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13. ABSTRACT *(Maximum 200 words)*
Many nonlinear systems evolve into nonlinear solitary waves and dispersing radiation. We describe publications which detail how such solitary waves can interact with radiation and also how such interactions are affected by various perturbations such as damping, filtering, amplifying and Raman pumping. Besides perturbation techniques, we also find that we can describe these interactions via the Rayleigh-Ritz variational method, which has been used to study dissipation. A danger in this method is that it could generate potentially false instabilities. However, we have also detailed how and when this could occur.

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Technical Report on ONR Grant No. N00014-95-1-0323
For the Period 11/01/94–10/31/95

RECENT ACCOMPLISHMENTS

by D.J. Kaup and his research group

First, we will describe some of our most important results. Then afterwards, we shall delineate other publications of interest.

1. Optimum Reshaping of an Optical Soliton by a Nonlinear Amplifier, Sergey Burtsev, D.J. Kaup and Boris A. Malomed, (to appear JOSA B). In this paper, we show that there is an optimum set of parameters for a nonlinear amplifier such that the radiation generated and lost is a minimum.

2. The Control of the Center Guided Soliton by the Sliding Frequency Filter, S. Burtsev and D.J. Kaup. (to appear in Phys. Rev.). This paper is the first to use second–order soliton perturbation theory to analyze the growth and behavior of the continuous spectra due to an array of sliding frequency filters for a center–guided soliton in an optical fiber. The major result, not only for amplitude sensitive amplifiers, but also for phase–sensitive amplifiers, is that there is a restricted range in which the amplification will be stable. The two limits are simply that if one slides the frequency too fast, then one may lose the soliton, and if one slides it too slow, then the radiation which is created at each amplification can grow and saturate.

3. Interaction of a Soliton with a Strong Inhomogeneity in a Nonlinear Fiber, Sergey Burtsev, D.J. Kaup and Boris A. Malomed, [Phys. Rev. E **52**, 4474-81 (1995)]. Some potentially useful applications of short, tailored, optical fiber segments are explored in this paper. We consider what happens when short fiber segments with different dispersion and nonlinear coefficients are inserted into a normal fiber. An interesting result of this work is that with a short segment containing an increased nonlinear coefficient, spliced into a regular optical fiber, one can take a pulse with twice the amplitude of a soliton and split it into two equal solitons, each propagating in different directions. Thus this is a practical means of splitting a single pulse into two.

4. The Variational Principle for Nonlinear Waves with Dissipative Terms, D.J. Kaup and Boris A. Malomed, [Physica D **87**, 155-9 (1995)]. Although numerical methods are readily available for solving general evolution equations, nevertheless, the advantages of having even approximate, analytical solutions and/or an equivalent set of ODE's is

very well appreciated. Here we discuss general methods for using the Rayleigh–Ritz variational method with trial functions to obtain reduced equations of motion for any evolution equation. As a model, we take the damped NLS with the addition of the Raman interaction term.

5. Tails and Decay of a Raman-Driven Pulse in a Nonlinear Optical Fiber, D.J. Kaup and Boris A. Malomed, [JOSA B **12**, 1656-62(1995)]. Over very long distances, the Raman interaction can cause a soliton to decay, which can be quite important for very short pulses. Because this interaction only becomes significant after the soliton has propagated over long distances, the numerical solution of this problem is very difficult. However this problem is ideally suited to an analytical asymptotic analysis. We have done this here and have shown that the soliton decays in a finite time. We have also given the asymptotical form of the solution for large times and discussed the general evolution of soliton undergoing decay via the Raman interaction.

6. Variational Principle for the Zakharov-Shabat Equations, D. J. Kaup and Boris A. Malomed, [Physica D **84**, 319-28 (1995)]. Although numerical methods are readily available for solving the Zakharov–Shabat eigenvalue problem, there is still much value in having analytic, approximate solutions. This paper explores some of the results that can be obtained when the Rayleigh–Ritz variational method is applied to finding the eigenvalue spectra of the Zakharov–Shabat eigenvalue problem.

7. Stimulated Raman Scattering by a Point-like Medium - Classical and Quantum Treatments, D.J. Kaup, A.E. Kozhekin, and V.I. Rupasov. (accepted by Phys. Rev. A). In this paper, we have studied the quantum nature of the SRS problem when the medium is short compared to the length of the envelope of the pump (which is the experimental situation). In addition to accounting for the pump depletion, we have also presented means for evaluating the expectation values of the intensity, medium excitation and phase correlations.

8. Exactly Solvable 1D Model of Resonance Energy Transfer, D. J. Kaup and V. I. Rupasov (submitted to J. of Physics A). In performing the research on the above manuscript, we also found a means for solving the one–dimensional quantum two–level problem for the emission and absorption of radiation in such a manner that one can maintain causality.

9. The squared eigenfunctions of the Massive Thirring Model in Laboratory Coordinates, D. J. Kaup and T. I. Lakoba, (to appear in Journal of Mathematical Physics). There

are models for interacting nonlinear optical beams that have the massive Thirring model as one limit. This result allows us to develop a singular perturbation theory for such limits, which can provide additional information about such models.

10. Variational Method: How It Can Generate False Instabilities, D. J. Kaup and T. I. Lakoba, (submitted to J. Math. Phys.). The utility and confidence of information obtained from the Rayleigh–Ritz variational method can vary, depending of the validity of the trial functions used. Here we study the possible generation of false instabilities due to a poor choice of trial functions. We are able to show that for the NLS and the vector NLS, one may easily avoid any and all false instabilities. However for models related to the massive Thirring model, there is always the possibility of a false instability occurring (a false instability is where the variational method gives an unstable mode, when in actuality there is none).

During the last year, other publications of interest were:

1. Vibration Modes of a Vector Soliton in a Nonlinear Optical Fiber, D.J. Kaup, Boris A. Malomed, and Richard S. Tasgal, The Proceedings of Workshop on Nonlinear Coherent Structures in Physics and Biology, 1-4 June 1993, Bayreuth, Germany) *Nonlinear Coherent Structures in Physics and Biology)*, pp. 365-368, Eds: K.H. Spatschek and F.G. Mertens [Plenum Press, New York, (1994)].

2. A Model Cylindrical Magnetron Vlasov Distribution Function, D.J. Kaup and S. Roy Choudhury, Physics of Plasmas **1**, 3437-3443 (1994).

3. Nonlinear Evolution of Langmuir and Electromagnetic Pulses in a Warm, Unmagnetized Plasma: Modulational Instability, Integrability, and Self–focusing in (2+1)-Dimensions, Ronald E. Kates and D.J. Kaup, J. Plasma Physics **52**, 75-90 (1994).

4. Integrable Stimulated Raman-Scattering Systems with Damping, S.P. Burtsev and D.J. Kaup, J. Phys. A. **27**, 5623 (1994).

The following is a list of work to be published, together with the publication in which they will appear:

1. Variational Principle for Crossed–field Devices, D. J. Kaup and Gary E. Thomas, (submitted to J. of Plasma Physics).

2. O–mode Conversion into Upper–hybrid and Bernstein Modes in Ionospheric Modification Experiments, N.N. Rao, D.J. Kaup, and S. N. Antani, (submitted to Radio Science).