Nonlinear optics and dynamics of atoms, molecules in an electromagnetic field and laser systems with elements of a chaos

V. Buyadzhi[1], A. Glushkov[1], G. Prepelitsa[1], and V. Ternovsky[1]

[1] *Odessa State University - OSENU, Odessa*

Presenting Author: vbuyad@mail.ru, dirac13@mail.ru

The paper is devoted to carrying out fundamentally new approaches to the universal quantum-dynamic and chaos-geometric modelling and analysis of the chaotic dynamics of nonlinear processes in atomic and molecular systems in intense electromagnetic fields and quantum-generator and laser systems and devices (including single-modal laser with an absorbing cell, a semiconductor laser coupled with feedback with delay, the system of semiconductor quantum generators, combined through a general cavity, fiber lasers). In order to make modelling chaotic dynamics it has been constructed improved complex system (with chaos-geometric, neural-network, forecasting, etc. blocks) that includes a set of new quantum-dynamic models and partially improved non-linear analysis methods including correlation (dimension D) integral, fractal analysis, average mutual information, false nearest neighbours, Lyapunov exponents (LE), Kolmogorov entropy (KE), power spectrum, surrogate data, nonlinear prediction, predicted trajectories, neural network methods etc [1-3]. It is carried out modelling of chaotic dynamics of the Li, Rb Rydberg states in (n = 115,125; m = 0) in a static magnetic field B = 4.5T and oscillating electric field with frequency f=102MHz) and shown that stochastic changing, fragmentation, extinction and again appearing of the peaks in power spectrum is occurred. There are firstly obtained original data on the LE, correlation, embedding, Kaplan-York D, KE and presented picture of the quantum fluctuations, stabilization, destabilization, delocalization, fractal properties and conditions for the KAM theorem. It has been presented a new approach to modelling the chaotic dynamics of diatomic molecules in intense electromagnetic field, which is , firstly, based on the numerical solution of the time-dependent Schrödinger equation and realistic model Simons-Parr-Finlan potential for diatomic molecules (quantum unit) and, secondly, the universal chaos-geometric nonlinear analysis unit, which includes the application of methods of correlational integral, LE and spectrum strength etc to analysing time series of populations, induced polarization. There are determined quantitative parameters of the GeO molecule chaotic dynamics in linear polarization filed (intensity of 25 GW/cm^2), including, correlation D (2.73), embedding D, Kaplan-York D (2.51), LE (the first two are positive, +, +), KE etc. It is numerically investigated chaos dynamics generation in the erbium one-ring fibre laser (EDFL, 20.9mV strength, = 1550.190nm) with the control parameters: the modulation frequency f and dc bias voltage of the electro-optical modulator. It is shown that in depending upon f, V values there are realized 1-period (f = 75MHz, V = 10V and f = 60MHz, V = 4V), 2-period (f = 68 MHz, V = 10V or f = 60MHz, V = 6V), chaotic (f = 64MHz, V = 10 V and f = 60MHz, V = 10V) regimes; there are calculated LE, correlation, embedding, Kaplan-York dimensions, Kolmogorov entropy and theoretically shown that chaos in the erbium fiber laser device is generated via intermittency by increasing the DC bias voltage and period-doubling bifurcation by reducing the frequency modulation computers in the ful agreement with experiment [4].

References

[1] A. Glushkov *et al.* Nonlin. Proc.in Geophys. **11**, 285–294 (2004); S. Kuznetsov, D. Trubetskov Izv.Vuzov. Ser. Radiophys. **XLVII**, 1–7 (2004)

[2] A. Glushkov *et al.* Atm. Environment. **42**, 7284–7292 (2008); Adv.in Space Res. **42**, 1614–1618 (2008)

[3] A. Glushkov A. Svinarenko, V. Buyadzhi *et al.*, *Adv. in Neural Networks, Fuzzy Systems and Artificial Intelligence, Ser.: Recent Adv. in Computer Engineering* (WSEAS, Gdansk, 2014) **21**, 143-160

[4] T. Cheng *et al.* Phys. Lett. A. **265**, 384–390 (2000); C. Feng *et al.* Chin. Phys. B. **21**, 100504 (2013)