

Article

Solvability of nonlinear equations in case of branching solutions

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Abstract: The necessary and sufficient conditions of existence of the nonlinear operator equations' branches of solutions in the neighbourhood of branching points are derived. The approach is based on reduction of the nonlinear operator equations to finite-dimensional problems. Methods of nonlinear functional analysis, integral equations, spectral theory based on index of Kronecker-Poincaré, Morse–Conley index, power geometry and other methods are employed. Proposed methodology enables justification of the theorems on existence of bifurcation points and bifurcation sets in the nonstandard models. Formulated theorems are constructive. For a certain smoothness of the nonlinear operator, the asymptotic behaviour of the solutions is analysed in the neighbourhood of the branch points and uniformly converging iterative schemes with a choice of the uniformization parameter enables the comprehensive analysis of the problems details. General theorems are illustrated on the nonlinear integral equations.

Keywords: branch points; bifurcation points; Fredholm operator; uniformization; asymptotics; iterations; regularization

1. Introduction

The progress in the methods of analysis development and the new nonlinear problems of applied mathematics enable the nonlinear functional analysis novel concepts formulation. In the seminal paper of L.A. Lusternik [1] the main directions of this field paved the anevue for the branching theory of nonlinear equations development. The classic works of A.M. Lyapunov, A.I. Nekrasov, J.H. Poincaré, M.A. Krasnoselsky [2], J. Toland and others contributed to this field. In their studies, reductions of the given nonlinear models to the finite-dimensional systems with parameters were used. The finite-dimensional equivalent system is now known as Lyapunov-Schmidt branching system and the corresponding method is known as Lyapunov-Schmidt (LS) method. In the review [3] and monograph of M.M. Vainberg and V.A. Trenogin [4] the basement of the analytical theory of branching solutions in Banach spaces with applications is given. These works contributed to the modern functional analysis development with many applications [5–22].

Studies of the integral equations in mechanics played the principal role not only in LS method development, but also initiated the way for functional analysis new chapters construction. Studies of integral equations' bifurcation points are necessary in various mathematical models in the various fields. For example, for some parameter values there the loss of stability may occur and another series of solutions branches off from that bifurcation point.

Such problems include both classical problems of the critical load of the rod and the formation, the emergence of new forms of equilibrium of rotating fluids, a branch at a critical wind speed from

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