

Contents

Lecture One	
Introduction	1
Lecture Two	
Coherent Interaction	5
<i>Resonant interaction. Relative populations and polarization. Excitation in constant-amplitude field. Dynamic field broadening. Nutations. Pulsed excitation. Slow-varying-amplitude method. Pulse area, $\frac{\pi}{2}$- and π-pulses. Coherent damping.</i>	
Lecture Three	
Photon Echo and Self-Induced Transparency Phenomena	18
<i>Polarization produced by two short resonant pulses. Reversible unphasing. Recollection in phase. Dependence on pulse area. Duration of echo signal. Wave equation. Sine-Gordon equation. Automodel solution. 2π-pulse. Propagation velocity. Spectroscopic applications.</i>	
Lecture Four	
Relaxation Processes	30
<i>Density matrix. Relaxation matrix. Equations of motion of the density matrix. Bloch's equations. Longitudinal and transverse relaxations. Relaxation in a gas. Relaxation due to the interaction with a thermostat. Spontaneous radiation.</i>	
Lecture Five	
Susceptibility of a Two-Level System	43
<i>Solution of density matrix equations of motion in resonant approximation, stationary solution. Difference of populations. Dipole moment. Absorption. Susceptibility. Line width and homogeneous broadening. Saturation effect. Field broadening. Dispersion relations.</i>	
Lecture Six	
Saturation of Inhomogeneously Broadened Lines	52
<i>Homogeneous bunches. Distribution in frequencies. Lorentz and Gaussian line shapes. Doppler broadening. Saturation of homogeneously and inhomogeneously broadened lines. Burning out the gap. Assortment in velocities. Intra-Doppler spectroscopy. A solid.</i>	

Lecture Seven

Laser Gas-Kinetics 66

Basic equation. Relaxation and collisions in laser gas-kinetics. Acceleration of molecules (atoms) by a travelling light wave field. Change in the motion of resonant particles in the standing wave field. Diffusion in momentum space.

Lecture Eight

Laser Gas-Kinetics (continued) 79

Light-induced drift. Asymmetry of distribution in momenta. Drift flows. Atoms and molecules. Difference in transport cross sections of excited and unexcited states. Detuning from line center. Saturation.

Lecture Nine

Multiphoton Processes 90

Quasi-energy method. Two-photon excitation of a three-level system. Two-photon resonance. Composite matrix element. Field dependence of resonant frequency. Multilevel system. Total composite matrix element. Multiphoton resonance in a two-level system. Polychromatic irradiation. Frequency sweep. Relay-type occupation.

Lecture Ten

Coherent Processes**in Complicated Multilevel Systems** 108

Statistical approach to spectrally complicated systems. Ensemble average. "Isolated level-band" system. Dense band. Decay of lower level into the band. Quasicontinuum. Distribution of populations in the band. Nondense band, nonsmooth distribution of matrix elements. Number of levels in the region of Stark withdrawal. "Band-band"-type system. Degenerate bands.

Lecture Eleven

Coherent Processes**in Complicated Multilevel Systems (continued)** 125

Two nondegenerate bands. Kinetic equations. Degenerate level-nondegenerate band. Multiband system. Diffusion of populations in bands. Occupation of resonance vicinities. Kinetic coefficients of diffusion. Decay of multiband system in continuum. Competition of the decay and excitation rates. The switching of decay channels by the field. Relaxation of the simple oscillator energy into a thermostat.

Lecture Twelve

Collisional Relaxation 140

Strong and weak collisions. The Weisskopf radius. Strict resonance, V - T -relaxation, V - V -exchange, V - V' -exchange. Collisional dynamics of the single-particle density matrix. Weak collisions of simple oscillators, the Boltzmann distribution. Strong collisions, τ -approximation. Weak collisions of anharmonic oscillators, the Rich-Treanor and Gordíez-Osipov-Shelepin distributions.

Lecture Thirteen	
Parametric Phenomena as Processes in Multilevel Systems	157

Linear and nonlinear coupling between oscillators, linear and nonlinear polarizabilities. Harmonics and undertones. Cubic nonlinearity. Compound level schemes, multilevel transitions in them. Intermediate resonances. IRS, the Stokes and anti-Stokes components. CARS. Spontaneous processes, probability of spontaneous decay and spontaneous scattering. Spontaneous processes in the presence of a strong field.

Lecture Fourteen	
Resonant Excitation of Atoms	173

Selective two-step ionization of atoms. Spectroscopic condition. Probability of excitation and ionization. Resonant transfer of excitation energy, resonant recharge. Laser isotope separation in atomic vapor, conditions of its effectiveness. Autoionization, methods of artificial autoionization. Multiphoton ionization of atoms. Example of three-photon ionization of metastable helium atoms. Parametric generation.

Lecture Fifteen	
Spectra of Molecules	188

The Born-Oppenheimer parameter. Hierarchy of spectra. Normal vibrations. Anharmonicity. Rotations. K-degeneracy, hyperfine splitting. Vibrational-rotational interactions. Three-dimensional oscillator, anharmonic removal of degeneracy. The Coriolis splitting. Hybrid states. The Fermi resonance. Dipole transitions. IR-active modes. Rotational selection rules. P-, Q- and R-branches. Hot bands. Stochastization of vibrations.

Lecture Sixteen	
Excitation of Molecules	209

Simple-oscillator model. Anharmonicity and overcoming it by means of a strong field. Polyatomic molecules. Model of the excited mode damped by the interaction with a thermostat. Classical and quantum approaches. Large polyatomic molecules. Longitudinal and transverse relaxations. Fermi resonances, soft modes. Small polyatomic molecules. Number of atoms. Three stages of excitation. Excitation of quasicontinuum. Kinetic coefficients. Phase-volume average. Single degree of freedom of three-fold degenerate mode excitation. Spectral dependencies.

Lecture Seventeen	
Excitation of Molecules (continued)	229

Lower levels. Multiphoton resonances. Fraction of excited molecules. Two-photon Q-branch of a spherical top. Saturation. Large molecules. RRKM model. Small polyatomic molecules, multidimensional motion in a potential well, stochasticity, probability of dissociation. Experimental studies. Examples of CF₃I- and SF₆-molecules. Fermi resonances. Spectral dependencies of kinetic coefficients. Red shift. Sharp resonant structure of the spectrum of lower levels.

Lecture Eighteen

Excitation of Colliding Molecules 242

Vibrational exchange in collisions of simple oscillators. Vibrational heating in the absence and in the presence of vibrational-translational relaxation. V-V'-exchange, preferable heating of a softer oscillator. Radiational-collisional cascade, vibrational temperature greatly exceeding translational one, pulsed and continuous irradiation regimes. Collisions of anharmonic oscillators, possibility of population inversion. Polyatomic molecules, bottleneck broadening. Photon-assisted collisions, the Rabi and Weisskopf frequencies.

Lecture Nineteen

Excitation of Electronic Transitions in Molecules 257

Diatom molecule. Franck-Condon principle. Polyatomic molecules, generalization of Franck-Condon principle. Term-to-term transition at vibrational motion. Repulsion of "intersecting" terms. Landau-Zener transition. Intramolecular conversion. Photochemistry. Single- and multiphoton excitation. IR-UV irradiation, possibility of selective breaking of bonds. Change of distribution functions of reactants under the action of radiation. Chemical-kinetic equation. IR-laser irradiation.

Lecture Twenty

Laser Thermochemistry. Processes on a Surface 269

Laser energy supply, its rate and resonant properties. Ambiguity, hysteresis, catastrophes. Back loops, periodic regimes. Stochastic attractors. Laser thermochemical pyrolysis and synthesis. Nontriviality of the products of laser thermochemistry. Thermochemistry on phase boundary surface, oxidation and combustion of metals in laser radiation field. Spatial instability. Cold wall thermochemistry. Physical adsorption. Van der Waals forces. Polarizational interaction of molecules in resonant laser field. Deepening the adsorption potential, hampering the diffusion through radiation-transparent structures with a developed surface.

Lecture Twenty-one

**Self-Influence of Laser Radiation
in Intense Resonant Interactions** 280

Polarization and susceptibility. Self-influence at collisionless multiphoton excitation of molecules. Shift of dispersion curve. Pulse shortening. Self-focusing, self-defocusing, waveguide modes. Wave front inversion in four-wave interaction. Inverting mirror. Dynamic holography. Delayed self-influence at thermochemical interactions.

Afterword 289**Appendix** 291

1. Dicke's Cooperative Effect 291

2. Dipole-Dipole Interaction
as a Process in Multilevel Systems 294**Bibliography** 295**Bibliography to the English Edition** 299**Subject Index** 301