New Laser-Electron Nuclear Effects in the Nuclear γ Transition Spectra of Molecular Systems

A.V. Glushkov[1,2], S.V. Malinovskaya[1], O.Yu. Khetselius[1]

[1]*Odessa University, P.O.Box 24a, Odessa-9, 65009, South-East, Ukraine*
[2]*Institute of Spectroscopy, Russian Acad.Sci., Troitsk-Moscow, 142090, Russia*

A new class of problems has been arisen in the modern quantum optics and spectroscopy and connected with modelling of the co-operative laser-electron-nuclear phenomena in molecular systems [1]. It includes a calculation of the probabilities and energies of the mixed γ-optical quantum transitions in atoms and molecules, intensities of the complicated γ-transitions due to the changing of the molecular excited states population under action of laser radiation, quantum chemical calculation of the complex "laser-nuclear-molecule" systems. Due to the emission or adsorption of the nuclear γ-quantum in molecules there is changing the electron vibration-rotation states. As result, general energetic and spectral properties of system are changed. We at first develop a new, consistent, quantum-mechanical approach to calculation of the electron-nuclear γ transition spectra (set of vibration satellites in molecule) of nucleus in molecule, based on the relativistic density functional (DF) formalism and energy approach (S-matrix formalism of Gell-Mann and Low) [1,2]. Decay and excitation probability are linked with imaginary part of the molecule - field system. Calculation results of electron-nuclear γ-transition spectra of the nucleus in some atomic and multiatomic systems are given. As illustration in fig. 1 a spectrum of emission and adsorption of nucleus ^{127}I (E_γ = 203 keV) in molecule of H^{127}I is presented (the initial state of molecule: $v_a = 0$, $J_a = 0$). Estimates are made for vibration-nuclear transition probabilities for number of molecules: diatomics, three-atomic XY_2 ($D_{\infty h}$), four-atomic XY_3(D_{3h}), five-atomic XY_4(T_d), six-atomic XY_3Y_2 (D_{3h}), seven-atomic XY_6(O_h) ones.

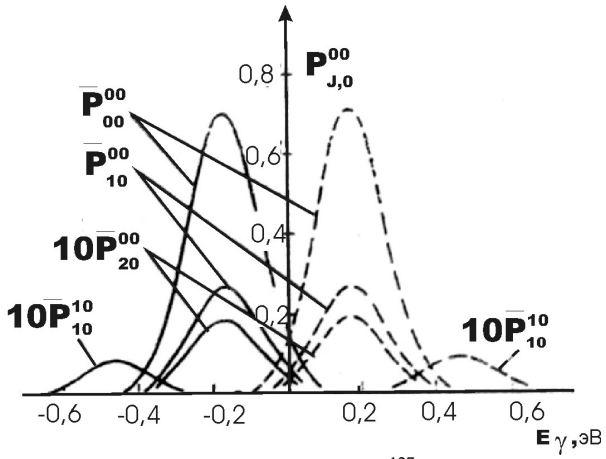

Fig. 1: Spectrum of emission and adsorption of nucleus ^{127}I (E_γ = 203 keV) in molecule of H^{127}I.

[1] L.N. Ivanov, V.S. Letokhov, JETP 93 (1987) 396-404; V. Letokhov, V. Minogin, JETP 69 (1975) 1369-1376; A.V. Glushkov, L. Ivanov, Phys. Lett. A 170 (1992) 33-38.
[2] A.V. Glushkov, S.V. Malinovskaya, Int. Journ.Quant.Chem. 99 (2004) 889-936; 104 (2005) 496-500; 104 (2005) 512-562; J.Phys.CS, 188 (2005) 199-208.