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**BIFURCATION AND  
NONLINEAR EIGENVALUE  
PROBLEMS:  
A TENTATIVE BIBLIOGRAPHY**

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# BIFURCATION AND NONLINEAR EIGENVALUE PROBLEMS :

## A TENTATIVE BIBLIOGRAPHY

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Being updated steadily

Bifurcation theory deals with parameter dependent problems. It was initially concerned with the situation where two or more different branches of solutions intersect or where the number of solutions changes when the parameter varies.

One may explain the name Bifurcation given to that theory by the analogy of a stroller who walks along a trail and meets a bifurcation on his path. Now this simplest case of bifurcation is called PITCHFORK bifurcation (see e.g. [392]).

As previously studied problems were very often equations of the form  $F(u) = \lambda u$  in Banach space,  $\lambda$  being a real parameter and dependence upon  $u$  being nonlinear, one called those problems Nonlinear Eigenvalue Problems instead of bifurcation problems. However this denomination justified by a peculiar form of the equations leads to consequential mistakes with Genera-

BIFURCATION AND NONLINEAR EIGENVALUE PROBLEMS :

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Résumé :

Cette bibliographie préliminaire de problèmes de bifurcation et de valeurs propres non linéaires essaye de donner une vue assez complète de la littérature mathématique occidentale qui existe sur ce sujet. Ce fascicule avec 806 entrées et 365 auteurs est un document provisoire devant être complété par de nouvelles références dans le but d'établir une base de données de théorèmes.

Abstract :

This tentative bibliography of bifurcation and nonlinear eigenvalue problems tries to give a comprehensive account of the western existing mathematical literature on this field of research. This issue with 806 entries and 365 authors is a preliminary document destined to be strengthened by addition of new references for the purpose of to make up a theorem-data-base.

lized eigenvalue problems  $Au = B(\lambda)u$ , where dependence upon  $u$  is linear, also called Nonlinear eigenvalue problems.

Together with the term bifurcation, the terms peeling, branching, buckling, snapping, synergetics are used accordingly to the special part of the theory or applications being studied.

Since, mainly the work of E. Hopf, bifurcation theory is also concerned with the situation where there is a qualitative change on the nature of solutions. Bifurcation of limit cycles from singular points, bifurcation of tori from limit cycles, cascade of bifurcations toward weak turbulence and many other examples can be furnished of such a qualitative change. In fact important improvements of bifurcation theory are now done in this area.

In its first issue with 806 entries and 365 different authors, this tentative bibliography tries to give a comprehensive account of the western existing mathematical literature on this field of research. That issue is merely a preliminary document destined to be strengthened by addition of new entries. In this aim the author would greatly appreciate receiving preprints, reprints or even references of articles which have not been included and hints on new researchs. Russian mathematical literature on this field will be analysed in forthcoming issues together with the historical part of the theory which does not appear in this issue.

The entries of the bibliography are listed automatically by a five-levels tree-sorting worked out by a FORTRAN routine: BIBLIO developed by the author. The five levels are the following (in decreasing order)

- 1) alphabetical with respect to the authors
- 2) annual
- 3) alphabetical with respect to the names of journals, books
- 4) numerical with respect to the issues of journals
- 5) numerical with respect to the number of the first page of each article.

Abbreviations of names of journals are those used in MATHEMATICAL REVIEWS whenever they are available. Several entries (372) include the references to reviews in Mathematical Reviews so as to facilitate an easy access to condensed information (reviews or summaries). For some titles written in German or Italian an English translation in brackets is given (see e.g. [541], [796]). The topics covered here are listed in annex A.

The author's purpose in writing this bibliography is to provide usable self-contained information in the field of bifurcation theory and applications. This work is divided in three steps. The first one is the collecting of related reprints preprints or titles. This issue is the result of a first collecting. The second step is to do an analysis of all documents and a tree-classification (main branches being: the kind of

i) analysed documents

ii) studied problems

iii) results

iv) used tools

etc ....

from the branch ii) secondary branches may be those given in annex A. etc...)

For the third step of this work we have to consider figure 1 where we show the annual flow rate of entries in both Mathematical Review and Zentralblatt für Mathematik. This flow rate is strongly increasing and extrapolations give 85,000 entries for 1985 and 120,000 entries for 1990. There are more than 600,000 entries for the period 1940-1981. The number of all entries from 1940 to 1958 is equal to the number of all entries in 1980 and 1981.

One may suppose that the number of articles and books related to bifurcation in the literature covered by M.R. and Zbl. is between 2,000 and 5,000. These numbers are given taking into account the procedure used for the first collecting. Then bifurcation theory and applications represent from 0,3% to 0,8% of mathematics. This seems of a reasonable size to achieving a quasi-exhaustive analysis of all contributions in this field. As it appears that information belonging to these contributions is redundant, a strong way to simplify access to the results is to compare theorems, hypotheses, proofs between them and to give the synthesis either in the form of an encyclopaedia or in a "theorem-data-base" form. The second form is more convenient to future readers and corresponds to the fact that in the near future it will not be possible to read more than one per thousand of the mathematical publications. Then the third step of this work is the making-up of a "theorem-data-base" in bifurcation theory and applications which synthetize all results hypotheses, proofs, applications of bifurcation theory. The realization of this third step requires both people and computing systems. Every form of help is welcome.

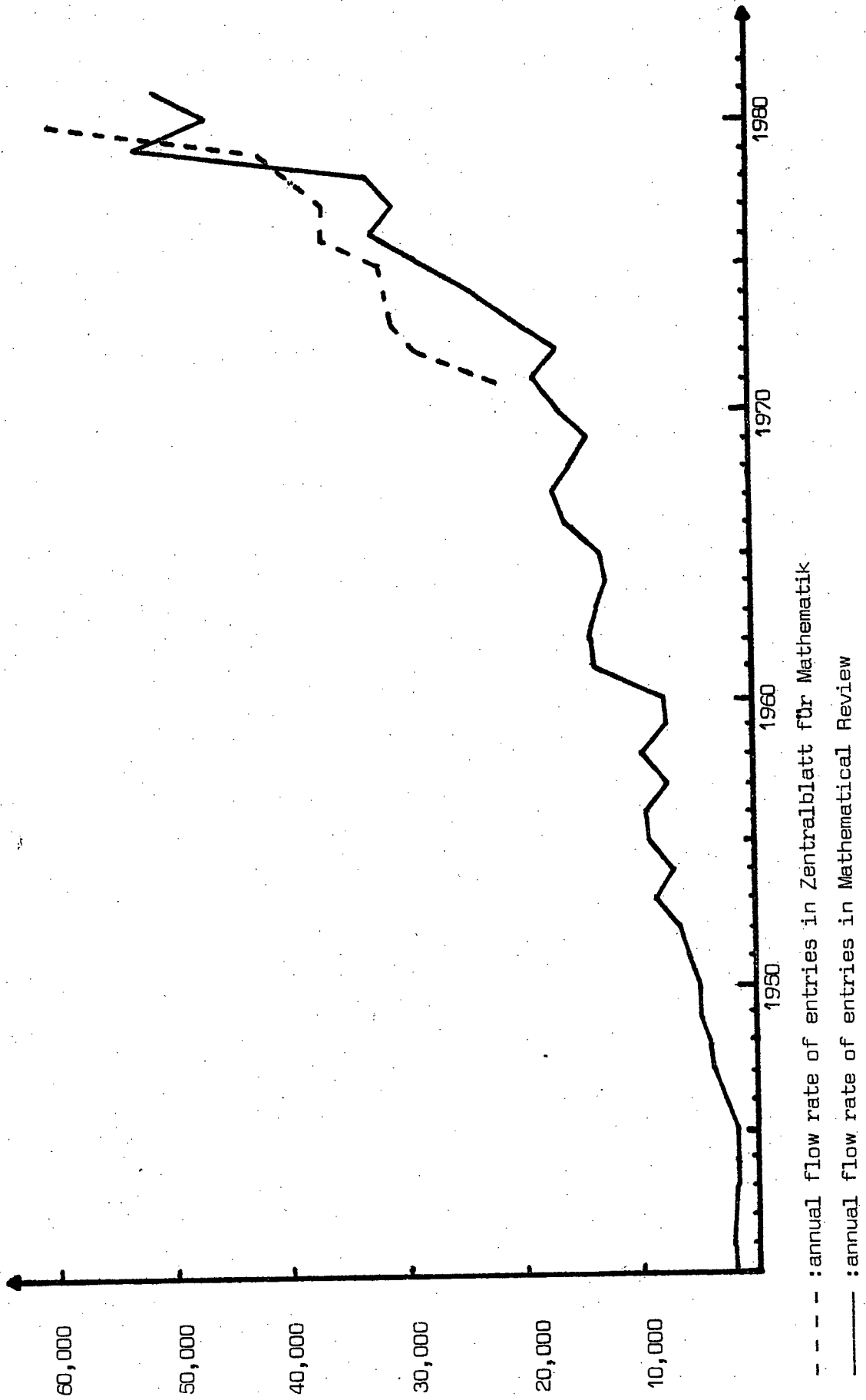


Figure 1

## Annex A.

The topics covered in this issue include concerning:

1) the type of bifurcation or branching

{asymptotic, of codimension two, coincident, degenerate, dimensional, generic, global, Hopf, Hopf-Friedrichs, imperfect, local, perturbed, pitchfork, repeated, secondary, semi-symmetric } bifurcation.

{complex, one-sided } bifurcation points

bifurcation at {eigenvalue of odd multiplicity, double eigenvalue }

bifurcation from {continuous spectrum, essential spectrum, infinity, normal eigenvalue, multiple eigenvalue }

bifurcation in {Hilbert space, infinite dimension, locally convex topological vector spaces, normed spaces, ordered Banach spaces }

bifurcation in a neighbourhood of a non-isolated symmetry, bifurcation in variational case, bifurcation into tori, bifurcation to {chaotic regime, homoclinic orbit }, bifurcation together more than one norm, bifurcation under nongeneric conditions, bifurcation without eigenvalue. Interaction of bifurcations, Integral averaging bifurcation, Pattern and Cellular bifurcation.

{axisymmetric, semi-symmetric branching }

kind of parameter: multiparameter, real parameter, without parameter

studies of: branches of bifurcation, continuum (continua), isolated critical continua, turning points

2) the type of studied problems:

i) Bending, Buckling, Post buckling, Peeling, Snapping, Whirling

Axisymmetric bending of shallow spherical shells, Nonlinear bending of circular plates,

Buckling of {{{shallow } spherical } caps, compressed elastic column, {circular, clamped, {thin } elastic } plates, plate with general edge conditions, nonlinearly elastic {arches, rods }, rotating rods, {clamped, rigidly clamped hemispherical, {thin } spherical } shells, cylindrical shells with small curvature, hollow spheres and hemispheres, elastic-plastic solids in the plane {strain, stress }}, membrane buckling, {non linear } buckling of rectangular plates, buckling and postbuckling of three-hinged portal frame, buckling for the set of umbilic catastrophes.

Collapse of shallow elastic membranes. Nonlinear deflections of shallow spherical shells, axisymmetric deformation of conical shells, spatial deformation of {nonlinear elasticity, nonlinear elastic {rods, structures } }.



Peeling of multiple generating singular points. Post-buckling of { an asymmetric two-bar frame, elastic structures }. Topological classification of post-buckling phenomena. Shear and necking instabilities in nonlinear elasticity. Spherical cap snapping. Nonlinear vibrations of simply supported beams. Whirling of { circular plates, heavy elastic strings }.

ii) names of equations

{ First BBGKY, non-linear Boltzmann, Boussinesq, chaos form prototype, Duffing, Feigenbaum functional, { Fitzhugh's } nerve-conduction, Ginzburg-Landau, Grad-Shafranov, Hartree, Hartree-Fock, Hogkin-Huxley, Master, Mathieu, { incompressible } Navier-Stokes, Orr-Sommerfeld, quasi-geostrophic, Sine-Gordon, Volterra's population, Von Karman } equation, { differential, logistic } difference equation, { { autonomous, retarded } functional, integro, multi-valued, stochastic } differential equation, { differential delay, semi-linear evolution, nonlinear { functional, integral }, quadratic integral, quasi-linear elliptic } equation.

Non-linear second order O.D.E. on the half-line, second order O.D.E. on differentiable manifolds. Non-linear { elliptic, hyperbolic, parabolic } P.D.E. Equation arising in population genetics, equations with { non local potentials, unbounded linearized part }.

iii) names of models

{ Ecosystem, Field-Noyes, Fitzhugh-Nagumo nerve conduction, Onsager's, density dependent population } model(s).

Fluid flow model of Lorenz, Kauffman's model of morphogenesis, model for the respiratory process of bacterial culture.

iv) names of operators

{ monotonically compact, completely continuous, non continuous, positively convex, Fredholm, non-compact, non-symmetric gradient, Green's, compact integral, nonlocal, maximal monotone, monotone nonlinear, { nondifferentiable, odd } potential, odd variational } operators.

{ sublinear } Hammerstein operators { with oscillation kernels }

v) names of problems

{ Alternative, Benard, free boundary, free surface, immune response, mildly non-linear eigenvalue, obstacle, predator-prey, { nonlinear } Steklov, sublinear Sturm-Liouville, { { asymptotically } superlinear } Sturm-Liouville, Taylor, variational } problem.

Dirichlet and Neumann problem without eigenvalue, problems { for unbounded domains, with discontinuous non-linearities, in rheological fluid mechanics }.

vi) names of systems

{biological, chemical, complex, {resonant} dynamical, ecological, simple feedback, gradient, first order Hamiltonian, realistic immobilized enzyme, nonlinear integro differential, second order {Lagrangian, non-Lagrangian}, piecewise linear non autonomous, predator-prey, quadratic, reaction-diffusion, statistically stressed fluid } systems, system possessing a first integral, Hamiltonian systems at resonance, reactive-diffusive system with Arrhenius kinetics.

vii) miscellaneous

Belousov-Zhabotinskii reaction, buoyant dissipative motions in vertical channels, chemical reactor, classification and unfolding, Ekman flow, exchange of stabilities, Fredholm mapping, frequency locking, completely unstable flows on the cylinder, Galton-Watson processes, Hamilton's principle, Hénon attractor, the hunting of a railway axle, hysteresis, K-set contractions, Lorenz attractor; Morse-Smale flows, nonlinear recurrence relation, nonlinear three waves coupling, onset of turbulence, pattern formation in convective phenomena, analysis of spatial and temporal pattern formation, Poiseuille flow, Rayleigh-Benard experiment, rotating and convecting fluids, solutions with crystalline symmetry, forced Van der Pol oscillator, {bifurcating, permanent} waves.

Bifurcation in economic equilibrium theory, bifurcation of {map of interval, orientation reversing diffeomorphisms of the circle, quadratic function, triple periodic orbits}, Hopf bifurcation for nonlinear semi-groups.

3) The type of the tools

i) Degree, Index

{generalized, Leray-Schauder, topological} degree, generalized cohomological index theories for Lie group actions, {fixed point, fuller, Seifert, alternative topological} index.

ii) methods

ia) numerical methods

{shooting, numerical} algorithm, {discrete, numerical} approximation, continuation of Newton's method through bif. points, constructive technique, finite element method, interactive computer graphics, numerically irrelevant solutions convergent iteration scheme.

iib) classical methods

{continuation, group theoretic, Lyapunov, Lyapunov-Schmidt, Newton, Nystrom, Poincaré's perturbation, projection, variational} methods.

iii) Theories

bifurcation theory of M.A. Krasnoselskii, {catastrophe, asymptotic fixed point, critical point, group representation, Lusternik-Schnirelman, Morse, singularity,

stability } theories.

Generalized cohomological index theories for Lie group action.

iv) others

A priori bounds, calculus of variations in the large, center manifold, concave solutions, alternative of Fredholm, factorization theorems, multiple positive fixed point, Floquet exponents, generalized inverse {of a linear differential operator}, genericity, global {analysis, homotopies}, group {actions, representation}, transformations groups, implicit function theorem, monotone iterations, anti-maximum principle, minimax principle, perturbation, reduction principle, structural stability, symmetry breaking, {global} topological perturbations, type of Marston-Morse.

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