

## Renormalization and transition to chaos in area preserving nontwist maps

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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  $(J, \theta)$  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  $H_1$ .

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# Renormalization In Areapreserving Maps

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