson and S B Kuksin Siegel disks and renormalization fixed points by M Yampolsky **Renormalization Group Applications in Area-preserving Nontwist Maps and Relativistic Quantum Field Theory** Alexander Wurm, 2002 [Directions In Chaos - Volume 1](#) Bailin Hao, 1987-12-01 This volume the first of a two volume book consists of a collection of comprehensive reviews and lectures written by active researchers on topics in chaotic phenomena **Chaotic Dynamics of Nonlinear Systems** S. Neil Rasband, 2015-08-19 Introduction to the concepts applications theory and technique of chaos Suitable for advanced undergraduates and graduate students and researchers Requires familiarity with differential equations and linear vector spaces 1990 edition **The Transition to Chaos** Linda Reichl, 2021-04-12 Based on courses given at the universities of Texas and California this book treats an active field of research that touches upon the foundations of physics and chemistry It presents in as simple a manner as possible the basic mechanisms that determine the dynamical evolution of both

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