Few-Body Systems

Editor in Chief: W. Plessas, Graz

Supplement 13

Resonances in Few-Body Systems

Proceedings of the International Workshop, Sárospatak, Hungary, September 4–8, 2000

Edited by
A. T. Kruppa and *R. G. Lovas*

SpringerWienNewYork

Few-Body Systems

Editor in Chief: W. Plessas, Graz

Supplement 13

Resonances in Few-Body Systems

Proceedings of the International Workshop, Sárospatak, Hungary, September 4–8, 2000

Edited by
A. T. Kruppa and *R. G. Lovas*

SpringerWienNewYork

Dr. András T. Kruppa
Dr. Rezső G. Lovas
Institute of Nuclear Research
Hungarian Academy of Sciences
Debrecen, Hungary

Printing was supported by the Bundesministerium für Bildung, Wissenschaft und Kultur, Wien, Austria

Typesetting: Camera-ready by authors
Printing: Druckerei Novographic, A-1230 Wien
Binding: Papyrus, A-1100 Wien

Printed on acid-free and chlorine-free bleached paper
SPIN: 10856958

With 115 Figures

CIP data applied for

ISSN 0177-8811
ISBN 3-211-83766-3 Springer-Verlag Wien New York

Organizing Committee

V.B. Belyaev
J. Darai
B. Kónya
A.T. Kruppa
R.G. Lovas (chairman)
J.Zs. Mezei
Z. Papp
J. Révai
W. Sandhas
T. Vertse

International Advisory Committee

W. Domcke (Munich)
W. Glöckle (Bochum)
C. Green (Colorado)
Y.K. Ho (Taipei)
R.J. Liotta (Stockholm)
J. Macek (Oak Ridge)
W. Plessas (Graz)
J.M. Richard (Grenoble)
D.O. Riska (Helsinki)
S.L. Yakovlev (St. Petersburg)
T. Yamazaki (Tokyo)

Sponsors

The United Nations Educational, Scientific and Cultural Organization, ROSTE, Venice Office
State Secretary, Ministry of Education, Hungary
National Fund for Scientific Research, Hungary
MOL, Hungarian Oil Company
Research & Development Division, Ministry of Education, Hungary
International Centre for Workshops on Theoretical Physics, Budapest
Hungarian Academy of Sciences
Rexpo Ltd., Debrecen

Foreword

This volume contains the proceedings of the International Workshop on Resonances in Few-Body Systems held in Sárospatak, at the Tokaj wine area, Hungary, from 4 to 8 September, 2000.

Resonances belong to the most widespread natural phenomena. They occur in systems ranging from macroscopic elastic bodies to systems of elementary particles. Any system that has eigenfrequecies and is coupled to its environment can show resonances. A resonance may be considered an eigenstate of a system. Although it has a finite life-time, the eigenstate concept can be formulated precisely even in quantum mechanics, as a kind of generalization of the quantum mechanical notion of an eigenstate.

The very word 'eigenstate' suggests that the properties of these states are characteristic of the system itself: of its composition, size, number of degrees of freedom, excitation mechanisms etc. Very often there are no bound states or just a few. In studying microscopic systems, it is therefore most important to study their resonances.

From the theoretical point of view, resonances are of interest if they can be described with some degree of accuracy. In non-relativistic quantum mechanics precise description is possible for two-body systems, which support the simplest resonances. These cases are well understood, at least in principle, and offer no novelty. The case of more than two but not too many particles are more interesting and challenging. The description may still be exact, or at least satisfactory. A further step towards complexity is that some constituents may have intrinsic structures and may be excited within the system.

Few-body resonances are in the frontiers of resonance studies. Very similar problems occur in atomic and molecular physics, nuclear physics and high-energy physics. The tools they can be tackled with may also be very similar. The meeting has shown the usefulness of cross-fertilization: it has helped to reduce the language barrier between the disciplines and has shown up the common methodological aspects. The present volume is hoped to further communication between different fields.

The articles in the volume are ordered according to the fields they belong to. The papers on atomic and molecular physics are concerned mainly with resonance states observable in atomic collisions. Most papers on nuclear physics discuss the structure of nuclei near or beyond the drip lines: three-nucleon systems, neutron-halo nuclei as well as heavy nuclei. The third category contains papers relevant to both fields either because of the phenomena or because of the methods discussed. The title *Exotic Systems, Bayons, Hadrons and Quarks* covers papers on medium- and high-energy (nuclear) physics. They are separated from other nuclear physics papers since the theoretical concepts used in them are rather specific. Most papers are theoretical, but quite a few are linked with experiments closely through the data they are dealing with.

Acknowledgement. The publication of this volume has been made possible by a grant received from UNESCO. The organizers are very grateful for this support as well as for the kind help offered by some participants in a critical period. The organizers are grateful to all participants for their interesting contributions.

Debrecen, 17 October, 2001

A.T. Kruppa and R.G. Lovas

SpringerJournals

Few-Body Systems

The journal is devoted to the publication of original research work, both experimental and theoretical, in the field of few-body systems. Conceptually such systems are understood as consisting of a small number of well-defined constituent structures. Investigations of the behaviour of these systems form the central subject matter of the journal. Systems for which an equivalent one-body description is available or can be designed, and large systems for which specific many-body methods are needed are outside the scope of the journal. The focus of interest lies in the research methods, properties, and results characteristic of few-body systems. Particular examples of few-body systems are light nuclei, light atoms, small molecules, but also celestial systems, "elementary" particles (considered as systems of few constituents) or larger systems with a few-particle substructure.

Subscription Information
2002. Vols. 32 + 33 (4 issues each)
EUR 766,– plus carr. charges, approx. US $ 923.00 including carriage charges
ISSN 0177-7963 (print edition), Title No. 601
ISSN 1432-5411 (electronic edition)

This journal is included in the program:
"LINK – Springer Print Journals Go Electronic"
ISSN (electronic edition): 1432–5411

View table of contents and abstracts online at: **www.springer.at/fbs**

SpringerWienNewYork

A-1201 Wien, Sachsenplatz 4–6, P.O. Box 89, Fax +43.1.330 24 26-62, e-mail: journals@springer.at, Internet: **www.springer.at**
D-69126 Heidelberg, Haberstraße 7, Fax +49.6221.345-229, e-mail: orders@springer.de
USA, Secaucus, NJ 07096-2485, P.O. Box 2485, Fax +1.201.348-4505, e-mail: orders@springer-ny.com
Eastern Book Service, Japan, Tokyo 113, 3–13, Hongo 3-chome, Bunkyo-ku, Fax +81.3.38 18 08 64, e-mail: orders@svt-ebs.co.jp

SpringerPhysics

Shinsho Oryu, Masayasu Kamimura, Souichi Ishikawa (eds.)

Few-Body Problems in Physics '99

Proceedings of the 1st Asian-Pacific Conference, Tokyo, Japan, August 23–28, 1999

2000. XIX, 529 pages. 232 figures.
Hardcover DM 232,–, öS 1626,–, as of Jan. 2002 EUR 118,–
Reduced price for subscribers to "Few-Body Systems":
DM 208,80, öS 1463,40, as of Jan. 2002 EUR 106,20
(Recommended retail prices)
All prices are net-prices subject to local VAT.
ISBN 3-211-83503-2
Few-Body Systems, Supplementum 12

The book contains invited and contributed talks presented at the 1st Asian-Pacific Conference on Few-Body Problems in Physics, held in Tokyo (Japan), August 23–28, 1999. The conference was initiated in the Asian-Pacific area as a counterpart to the successful European and North American conferences.

The papers in the volume are grouped into eight categories:
- Atomic and Mesoscopic Systems
- Few-Body Problems in Nuclear Astrophysics
- Unstable Nuclei and Nuclear Cluster Systems
- Hadronic Structure and Quantum Chromodynamics
- Relativity in Few-Body Dynamics
- Electromagnetic Interactions in Few-Body Systems
- Hypernuclei and YN and YY Interactions
- Few-Nucleon Systems

SpringerWienNewYork

A-1201 Wien, Sachsenplatz 4–6, P.O. Box 89, Fax +43.1.330 24 26, e-mail: books@springer.at, Internet: www.springer.at
D-69126 Heidelberg, Haberstraße 7, Fax +49.6221.345-229, e-mail: orders@springer.de
USA, Secaucus, NJ 07096-2485, P.O. Box 2485, Fax +1.201.348-4505, e-mail: orders@springer-ny.com
Eastern Book Service, Japan, Tokyo 113, 3–13, Hongo 3-chome, Bunkyo-ku, Fax +81.3.38 18 08 64, e-mail: orders@svt-ebs.co.jp

SpringerPhysics

Bertrand Desplanques et al. (eds.)

Few-Body Problems in Physics ´98

Proceedings of the 16th European Conference on
Few-Body Problems in Physics, Autrans, France, June 1–6, 1998

1999. XIX, 548 pages. 217 figures. 1 frontispiece.
Hardcover DM 232,–, öS 1626,–, as of Jan. 2002 EUR 118,–
Reduced price for subscribers to "Few-Body Systems":
DM 208,80, öS 1463,40, as of Jan. 2002 EUR 106,20
(Recommended retail prices)
All prices are net-prices subject to local VAT.
ISBN 3-211-83280-7
Few-Body Systems, Supplementum 10

The book contains invited and contributed talks presented at the 16th European Conference on Few-Body Problems in Physics, held in Autrans (France), June 1–6, 1998.

The conference was devoted to the description and the properties of few-body systems in various fields of physics. Contributions essentially concern the following topics: resolution methods for few-body problems, mathematical aspects, relativity, few-body dynamics: atomic and mesoscopic systems, threshold effects and stability limit, few-body dynamics: nuclear and particle systems.

SpringerWienNewYork

A-1201 Wien, Sachsenplatz 4–6, P.O. Box 89, Fax +43.1.330 24 26, e-mail: books@springer.at, Internet: www.springer.at
D-69126 Heidelberg, Haberstraße 7, Fax +49.6221.345-229, e-mail: orders@springer.de
USA, Secaucus, NJ 07096-2485, P.O. Box 2485, Fax +1.201.348-4505, e-mail: orders@springer-ny.com
Eastern Book Service, Japan, Tokyo 113, 3–13, Hongo 3-chome, Bunkyo-ku, Fax +81.3.38 18 08 64, e-mail: orders@svt-ebs.co.jp

SpringerPhysics

Silvano Simula et al. (eds.)

N* Physics and Nonpertubative Quantum Chromodynamics

Proceedings of the Joint ECT*/JLAB Workshop,
Trento, Italy, May 18–29, 1998

1999. XV, 372 pages. 130 figures.
Hardcover DM 169,–, öS 1183,–, as of Jan. 2002 EUR 85,–
Reduced price for subscribers to "Few-Body Systems":
DM 152,10, öS 1064,70, as of Jan. 2002 EUR 76,50
(Recommended retail prices)
All prices are net-prices subject to local VAT.
ISBN 3-211-83299-8
Few-Body Systems, Supplementum 11

The workshop was devoted to a summary of recent experimental and theoretical research on N* physics. Special emphasis was given to the information that photo- and electro-production of nucleon resonances can provide on the non-perturbative regime of quantum chromodynamics. Discussions among experimentalists and theoreticians were stimulated in order to pursue the interpretation of the huge amount of forthcoming data from several laboratories in the world. This volume contains both the invited lectures and the contributions. On the main topics, like single and double pion production, pi- and K-meson production, the GDH sum rule, and the spin of the proton.

SpringerWienNewYork

A-1201 Wien, Sachsenplatz 4–6, P.O. Box 89, Fax +43.1.330 24 26, e-mail: books@springer.at, Internet: www.springer.at
D-69126 Heidelberg, Haberstraße 7, Fax +49.6221.345-229, e-mail: orders@springer.de
USA, Secaucus, NJ 07096-2485, P.O. Box 2485, Fax +1.201.348-4505, e-mail: orders@springer-ny.com
Eastern Book Service, Japan, Tokyo 113, 3–13, Hongo 3-chome, Bunkyo-ku, Fax +81.3.38 18 08 64, e-mail: orders@svt-ebs.co.jp

Springer-Verlag and the Environment

WE AT SPRINGER-VERLAG FIRMLY BELIEVE THAT AN international science publisher has a special obligation to the environment, and our corporate policies consistently reflect this conviction.

WE ALSO EXPECT OUR BUSINESS PARTNERS – PRINTERS, paper mills, packaging manufacturers, etc. – to commit themselves to using environmentally friendly materials and production processes.

THE PAPER IN THIS BOOK IS MADE FROM NO-CHLORINE pulp and is acid free, in conformance with international standards for paper permanency.

Contents

Mathematical and General Aspects

Exotic Systems, Baryons, Hadrons and Quarks

Few-Body Systems Suppl. 13, 1–2 (2001)

Few-Body Systems

Opening Address

R.G. Lovas

Institute of Nuclear Research, Debrecen, P. O. Box 51, H–4001, Hungary

Welcome to Sárospatak, welcome to the International Workshop on Few-Body Resonances.

'Resonance' is a very nice word. It expresses resounding, not so much in the sense of 'echo'; rather as a 'repeated sound'. When you make a noise in the vicinity of a piano, some of the chords will repeat the sound as if they had been plucked. Resonances belong to the most general natural phenomena. Any system with eigenfrequecies which is coupled to its environment can show resonances. Resonances are excited and decay via their interactions with this environment, and the sharper, the more definite they are, the longer they live. Is that not fair to them? I think it is. But sooner or later they all decay, so they have finite life-times, like living creatures. But there is an important difference: the life expectancy of a resonance does not depend on when it was born. As if an aged person had the same life expectancy as a new-borne baby. Wouldn't that be agreeable for humans? I think it would, at least, for the aged ones.

Any system can show resonances, from particles to humans or to human societies. It has to contain at least two bodies (e.g., two particles or two persons). The elementary properties of resonances are best learned by studying two-body systems, but systems with more than two bodies are more interesting. This opinion is shared by the participants of this workshop as well as by novelists, who have created many love triangles and other polygons.

The site of the symposium has nothing to do with resonances unless we view this country as a decaying system. Although the inhabitants are fewer and fewer, it would still be far-fetched to call it a few-body system. Talking about ages and life-times, I should mention that the country is celebrating its millennium this year, but, fortunately, we have no evidence yet for her finite life-time.

Sárospatak is rich of historical reminiscences, but its historical role became significant in the second half of the Millennium. Together with our home town, Debrecen, it is one of the important places of Calvinist protestantism in this country and also one of the cradles of Hungarian culture. There is a famous, old school here, which rivals in fame with the Debrecen Reformed College. There