A generation of the quasi-solitons in the lasers: computer algebra approach

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The modern laser technique allows the generation of sub-10 fs pulses, that is close to the fundamental limit for optical region defined by the wave period (about of 2 fs). The analysis of the lasing dynamics and properties of such pulses is a very cumbersome task, which involves a consideration of the many nonlinear factors and needs the high-performance computers for numerical simulation. Moreover, the interpretation of the obtained results is very difficult and doesn't give a clear picture of the physical processes governing laser dynamics. Therefore there is a stable interest to the analytical and semi-analytical approaches, which is induced also by the development of the efficient and universal computer algebra systems such as Maple and Mathematica. Here we present the analysis of the ultrashort pulse dynamics in the passive or active mode-locked lasers, which is based on the analytical approach and is realized as the Maple 6 package [1].

The first stage of the analysis consists in the search of the soliton-like states of nonlinear dynamical equation describing ultrashort pulse propagation. In the noncoherent case, it is, as rule, a generalized 1+1 - dimensional Landau-Ginzburg equation, which can be analyzed by Hirota's method. The presence of coherent effects due to interaction of pulse with semiconductor saturable absorber can be taking into account by two-level scheme for absorber, that results in the nonlinear dynamical equation of oscillating type, which can not be integrated by standard methods. But, as it was found, there is the approximate solution, which is close to *sech*-shaped pulse. The characteristics of the obtained solutions are in the excellent agreement with experimental observations [2]. The further analysis is based on the aberrationless approximation, which assumes the change of the quasi-soliton parameters for pulse with approximately unchanged shape. As result, we obtain the system of first-order ODE, which describes the ultrashort pulse

evolution and can be easily integrated in framework of computer algebra approach. The utilization of this approach in the analysis of the Kerr-lens mode-locked continuous-wave solid-state lasers allows to describe the experimentally observed breezers-like states with complicated dynamics (regular and chaotic) [3]. The main advantages of our approach are the possibility of the clear physical interpretation and the absence of bulk numerical computations (full computation session for different laser systems takes about of 30 min on PIII-500). Moreover the basic computational blocks can be realized as on-line Java-calculators.

References

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