RUDN University

Steklov
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Moscow State University

DFDE • 2017

The 8th International Conference on Differential and Functional Differential Equations

Moscow, Russia, August 13–20, 2017

International Workshop “Differential Equations and Interdisciplinary Investigations”

Moscow, Russia, August 17–19, 2017

ABSTRACTS

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Integrable System with Dissipation on Tangent Bundle of Two-Dimensional Manifold

M. V. Shamolin

Lomonosov Moscow State University, Moscow, Russia

We study nonconservative systems for which the usual methods of study, e.g., Hamiltonian systems, are inapplicable. Thus, for such systems, we must “directly” integrate the main equation of dynamics. We generalize previously known cases and obtain new cases of the complete integrability in transcendental functions of the equation of dynamics of a lower- and multi-dimensional rigid bodies in nonconservative force fields.

Of course, the construction of the theory of integration for nonconservative systems (even of low dimension) is a quite difficult task in the general case. In a number of cases, where the systems considered have additional symmetries, we succeed in finding first integrals through finite combinations of elementary functions (see [1]).

We obtain a series of complete integrable nonconservative dynamical systems with nontrivial symmetries. Moreover, in almost all cases, all first integrals are expressed through finite combinations of elementary functions. These first integrals are transcendental functions of their variables, where the transcendence is understood in the sense of complex analysis and means that the analytic continuation of a function to the complex plane has essentially singular points. This fact is caused by the existence of attracting and repelling limit sets in the system (for example, attracting and repelling focuses).

We introduce a class of autonomous dynamical systems with one periodic phase coordinate possessing certain symmetries typical for pendulum-type systems. We show that this class of systems can be naturally embedded in the class of systems with variable dissipation with zero mean. The latter indicates that the dissipation in the system is equal to zero on average for the period with respect to the periodic coordinate. Although either energy pumping or dissipation can occur in various domains of the phase space, they are balanced in a certain sense. We present some examples of pendulum-type systems on lower-dimension manifolds relevant to dynamics of a rigid body in a nonconservative field [1, 2].

Then we study certain general conditions of the integrability in elementary functions for systems on the tangent bundles of two-dimensional manifolds. Therefore, we propose an interesting example of a three-dimensional phase portrait of a pendulum-like system describing the motion of a spherical pendulum in a flowing medium (see [2, 3]).

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On the Asymptotic Limit of the Effectiveness of Reaction-Diffusion Equations in Perforated Media

T. A. Shaposhnikova, A. V. Podolskiy
Lomonosov Moscow State University, Moscow, Russia

The talk focuses on the study of the asymptotic behaviour as $\varepsilon \to 0$ of the solution to the boundary value problem associated with the p-Laplace operator in a domain with an ε-periodically repeated inclusions on the boundary where a nonlinear Robin-type condition is specified. It is assumed that the size of the particles a_ε is of order ε^α, where $1 < \alpha < n/(n-p)$.

Let Ω be a bounded domain in $\mathbb{R}^n$ and G_ε be a set of particles. Define the sets $\Omega_\varepsilon = \Omega \setminus \overline{G_\varepsilon}$, $S_\varepsilon = \partial G_\varepsilon$, and $\partial\Omega_\varepsilon = \partial\Omega \cup S_\varepsilon$. Consider the problem

$$\begin{cases} -\Delta_p u_\varepsilon = f(x), & x \in \Omega_\varepsilon, \\ \partial_{\nu_p} u_\varepsilon + \beta(\varepsilon)\sigma(u_\varepsilon) = 0, & x \in S_\varepsilon, \\ u_\varepsilon = 1, & x \in \partial\Omega, \end{cases} \tag{1}$$

where $\Delta_p u \equiv \operatorname{div}(|\nabla u|^{p-2}\nabla u)$, $\partial_{\nu_p} u \equiv |\nabla u|^{p-2}(\nabla u, \nu)$, ν is the outward unit normal vector to S_ε, and $f \in L^{p'}(\Omega)$. We assume that σ is a continuous nondecreasing function with $\sigma(0) = 0$ satisfying the following growth condition: $|\sigma(u)| \leqslant C(1 + |u|^{p-1})$, $C > 0$. In (1), $\beta(\varepsilon)$ represents the so-called adsorption coefficient. It is possible that $\beta(\varepsilon) \to \infty$ as $\varepsilon \to 0$. So, on the one hand, the inclusions are tiny. On the other hand, there are strong processes on their boundaries, and various relations between the parameters a_ε and $\beta(\varepsilon)$ lead to different asymptotic behaviour of the solution.

This problem appears in chemical engineering in the design of fixed-bed reactors (see, for example, [1]). A quantity of great interest in the applications is the *effectiveness*, which can be expressed as

$$\mathcal{E}_\varepsilon = \frac{1}{|S_\varepsilon|} \int_{S_\varepsilon} \sigma(u_\varepsilon) dS \tag{2}$$