

On the Number of Limit Cycles in Perturbations of Quadratic Hamiltonian Systems ¹

E. HOROZOV and I. D. ILIEV

ABSTRACT

We prove that in quadratic perturbations of generic quadratic Hamiltonian vector fields with three saddle points and one centre there can appear at most two limit cycles. This bound is exact.

0. Introduction

The problem we solve in this paper belongs to a circle of problems arising in attempts to find an answer to the celebrated Hilbert 16-th problem (or – more precisely – to its second part) [9]. To place adequately our main result we briefly review some of the classical and recent developments in this subject.

The second part of Hilbert 16-th problem asks about "the maximum number and the positions of the limit cycles of Poincaré" for polynomial vector fields

$$(0.1) \quad \begin{aligned} \dot{x} &= X(x, y) \\ \dot{y} &= Y(x, y). \end{aligned}$$

Stated in such a form this problem obviously needs splitting into a series of concrete questions. Generally recognized as the most fundamental is the following:

- 1) *Find (explicitly) an upper bound $C(n)$ for the number of the limit cycles of all polynomial vector fields (0.1) of degree n or less.*

In problem 1) it is assumed that

- 2) *The number of the limit cycles of any individual vector field (0.1) is finite.*

In fact 2) was believed for many years to have been proved by Dulac [4]. About ten years ago it was found that [4] contains a gap. The complete proof (which is rather a theory than a plain solution to 2)) was achieved by Yu. Ilyashenko and J. Ecalle and substantial parts of it were published in [5], [11].

Until now problem 1) is not solved even for $n = 2$. V. I. Arnold [1] proposed a weaker version of this problem connected explicitly with the first, algebraic-geometric part of Hilbert 16-th problem. To state Hilbert - Arnold's problem

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Random Perturbations Of Hamiltonian Systems

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Random Perturbations of Dynamical Systems Mark I. Freidlin, Alexander D. Wentzell, 2012-05-31 Many notions and results presented in the previous editions of this volume have since become quite popular in applications and many of them have been rediscovered in applied papers In the present 3rd edition small changes were made to the chapters in which long time behavior of the perturbed system is determined by large deviations Most of these changes concern terminology In particular it is explained that the notion of sub limiting distribution for a given initial point and a time scale is identical to the idea of metastability that the stochastic resonance is a manifestation of metastability and that the theory of this effect is a part of the large deviation theory The reader will also find new comments on the notion of quasi potential that the authors introduced more than forty years ago and new references to recent papers in which the proofs of some conjectures included in previous editions have been obtained Apart from the above mentioned changes the main innovations in the 3rd edition concern the averaging principle A new Section on deterministic perturbations of one degree of freedom systems was added in Chapter 8 It is shown there that pure deterministic perturbations of an oscillator may lead to a stochastic in a certain sense long time behavior of the system if the corresponding Hamiltonian has saddle points The usefulness of a joint consideration of classical theory of deterministic perturbations together with stochastic perturbations is illustrated in this section Also a new Chapter 9 has been inserted in which deterministic and stochastic perturbations of systems with many degrees of freedom are considered Because of the resonances stochastic regularization in this case is even more important

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Systems, 1995 *Lyapunov Exponents for Small Random Perturbations of Nilpotent and Hamiltonian Systems* Levon Goukasian, 2001 *Qualitative and Asymptotic Analysis of Differential Equations with Random Perturbations* Anatoliy M. Samoilenko, Oleksandr Stanzhytskyi, 2011

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especially to the conference organizers for making the event so successful Pao Liu Chow Boris Mor dukhovich and George Yin of the Department of Mathematics at Wayne State University did a superb job organizing this first rate event and in editing these proceedings We take this opportunity to thank the National Science Foundation for its support of the IMA

Lyapunov Exponents Arkady Pikovsky, Antonio Politi, 2016-02-11 Lyapunov exponents lie at the heart of chaos theory and are widely used in studies of complex dynamics Utilising a pragmatic physical approach this self contained book provides a comprehensive description of the concept Beginning with the basic properties and numerical methods it then guides readers through to the most recent advances in applications to complex systems Practical algorithms are thoroughly reviewed and their performance is discussed while a broad set of examples illustrate the wide range of potential applications The description of various numerical and analytical techniques for the computation of Lyapunov exponents offers an extensive array of tools for the characterization of phenomena such as synchronization weak and global chaos in low and high dimensional set ups and localization This text equips readers with all the investigative expertise needed to fully explore the dynamical properties of complex systems making it ideal for both graduate students and experienced researchers

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