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Book reviews

Laser Crystals

Their Physics and Properties

ALEXANDER A. KAMINSKII

Translation edited by H. F. Ivey

Springer Series in Optical Sciences Vol. 14

Springer-Verlag, Berlin, Heidelberg, New York 1981
[pp. i–xiv +456, with 89 Figs. and 56 Tables].

The monograph by A. KAMINSKII is devoted to analysis of the optical-physical properties of laser crystals doped with transition metal and rare earth ions.

The author reviews the latest developments in the field and systematizes the basic properties of these crystals.

Chapters II–IV contain the basic model of the absorption and emission of light in laser crystals, basic concepts of crystal field theory, the theories concerning optical transition intensities, as well as operating schemes and types of lasers based on activated crystals.

In Chapter V the author gives a large review of the basic laser properties of activated laser crystals. This review is both original and useful and it certainly will be appreciated by both the users of laser crystals and physicists engaged in creating new crystalline lasers and studying their properties. It may be also treated as a rich and convenient source of reference.

The material is presented by the author in a clear and well organized form. This interesting book is much recommended for anyone working in the field of quantum electronics, laser crystals spectroscopy and crystallography of activated crystals.

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Solitons

Mathematical Methods for Physicists

G. EILENBERGER

Springer Series in Solid State Sciences Vol. 19

Springer-Verlang, Berlin, Heidelberg, New York 1981
[pp. i–viii + 192, with 31 Figs.]

The discovery of the soliton has exerted a profound influence on the mathematical sciences. Mathematicians consider solitons an interesting solution of certain special classes of nonlinear partial differential equations of evolution. A special property of these equations is that each of them is integrable, i.e., one can find a canonical transformation which carries the coordinates in which the equation is originally given to new coordinates which are action-angle variables. This canonical transformation is the nonlinear analogue of the Fourier transform. Other striking properties of these equations are as follows: i) they have particle-like solutions (specifically localized in space) while small amplitude solutions are wave-like and extended, ii) the particle-like solutions maintain their identity in the presence of other excitations of the same type, e.g., two "solitary waves" solitons can penetrate each other and outgoing from the "place of collision" they conserve the previous shape, iii) if the equation or system of equations is considered as a Lagrangian formulation of some field theory, then it has infinitely many constants of motion, and iv) in terms of canonical variables the Hamiltonian is separable into two parts describing highly nonlinear solitary excitations and spatially extended excitations.

This fact, that certain exact methods could be developed to solve a class of general nonlinear problems was the necessary cornerstone upon which many important physical methods are now being based.

It is evident that methods of theoretical physics have been dominated, for a long time, mostly by linear equations. Generations of physicists have thought and calculated in terms of expansions in normal modes, non-interacting or "almost non-interacting" excitations, i.e., from more abstract point of view, in terms of linear vector spaces. The description, where states of the system are orthonormal vectors in some Hilbert space provided powerful analytical tools to be applied in classical and quantum physics. However, during last decades it has more distinctly appeared in many areas of physics that nonlinearity can result in qualitatively new phenomena which cannot be described via the perturbation theory starting from linearized equations. A great difficulty concerning nonlinear problems was the apparent lack of any comparable unifying procedure. From this point of view it was really a great surprise that there exist a rather large number of specific nonlinear evolution equations, mostly in one spatial dimension, which permit a complete analytic solution in the closed form. Though these exact systems are valuable models, the physicist is not so frequently concerned with them, either because most physical situations are obviously three dimensional or because in any case the equation considered has a limited range of relevance. It is striking, however, that so many integrable Hamiltonian systems are prototypes for classes of problems in the natural sciences. These analytically tractable models are extremely valuable when regarded as starting approximations for more realistic problems and permit, what is very important, to develop corresponding singular perturbation theories. Exactly integrable systems are also attractive theoretical models in quantum field theory and statistical mechanics because of Hamiltonian separability. In some sense, they can play the potential role as pure harmonic systems do in linear physics.

Among infinitely many equations which exhibit soliton solutions only three are particularly important for physical applications. These are: the Korteweg-de Vries (KdV), the sine-Gordon (SG), and the nonlinear one with cubic term (Schrodinger equations). The KdV equation combines both the effect of weak nonlinearity and the effect of small dispersion, whereas NS equation typically describes the self-modulation of an almost monochromatic wave with linear dispersion and weak nonlinearity. The SG and related equations are certainly the most recurrent in condensed matter physics since they involve the very common ingredients of a kinetic term, translational, rotational, etc., a linear strain potential term and a periodic local potential term producing the nonlinearity.

Solitons – Mathematical Methods for Physicists presents detailed introduction into the theory of equations exhibiting soliton solutions, written in a manner and language appropriate for physicists on the level of graduate course in theoretical physics. The required mathematical background consists of elements of the function theory, complex analysis, theory of differential equations and some basic facts from functional analysis. The main aim is to present with necessary rigor and completness the new mathematical ideas and computational methods that have been developed in this field emphasizing links between the inverse scattering theory and integrability problems.

The first chapter introduces the reader into the problem through some general considerations on possible nonlinearities in classical field theories and presents the examples of soliton solutions together with wide area of applications.

The "serious" theory starts from chapter 2, where KdV equation is examined first from physical point of view, then it is treated as a classical Lagrangian field theory with discussion of the conservation laws and concerned with the inverse scattering problem in chapter 3. The inverse scattering theory for other equations is developed in chapter 4. The most interesting (at least for solid state physicists) sine-Gordon equation is investigated in chapters 5 and 6 including the discussion of the way to construct a reasonable equilibrium statistical mechanics for soliton excitations. The last chapter is devoted to the instructive analogue of the problem which can be constructed in terms of difference equations and interpreted as nonlinear mechanics of some one-dimensional lattice (Toda Lattice).

The book seems to be very useful for physicists having necessary preliminary preparation. To those who might want to investigate, or at least to understend more deeply, applications of the soliton systems, it offers a self-contained introduction which would spare them a tedious search of the original literature. The presentation is very clear though concise. The reader cannot find many places with reformulations of the type "in other words", "zwischenrufs", etc. and should be very careful like a reader of a purely mathematical text. Thus, in our opinion, the book can hardly be recommended to an average experimentalist interested only in short presentation of main ideas but will be an excellent introduction for young theoreticians and other persons looking for some "working ability" in this subject.

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Tables of laser lines in gases and vapours

Springer Series in Optical Sciences Vol. 2

R. BECK, W. ENGLISCH, K. GÜRS

Third revised and enlarged edition

Springer-Verlag, Berlin, New York, Heidelberg 1980
[pp. i–ix + 246]

In some applications of lasers a strictly defined wavelength of the used radiation is required. This concerns, among others, such techniques as Raman spectroscopy, optical pumping, laser chemistry and isotope separation. The tables of laser lines in gases are especially useful when attempting to find a laser suitable for definite purposes. The new third edition of the tables by R. BECK, W. ENGLISCH and K. GÜRS has been revised and widened to include about 1.000 additional lines and the description of 6.145 transitions. The book contains the computer-tabulated data concerning all the spectral lines for which the laser actions were either observed or theoretically predicted as possible (which is distinctly marked in the text).

The first part of tables contains a list of the lines ordered according to the active medium used. The source references and the transition identification for the molecule lines are given. Also, typical conditions to obtain the laser action for each medium are given

In the second part of the tables the same lines are ordered according to the wavelengths. These cover the spectral range from 109.816 nm to 1990.75 μm. The computer technique applied by the authors in the compilation of all the available data makes them up-to-date. Some pages appear to be not quite convenient to read due to low quality of the print but in my opinion it by no means creates any essential difficulty in using the book.

Rich bibliography, facilitating the contact with the source information, is another merit of this book, which is a valuable help for the scientists working in the fields mentioned at the beginning of this text.

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