A. Publications in International Journals with referees (48)
B. Books (3), and
   Invited Chapter (Monograph) in a Book (1)
   Invited Review Article with referees (1)
C. Publications in International Conference proceedings with editorial-type refereeing and /or referees (21)
D. Topical conference proceedings or international schools proceedings (8)
E. Publications in Popular Science Magazines (1)

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The numbering is global and it runs from older to newer publications.

Heterocitations 379 (color black)
Additionally (Lists of red and green items are not at all complete):
Citations from collaborators 99 (color blue)
Heterocitations in technical reports, abstracts, talks, to book where I am coauthor as a whole, etc 7 (color red)
Citations from collaborators in technical reports and abstracts 7 (color green)

According to the data shown below, my h-index (heterocitations only) is 11
my h-index (heterocitations and citations from collaborators excluding self-citations) is 13
A. Publications in International Journals with referees (48)

A48] Periodic polymers with increasing repetition unit: Energy structure and carrier transfer
K. Lambropoulos, C. Vantaraki, P. Bilia, M. Mantela, and C. Simserides*
doi: 10.1103/PhysRevE.98.032412
Also at arXiv arXiv:1808.05614
We study the energy structure and the transfer of an extra electron or hole along periodic polymers made of N monomers, with a repetition unit made of P monomers, using a tight-binding wire model, where a site is a monomer (e.g., in DNA, a base pair), for P even, and deal with two categories of such polymers: made of the same monomer (GC…, GGCC…, etc.) and made of different monomers (GA…, GGAA…, etc.). We calculate the highest occupied molecular orbital (HOMO) and lowest unoccupied molecular orbital (LUMO) eigenspectra, density of states, and HOMO-LUMO gap and find some limiting properties these categories possess, as P increases. We further examine the properties of the mean over time probability to find the carrier at each monomer. We introduce the weighted mean frequency of each monomer and the total weighted mean frequency of the whole polymer, as a measure of the overall transfer frequency content. We study the pure mean transfer rates. These rates can be increased by many orders of magnitude with appropriate sequence choice. Generally, homopolymers display the most efficient charge transfer. Finally, we compare the pure mean transfer rates with experimental transfer rates obtained by time-resolved spectroscopy.

A47] Spectral and transmission properties of periodic 1D Tight-Binding lattices with a generic unit cell: an analysis within the transfer matrix approach
K. Lambropoulos, and C. Simserides
Journal of Physics Communications 2 (2018) 035013 (19 pages)
doi: 10.1088/2399-6528/aab065
We report on the electronic structure, density of states and transmission properties of the periodic one-dimensional Tight-Binding (TB) lattice with a single orbital per site and nearest-neighbor hoppings, with a generic unit cell of u sites. The determination of the eigenvalues is equivalent to the diagonalization of a real tridiagonal symmetric u-Toeplitz matrix with (cyclic boundaries) or without (fixed boundaries) perturbed upper right and lower left corners. We solve the TB equations via the Transfer Matrix Method, producing analytical solutions and recursive relations for its eigenvalues, closely related to the Chebyshev polynomials. We examine the density of states and provide relevant analytical relations. We attach semi-infinite leads, determine and discuss the transmission coefficient at zero bias and investigate the peaks number and position, and the effect of the coupling strength and asymmetry as well as of the lead properties on the transmission profiles. We introduce a generic optimal coupling condition and demonstrate its physical meaning.

A46] Electronic structure and charge transport properties of atomic carbon wires
K. Lambropoulos and C. Simserides*
Physical Chemistry Chemical Physics 19 (2017) 26890 - 26897
doi: 10.1039/c7cp05134d
Heterocitations 4
Atomic carbon wires represent the ultimate one-atom-thick one-dimensional structure. We use a Tight-Binding (TB) approach to determine the electronic structure of polyynic and cumulenic carbynes, in terms of their dispersion relations (for cyclic boundaries), eigenspectra (for fixed boundaries) and density of states (DOS). We further derive the transmission coefficient at zero bias by attaching the carbynes to semi-infinite metallic leads, and demonstrate the effect of the coupling strength and asymmetry to the transparency of the system to incident carriers. Finally, we determine the current-voltage (I-V) characteristics of carbynes and study the effect of factors such as the weakening of the coupling of the system to one of the leads, the relative position of the Fermi levels of the carbyne and the leads, the leads’ bandwidth and, finally, the difference in the energy structure between the leads. Our results confirm and reproduce some of the most recent experimental findings.

A45] RT-TDDFT study of hole oscillations in B-DNA monomers and dimers
M. Tassi, A. Morphis, K. Lambropoulos, and C. Simserides
Cogent Physics (2017)
doi: 10.1080/23311940.2017.1361077
Heterocitations 1
We employ Real-Time Time-Dependent Density Functional Theory to study hole oscillations within a B-DNA monomer (one base pair) or dimer (two base pairs). Placing the hole initially at any of the bases which make up
a base pair, results in THz oscillations, albeit of negligible amplitude. Placing the hole initially at any of the base pairs which make up a dimer is more interesting: For dimers made of identical monomers, we predict oscillations with frequencies in the range $f \approx 20-40$ THz, with a maximum transfer percentage close to 1. For dimers made of different monomers, $f \approx 80-400$ THz, but with very small or small maximum transfer percentage. We compare our results with those obtained recently via our Tight-Binding approaches and find that they are in good agreement.

**A44** Electronic structure and carrier transfer in B-DNA monomer polymers and dimer polymers:
Stationary and time-dependent aspects of wire model vs. extended ladder model
Physical Review E 94 (2016) 062403 (22 pages)
doi: 10.1103/PhysRevE.94.062403
Related version at arXiv arXiv:1609.00235v1

Heterocitations 4
We employ two Tight-Binding (TB) approaches to systematically study the electronic structure and hole or electron transfer in B-DNA monomer polymers and dimer polymers made up of $N$ monomers (base pairs): (I) at the base-pair level, using the on-site energies of base pairs and the hopping integrals between successive base pairs, i.e., a wire model and (II) at the single-base level, using the on-site energies of the bases and the hopping integrals between neighboring bases, i.e., an extended ladder model since we also include diagonal hoppings. We solve a system of MD (“matrix dimension”) coupled equations [(I) $MD = N$, (II) $MD = 2N$] for the time-independent problem, and a system of MD coupled 1st order differential equations for the time-dependent problem. We perform a comparative study of stationary and time-dependent aspects of the two TB variants, using realistic sets of parameters. The studied properties include HOMO and LUMO eigenspectra, occupation probabilities, Density of States (DOS) and HOMO-LUMO gaps as well as mean over time probabilities to find the carrier at each site [(I) base pair or (II) base], Fourier spectra, which reflect the frequency content of charge transfer (CT) and pure mean transfer rates from a certain site to another. The two TB approaches give coherent, complementary aspects of electronic properties and charge transfer in B-DNA monomer polymers and dimer polymers.

**A43** Wire and extended ladder model predict THz oscillations in DNA monomers, dimers and trimers
doi: 10.1088/0953-8984/28/49/495101
Related version at arXiv arXiv:1609.00180v1

We call monomer a B-DNA base pair and study, analytically and numerically, electron or hole oscillations in monomers, dimers and trimers. We employ two Tight Binding (TB) approaches: (I) at the base-pair level, using the on-site energies of the base pairs and the hopping parameters between successive base pairs i.e. a wire model, and (II) at the single-base level, using the on-site energies of the bases and the hopping parameters between neighbouring bases, specifically between (a) two successive bases in the same strand, (b) complementary bases that define a base pair, and (c) diagonally located bases of successive base pairs, i.e. an extended ladder model since it also includes the diagonal hoppings (c). For monomers, with TB II, we predict periodic carrier oscillations with frequency $f \approx 50-550$ THz. For dimers, with TB I, we predict periodic carrier oscillations with $f \approx 0.25-100$ THz. For trimers made of identical monomers, with TB I, we predict periodic carrier oscillations with $f \approx 0.5-33$ THz. In other cases, either with TB I or TB II, the oscillations may be not strictly periodic, but Fourier analysis shows similar frequency content. For dimers and trimers, TB I and TB II are successfully compared giving complementary aspects of the oscillations.

**A42** Lowest ionization and excitation energies of biologically important heterocyclic planar molecules
M. Mantela, A. Morphis, M. Tassi, and C. Simserides*
Molecular Physics 114 (2016) 709-718
doi: 10.1080/00268976.2015.1113313

Heterocitations 2
We calculate the lowest ionization and excitation energies in a variety of biologically important molecules, i.e. r-conjugated systems like DNA and RNA bases and isomers plus related heterocyclic molecules. For approximately half of these molecules there are no experimental and theoretical/numerical data in the
literature, as far as we know. These electronic transitions are mainly but not exclusively of $n$ and $n\pi^*$ character, respectively. We perform symmetry-constrained Density Functional Theory (DFT) geometry optimization at the B3LYP/6-311++G** level of theory. At the DFT obtained ground-state geometries, we calculate vertical ionization energies with Ionization Potential Coupled Cluster with Singles and Doubles (IP-EOMCCSD) and vertical excitation energies with the Completely Renormalized Equation of Motion Coupled Cluster with Singles, Doubles, and non-iterative Triples (CREOMCCSD(T)) method. We also investigate whether a simple semi-empirical Hückel-type model approach with novel parametrization could provide reasonable estimates of the lowest $n$ ionization and $n\pi^*$ excitation energies. Our Coupled Cluster (CC) results are in very good agreement with experimental data, while the Hückel-type model predictions generally follow the trends with some deviation. Finally, we investigate the effect of basis set in IPEOMCCSD energies and we compare our CR-EOMCCSD(T) results with Time Dependent DFT (TDDFT) ones.

A41) Unbiased charge oscillations in B-DNA: monomer polymers and dimer polymers
K. Lambropoulos, M. Chatzieleftheriou, A. Morphis, K. Kaklamanis, M. Theodorakou, and C. Simserides*
doi: 10.1103/PhysRevE.92.032725
Related older version also at arXiv:1504.02638
We also published Publisher’s Note: Unbiased charge oscillations in B-DNA: Monomer polymers and dimer polymers [Phys. Rev. E 92, 032725 (2015)]
K. Lambropoulos, M. Chatzieleftheriou, A. Morphis, K. Kaklamanis, M. Theodorakou, and C. Simserides*
Physical Review E 93, 069902(E) (2016)
doi: 10.1103/PhysRevE.93.069902
Heterocitations 2

We call monomer a B-DNA base-pair and examine, analytically and numerically, electron or hole oscillations in monomer- and dimer-polymers, i.e., periodic sequences with repetition unit made of one or two monomers. We employ a tight-binding (TB) approach at the base-pair level to readily determine the spatiotemporal evolution of a single extra carrier along a N base-pair B-DNA segment. We study HOMO and LUMO eigenspectra as well as the mean over time probabilities to find the carrier at a particular monomer. We use the pure mean transfer rate $k$ to evaluate the easiness of charge transfer. The inverse decay length $\beta$ for exponential fits $k(d)$, where $d$ is the charge transfer distance, and the exponent $\eta$ for power law fits $k(N)$ are computed; generally power law fits are better. We illustrate that increasing the number of different parameters involved in the TB description, the fall of $k(d)$ or $k(N)$ becomes steeper and show the range covered by $\beta$ and $\eta$. Finally, both for the time-independent and the time-dependent problem, we analyze the palindromicity and the degree of eigenspectrum dependence of the probabilities to find the carrier at a particular monomer.

A40) THz and above THz electron or hole oscillations in DNA dimers and trimers
K. Lambropoulos, K. Kaklamanis, G. Georgiadis, and C. Simserides*
Annalen der Physik (Berlin) 526 (2014) 249–258
doi: 10.1002/andp.201400067
Heterocitations 2

We propose a non conventional source or receiver of THz and above THz electromagnetic radiation. Specifically, we predict electron or hole oscillations in DNA dimers (two interacting DNA base-pairs or monomers), with frequency in the range $f \approx 0.25$-100 THz (period $T \approx 10$-4000 fs) i.e. potentially emitting electromagnetic radiation mainly in the mid- and far-infrared with wavelengths $\approx 3$-1200 $\mu$m. The efficiency of charge transfer between the two monomers which make up the dimer is described with the maximum transfer percentage $p$ and the pure maximum transfer rate $pf$. For dimers made of identical monomers $p = 1$, but for dimers made of different monomers $p < 1$. Further, we extend the investigation to DNA trimers (three interacting DNA base-pairs or monomers). For trimers made of identical monomers the carrier oscillates periodically with $f \approx 0.5$-33 THz ($T \approx 30$-2000 fs); for 0 times crosswise purines $p = 1$, for 1 or 2 times crosswise purines $p < 1$. For trimers made of different monomers the carrier movement may be non periodic. Generally, increasing the number of monomers above three, the system becomes more complex and periodicity is lost; even for the simplest tetramer the carrier movement is not periodic.

A39) A systematic study of electron or hole transfer along DNA dimers, trimers and polymers
C. Simserides*
Chemical Physics 440 (2014) 31-41
doi: 10.1016/j.chemphys.2014.05.024
Heterocitations 9
Related work at arXiv
arXiv:1402.0654 A systematic study of electron or hole transfer along DNA dimers, trimers and polymers
A systematic study of carrier transfer along DNA dimers, trimers and polymers including poly(dG)-poly(dC), poly(dA)-poly(dT), GCGGCGC..., ATATAT... is presented allowing to determine the spatiotemporal evolution of electrons or holes along a $N$ base-pair DNA segment. Physical quantities are defined including maximum transfer percentage $p$ and pure maximum transfer rate $pT$ when a period $T$ is defined; pure mean transfer rate $k$ and speed $u = kd$, where $d$ is the charge transfer distance. The inverse decay length $\beta$ for the exponential fit $k = k_0 \exp(-\beta d)$ and the exponent $\eta$ for the power-law fit $k = k_0 N^{-\eta}$ are computed. $\beta = 0.2 \pm 2$ Å$^{-1}$, $k_0$ is usually $10^{-2}$, 10$^{-1}$ PHz, generally $\approx 10^{-4}$ to $10$ PHz. $\eta = 1.7 \pm 17$, $k_0'$ is usually $10^{-2}$ to $10^{-1}$ PHz, generally $\approx 10^{-4}$ to $10^0$ PHz. The results are compared with theoretical and experimental works. This method allows assessing the extent at which a specific DNA segment can serve for charge transfer.

**A38** Phase diagram and critical behavior of the random ferromagnet Ga$_{1-x}$Mn$_x$N
Physical Review B 88 (2013) 081201(R) (4 pages)
doi: 10.1103/PhysRevB.88.081201

Molecular beam epitaxy has been employed to obtain Ga$_{1-x}$Mn$_x$N films with $x$ up to 10% and Curie temperatures $T_C$ up to 13 K. The magnitudes of $T_C$ and their dependence on $x$, $T_C(x) \propto x^m$, where $m = 2.2 \pm 0.2$ are quantitatively described by a tight binding model of superexchange interactions and Monte Carlo simulations of $T_C$. The critical behavior of this dilute magnetic insulator shows strong deviations from the clean case, in particular, (i) an apparent breakdown of the Harris criterion; (ii) a non-monotonic crossover in the values of the susceptibility critical exponent $\gamma_{eff}$ between the high temperature and critical regimes, and (iii) a smearing of the critical region, which can be explained either by the Griffiths effects or by macroscopic inhomogeneities in the spin distribution with a variance $\Delta x = (0.2 \pm 0.1\%)$.

**A37** Density of states and extent of wave function: two crucial factors for small polaron hopping conductivity in 1D
M. Dimakogianni, C. Simserides, G. P. Triberis
Philosophical Magazine, 93 (2013) 2729-2748
doi: 10.1080/14786435.2013.785639
From Collaborators 1)

We introduce a theoretical model to scrutinize the conductivity of small polarons in one-dimensional disordered systems, focusing on two crucial --as will be demonstrated-- factors: the density of states and the spatial extent of the wave function. The investigation is performed for any temperature up to 300 K and under electric field of arbitrary strength up to the polaron dissociation limit. To accomplish this task we combine analytical work with numerical calculations.

**A36** Origin of low-temperature magnetic ordering in Ga$_{1-x}$Mn$_x$N
doi: 10.1103/PhysRevB.85.205204
Also at: arXiv:1202.6233v2 [cond-mat.mtrl-sci]
Heterocitations 19, From Collaborators 13 (+3)

By use of highly sensitive millikelvin superconducting quantum interference device magnetometry, the magnitude of the Curie temperature as a function of the Mn concentration $x$ is determined for thoroughly characterized Ga$_{1-x}$Mn$_x$N. The interpretation of the results in the frame of tight-binding theory and of Monte Carlo simulations allows us to assign the spin interaction to ferromagnetic superexchange and to point out the limited accuracy of state-of-the-art ab initio methods in predicting the magnetic characteristics of dilute magnetic insulators.

**A35** Intrinsic optical bistability in a two-subband system in a semiconductor quantum well: Analytical results
S. G. Kosionis, A. F. Terzis, C. Simserides, E. Paspalakis
We study theoretically the conditions under which optical bistability is achievable in a two-subband system in a semiconductor quantum well. We consider the interaction of the two-subband system with a continuous wave electromagnetic field, which induces intersubband transitions. For the description of the system dynamics we use the effective nonlinear density matrix equations. We solve these equations analytically, in the steady state, for a GaAs/AlGaAs quantum well structure. For several combinations of the values of the parameters three real solutions of the population inversion arise and the phenomenon of optical bistability prevails.

Reducing influence of antiferromagnetic interactions on ferromagnetic properties of p-(Cd,Mn)Te quantum wells
C. Simserides*, A. Lipińska, K.N. Trohidou, T. Dietl
Physica E: Low-dimensional Systems and Nanostructures 42 (2010) 2694-2697
doi: 10.1016/j.physe.2009.10.062
On the occasion of MSS-14
Also at arXiv:1308.4525v1 [cond-mat.mes-hall]

In order to explain the absence of hysteresis in ferromagnetic p-type (Cd,Mn)Te quantum wells (QWs), spin dynamics was previ- ously investigated by Monte Carlo simulations combining the Metropolis algorithm with the determination of hole eigenfunctions at each Monte Carlo sweep. Short-range antiferromagnetic superexchange interactions between Mn spins –which compete with the hole-mediated long-range ferromagnetic coupling– were found to accelerate magnetization dynamics if the the layer containing Mn spins is wider than the vertical range of the hole wave function. Employing this approach it is shown here that appreciate magnitudes of remanence and coercivity can be obtained if Mn ions are introduced to the quantum well in a delta-like fashion.

Linear and nonlinear optical properties of a two-subband system in a symmetric semiconductor quantum well
S. G. Kosionis, A. F. Terzis, C. Simserides, E. Paspalakis
Heterocitations 13, From Collaborators 6 (+1)

We study the linear and nonlinear optical response of intersubband transitions in a semiconductor quantum well. We describe the coupling of the quantum well structure with the electromagnetic field by using the nonlinear density matrix equations, in the two-subband approximation. We provide proper approximate analytical solutions to these equations that are used for the closed-form determination of the optical susceptibilities $\chi^{(1)}$, $\chi^{(2)}$, and $\chi^{(3)}$. We also explore the dependence of $\chi^{(1)}$, $\chi^{(2)}$, and $\chi^{(3)}$ on the electron sheet density for a specific double GaAs/AlGaAs quantum well.

Electronic parameters for charge transfer along DNA
L. G. D. Hawke, G. Kalosakas, C. Simserides
Also at arXiv:0908.1248v1 [physics.bio-ph]
Heterocitations 44 (+1), From Collaborators 2

We have also published Erratum to: Electronic parameters for charge transfer along DNA
L. G. D. Hawke, G. Kalosakas, and C. Simserides
European Physical Journal E 34 (2011) 118
doi: 10.1140/epje/i2011-11118-4

We systematically examine all the tight-binding parameters pertinent to charge transfer along DNA. The π molecular structure of the four DNA bases (adene, thymine, cytosine, and guanine) is investigated by using the linear combination of atomic orbitals method with a recently introduced parametrization. The HOMO and LUMO wavefunctions and energies of DNA bases are discussed and then used for calculating the corresponding wavefunctions of the two B-DNA base-pairs (adenine-thymine and guanine-cytosine). The obtained HOMO and LUMO energies of the bases are in good agreement with available experimental values. Our results are then used for estimating the complete set of charge transfer parameters between neighboring bases and also between successive base-pairs, considering all possible combinations between them, for both electrons and holes. The calculated microscopic quantities can be used in mesoscopic theoretical models of electron or hole transfer along the DNA double helix, as they provide the necessary parameters for a tight-binding phenomenological description based on the molecular overlap. We find that usually the hopping parameters for holes are higher in magnitude compared to the ones for electrons. Our findings are also compared with existing calculations from first principles.
A31) Control of Intersubband Quantum Well Transitions with Chirped Electromagnetic Pulses  
E. Paspalis, C. Simserides, A. F. Terzis  
doi: 10.1063/1.3329377  
Heterocitations 8 (+1), From Collaborators 7 (+1)  
We study the interaction of chirped electromagnetic pulses with intersubband transitions of a double semiconductor quantum well. We consider the ground and first excited subbands and give emphasis to controlled intersubband population transfer. The system dynamics is described by the nonlinear density matrix equations that include the effects of electron-electron interactions. These equations are solved numerically for various values of the electron sheet density for a realistic double GaAs/AlGaAs quantum well, and the efficiency of population transfer is discussed.

A30) Multi-spin-subband structure of dilute magnetic semiconductor quantum wells: Feedback mechanism  
C. Simserides* , K. Kompouras  
Superlattices and Microstructures 46 (2009) 889-899  
doi:10.1016/j.spmi.2009.10.007  
Using a fully self-consistent envelope function approach, we focus on wide conduction band NMS (non-magnetic semiconductor)/DMS (dilute magnetic semiconductor)/NMS quantum wells, under weak external parallel magnetic field, where many spin-subbands are usually present. We concentrate on small values of the magnetic field because we want to investigate the influence of the feedback mechanism due to the difference of the concentrations of spin-up and spin-down carriers which could induce spontaneous spin-polarization i.e. in the absence of a magnetic field. We study the spin-subband structure, the spin-subband populations and the spin-polarization as functions of the sheet carrier concentration, \( N_s \), for different values of the magnitude of the exchange interaction, \(|J|\), between the itinerant carriers and the magnetic impurities. Our calculations for 0.01 T show that at 20 K the values of \(|J|\) necessary to make this feedback mechanism sufficiently strong are too high compared to the \(|J|\) values of common Mn-doped systems in the conduction band. However, the feedback mechanism will be sufficiently strong at low enough temperatures below 20 K for realistic values of \(|J|\). Moreover, we explain how increasing the sheet carrier concentration the heterostructure is transformed from an almost square quantum well to a system of two coupled heterojunctions with an intermediate soft barrier.

A29) Ferromagnetic properties of p-(Cd,Mn)Te quantum wells: Interpretation of magneto-optical measurements by Monte Carlo simulations  
doi: 10.1103/PhysRevB.79.235322  
Also at arXiv:0903.0406v1 [cond-mat.mtrl-sci]  
Heterocitations 9, From Collaborators 4  
In order to single out dominant phenomena that account for carrier-controlled magnetism in p-Cd1-xMnxTe quantum wells we have carried out magneto-optical measurements and Monte Carlo simulations of time dependent magnetization. The experimental results show that magnetization relaxation is faster than 20 ns in the paramagnetic state. Decreasing temperature below the Curie temperature \( T_C \) results in an increase of the relaxation time but to less than 10 ps. This fast relaxation may explain why the spontaneous spin splitting of electronic states is not accompanied by the presence of non-zero macroscopic magnetization below \( T_C \). Our Monte Carlo results reproduce the relative change of the relaxation time on decreasing temperature. At the same time, the numerical calculations demonstrate that antiferromagnetic spin-spin interactions, which compete with the hole-mediated long-range ferromagnetic coupling, play an important role in magnetization relaxation of the system. We find, in particular, that magnetization dynamics is largely accelerated by the presence of antiferromagnetic couplings to the Mn spins located outside the region, where the holes reside. This suggests that macroscopic spontaneous magnetization should be observable if the thickness of the layer containing localized spins will be smaller than the extension of the hole wave function. Furthermore, we study how a spin-independent part of the Mn potential affects \( T_C \). Our findings show that the alloy disorder potential tends to reduce \( T_C \), the effect being particularly strong for the attractive potential that leads to hole localization.

A28) Empirical LCAO parameters for pi molecular orbitals in planar organic molecules  
L. G. D. Hawke, G. Kalosakas, C. Simserides  
Molecular Physics 107 (2009) 1755–1771  
doi: 10.1080/00268970903049089  
Also at arXiv:0808.3984 [physics.chem-ph]  
Heterocitations 8, From Collaborators 1  
We present a parametrization within a simplified LCAO model (a type of Hueckel model) for the description of \( \pi \) molecular orbitals in organic molecules containing \( \pi \)-bonds between carbon, nitrogen, or oxygen atoms with \( sp^2 \) hybridization, which we show to be quite accurate in predicting the energy of the highest occupied \( \pi \) orbital
and the first n-n* transition energy for a large set of organic compounds. We provide four empirical parameter values for the diagonal matrix elements of the LCAO description, corresponding to atoms of carbon, nitrogen with one p_z electron, nitrogen with two p_z electrons, and oxygen. The bond-length dependent formula (proportional to 1/d^2) of Harrison is used for the non-diagonal matrix elements between neighboring atoms. The predictions of our calculations have been tested against available experimental results in more than sixty organic molecules, including benzene and its derivatives, polyacenes, aromatic hydrocarbons of various geometries, polyenes, ketones, aldehydes, azabenzenes, nucleic acid bases and others. The comparison is rather successful, taking into account the small number of parameters and the simplicity of the LCAO method, involving only p_z atomic orbitals, which leads even to analytical calculations in some cases.

A27) The n-n* molecular structure of flavin of FADH- enzymatic cofactor using the LCAO method
L. G. D. Hawke, C. Simserides*, G. Kalosakas
On the occasion of NN08
Heterocitations 2

The n-n* molecular structure (eigenenergies and eigenfunctions) of flavin tricyclic ring is calculated, using the linear combination of atomic orbitals (LCAO) method containing only p_z atomic orbitals. In respect to FADH- position opposite to DNA lesion in photolyase, flavin’s HOMO is found to be distributed in the central and distal side, while LUMO is localized in the distal side of flavin (the side that is closer to the adenine part of FADH– and farther than the DNA dimer lesion). LUMO1 as well as LUMO2 are mainly distributed in the proximal side of flavin (the side that is closer to the DNA dimer). Our findings are compared with previous theoretical results as well as with experimental values of known n-n* transitions.

A26) Principal thermodynamic properties of quasi two-dimensional carriers under in-plane magnetic field
C. Simserides*
Heterocitations 1

An external magnetic field, H, applied parallel to a quasi-two-dimensional carrier system modifies quantitatively and qualitatively the density of states. We examine how this affects primary thermodynamic properties, namely, the entropy, S, the internal and free energy, U and F, the magnetization, M, and the magnetic susceptibility, χ_m, using a self-consistent numerical approach. Although M is mainly in the opposite direction to H, the system is not linear. Hence, surprisingly, ∂M/∂H swings between negative and positive values, i.e. a diamagnetic to paramagnetic transition of entirely orbital origin is predicted. This phenomenon is important compared to the ideal de Haas-van Alphen effect, i.e. the corresponding phenomenon under perpendicular magnetic field. By augmenting temperature, the diamagnetic to paramagnetic transition fades away. The overall behaviour of entropy is also foreseen and consistently interpreted. While the entropy contribution to the free energy is very small at low temperatures, entropy shows a clear dependence on the external magnetic field.

A25) The effect of the size of self-assembled individual quantum dots on their PL spectra
A. Zora, C. Simserides, G. P. Triberis
On the occasion of the 3rd MNN 2007
Heterocitations 7

Based on an analytical expression for the photoluminescence (PL) intensity of individual quantum dots (QDs) in the linear regime, we investigate its dependence upon the size of self-assembled InGaAs QDs. We prove that decreasing the QD size, the PL-emission spectrum moves to higher energy, due to the confinement-induced blueshift of the electronic levels and the redshift from the increased Coulomb interaction caused by the compression of the exciton radii. This shift is in agreement with experimental results. Moreover, we show that larger dots provide more intense PL spectra.

A24) Effects of the task of categorizing FM direction on auditory evoked magnetic fields in the human auditory cortex
R. Koenig, C. Sielużycki, C. Simserides, P. Heil, H. Scheich
Heterocitations 9 (+1), From Collaborators 3

We examined effects of the task of categorizing linear frequency-modulated (FM) sweeps into rising and falling on auditory evoked magnetic fields (AEFs) from the human auditory cortex, recorded by means of whole-head magnetoencephalography. AEFs in this task condition were compared with those in a passive condition where
produces satisfactorily the experimentally observed PL signal of individual QD. Moreover, due to the density of states modification, not in the sing time caused by electron

dicharge, the magnitude of the spin polarized. We study how applying the Heisenberg equation of motion to the photon number expectation values, to the carrier distribution


We develop a fully quantum mechanical theory for the interaction of light and electron–hole excitations in semiconductor quantum dots. Our theoretical analysis results in an expression for the photoluminescence intensity of quantum dots in the linear regime. Taking into account the single-particle Hamiltonian, the free-photon Hamiltonian, the electron–hole interaction Hamiltonian, and the interaction of carriers with light, and applying the Heisenberg equation of motion to the photon number expectation values, to the carrier distribution


We investigate the emission spectra of individual lens-shaped self-assembled quantum dots (QDs) in the high-temperature regime, in order to contribute to the fine structural analysis and to the appreciation of the QDs optical response. Our theoretical analysis results in an expression for the photoluminescence (PL) intensity of QDs in the linear regime, which reproduces satisfactorily the experimentally observed PL signal of individual lens-shaped In0.5Ga0.5As self-assembled quantum dots (QDs). Using the appropriate material parameters, the theoretical predictions for the interlevel spacing as well as for the dephasing time caused by electron longitudinal optical phonon interactions are in a good agreement with experiment.

We study theoretically the potential for control of the electron population in a single GaAs/AlGaAs quantum well that is coupled by strong pulsed electromagnetic fields. Using numerical calculations we present conditions that lead to high-efficiency intersubband population inversion.

Due to the competition between spatial and magnetic confinement, the density of states of a quasi two-dimensional system deviates from the ideal step-like form both quantitatively and qualitatively. We study how this affects the spin-subband populations and the spin-polarization as functions of the temperature, T, and the in-plane magnetic field, B, for narrow to wide dilute-magnetic-semiconductor quantum wells. We focus on the quantum well width, the magnitude of the spin-spin exchange interaction, and the sheet carrier concentration dependence. We look for ranges where the system is completely spin-polarized. Increasing T, the carrier spin-splitting, Uo, decreases, while increasing B, Uo increases. Moreover, due to the density of states modification, all energetically higher subbands become gradually depopulated.

A21) Quasi two-dimensional carriers in dilute-magnetic-semiconductor quantum wells under in-plane magnetic field
C. Simserides* and I. Galanakis
Physica E: Low-dimensional Systems and Nanostructures 40 (2008) 1214-1216
doi: 10.1016/j.physe.2007.08.061
Heterocitations
Due to the competition between spatial and magnetic confinement, the density of states of a quasi two-dimensional system deviates from the ideal step-like form both quantitatively and qualitatively. We study how this affects the spin-subband populations and the spin-polarization as functions of the temperature, T, and the in-plane magnetic field, B, for narrow to wide dilute-magnetic-semiconductor quantum wells. We focus on the quantum well width, the magnitude of the spin-spin exchange interaction, and the sheet carrier concentration dependence. We look for ranges where the system is completely spin-polarized. Increasing T, the carrier spin-splitting, Uo, decreases, while increasing B, Uo increases. Moreover, due to the density of states modification, all energetically higher subbands become gradually depopulated.

A20) Theory of spontaneous emission of quantum dots in the linear regime
A. Zora, C. Simserides and G. P. Triberis
doi: 10.1088/0953-8984/19/40/406201
Heterocitations
We develop a fully quantum-mechanical theory for the interaction of light and electron–hole excitations in semiconductor quantum dots. Our theoretical analysis results in an expression for the photoluminescence intensity of quantum dots in the linear regime. Taking into account the single-particle Hamiltonian, the free-photon Hamiltonian, the electron–hole interaction Hamiltonian, and the interaction of carriers with light, and applying the Heisenberg equation of motion to the photon number expectation values, to the carrier distribution
functions and to the correlation term between the photon generation (destruction) and electron-hole pair, we obtain a set of luminescence equations. Under quasi-equilibrium conditions, these equations become a closed-set of equations. We solve them analytically, in the linear regime, and we find an approximate solution of the incoherent photoluminescence intensity. The validity of the theoretical analysis is tested by investigating the emission spectra in the high-temperature regime, interpreting the experimental findings for the emission spectra of a lens-shaped In0.5Ga0.5As self-assembled quantum dot. Our theoretical predictions for the interlevel spacing as well as for the dephasing time caused by electron-longitudinal optical phonon interactions are in good agreement with the experimental results.

A19) Spin-subband populations and spin polarization of quasi-two-dimensional carriers under an in-plane magnetic field

C. Simserides*


Heterocitations 7

Under an in-plane magnetic field, the density of states of quasi-two-dimensional carriers deviates from the occasionally stereotypic step-like form both quantitatively and qualitatively. Here we study how this affects the spin-subband populations and the spin-polarization as functions of the temperature, T, and the in-plane magnetic field, B, for narrow to wide dilute-magnetic-semiconductor quantum wells. We examine a wide range of material and structural parameters, focusing on the quantum well width, the magnitude of the spin-spin exchange interaction, and the sheet carrier concentration. Generally, increasing T, the carrier spin-splitting, Uosigma, decreases, augmenting the influence of the “minority”-spin carriers. Increasing B, Uosigma, increases and, accordingly, carriers populate “majority”-spin subbands while they abandon “minority”-spin subbands. Furthermore, in line with the density of states modification, all energetically higher subbands become gradually depopulated. We also indicate the ranges where the system is completely spin-polarized.

A18) Near-field magnetooabsorption of quantum dots

C. Simserides*, A. Zora, G. Triberis


selected for the Virtual Journal of Biological Physics Research: http://www.vjbio.org, 15 April 2006 issue

We investigate the effect of an external magnetic field of variable orientation and magnitude (up to 20 T) on the linear near-field optical absorption spectra of single and coupled III-V semiconductor quantum dots. We focus on the spatial as well as on the magnetic confinement, varying the dimensions of the quantum dots and the magnetic field. We show that the ground state exciton binding energy can be manipulated utilizing the spatial and the magnetic confinement. The effect of the magnetic field on the absorption spectra, increasing the near-field illumination spot, is also investigated. The zero-magnetic-field “structural” symmetry can be destroyed varying the magnetic field orientation and this affects the near-field spectra. The asymmetry induced (except for specific orientations along symmetry axes) by the magnetic field, can be revealed in the near-field but not in the far-field spectra. We predict that near-field magnetoeabsorption experiments, of realistic spatial resolution, will be in the position to bring to light the quantum dot symmetry. This exceptional symmetry-resolving power of the near-field magnetoeabsorption, is lost in the far field. The influence of the Coulomb interactions on the absorption spectra is also discussed. Finally, we show that certain modifications of the magnetoexcitonic structure can be uncovered using a realistically acute near-field probe of ~ 20 nm.

A17) A small polaron hopping model for multiphonon-assisted transport along DNA molecules, in the presence of disorder

G. Triberis, C. Simserides* and V. Karavolas

Physica E: Low-dimensional Systems and Nanostructures 32 (2006) 592–595

Proceedings of MSS12 (12th International Conference on Modulated Semiconductor Structures)

Heterocitations 5

We discuss a small polaron hopping model, in order to explain the intense temperature (T) dependence of the electrical conductivity (\(\sigma\)) observed at high temperatures along the DNA molecules. The model takes into account the one-dimensional character of the system as well as the presence of disorder in the DNA double helix. Theoretical considerations based on percolation lead to analytical expressions for the high temperature multiphonon-assisted small polaron hopping conductivity, the maximum hopping distance and their temperature dependence. For example, experimental data for the \(\lambda\)-phage DNA, the poly(dA)-poly(dT) DNA, and the native wet-spun calf thymus Li-DNA, follow nicely the theoretically predicted behavior, \(\ln \sigma \sim T^{-2/3}\), over wide high-T ranges. In contrast to some previously presented theoretical suggestions, our model leads to
realistic values for the maximum hopping distances, supporting the idea of multiphonon-assisted hopping of small polarons between next nearest neighbors of the DNA molecular “wire”. We also examine the low temperature case.

A16) Small polaron hopping transport along DNA molecules
G. P. Triberis, C. Simserides and V. C. Karavolas
Heterocitations 19, From collaborators 7
We present a small polaron hopping model for interpreting the strong temperature \(T\) dependence of the electrical conductivity, \(\sigma\), observed at high \(h\) temperatures along DNA molecules. The model takes into account the one-dimensional character of the system and the presence of disorder in the DNA double helix. Percolation-theoretical considerations lead to analytical expressions for the high temperature multiphonon-assisted small polaron hopping conductivity, the hopping distance and their temperature dependence. The experimental data for lambda phage DNA (\(\lambda\)-DNA) and poly(dA)–poly(dT) DNA follow nicely the theoretically predicted behaviour \((\ln \sigma \sim T^{-2})\). Moreover, our model leads to realistic values of the maximum hopping distances, supporting the idea of multiphonon-assisted hopping of small polarons between next nearest neighbours of the DNA molecular ‘wire’. The low temperature case is also investigated.

A15) Magnetic field effects on the near field spectra of quantum dots
A. Zora, C. Simserides*, G. Triberis
Proceedings of EXMATEC04 (7th Expert Evaluation & Control of Compound Semiconductor Materials & Technologies)
We theoretically investigate the linear near field absorption spectra of semiconductor quantum dots under magnetic field of variable orientation. We examine if the application of the magnetic field alone is sufficient to cause – increasing the spot illuminated by the near field probe – “unexpected” features to the absorption spectra.

A14) Properties of conduction-band dilute-magnetic-semiconductor quantum wells in an in-plane magnetic field: A density of states profile that is not step-like
C. Simserides*
Heterocitations 4
We examine how an in-plane magnetic field, \(B\), modifies the density of states (DOS) in narrow-to-wide, conduction-band dilute magnetic semiconductor (DMS) quantum wells. We demonstrate that the DOS diverges significantly from the famous step-like 2DEG form and this causes severe changes to the physical properties e.g. to the spin-subband populations, the internal and free energy, the Shannon entropy and the in-plane magnetization, \(M\). We predict a considerable fluctuation of \(M\) in cases of vigorous competition between spatial and magnetic confinement.

A13) Not-step-like Density of States and carrier distribution of conduction-band, narrow-to-wide Dilute Magnetic Semiconductor quantum wells under in-plane magnetic field
C. Simserides*
Proceedings of MSS11 (11th International Conference on Modulated Semiconductor Structures)
We analyze the important changes induced to the density of states (DOS) of narrow to wide conduction band Dilute Magnetic Semiconductor (DMS) quantum wells subjected to an in-plane magnetic field, \(B\). We show quantitatively that the DOS diverges significantly from the famous step-like 2DEG form, by providing results for many values of \(B\) an grades of spatial localization. This introduces changes to the pertinent electronic properties. The self-consistent approach is indispensable and the eigenvalue problem has to be solved for each subband index \(i\), spin \(\sigma\), and in-plane wavevector e.g. \(k_x\). We can select the appropriate parameters so that the structure is populated by carriers of spin down or exploit the effect of the depopulation of the higher spin-subbands to eliminate carriers with spin up.

A12) The Density of States and the pertinent Electronic Properties of the quasi 2DEG in Simple and DMS structures subjected to an in-plane magnetic field
C. Simserides*
Heterocitations 1
Proceedings of IWCE-9 (9th International Workshop on Computational Electronics)
We analyze the important changes induced to the density of states (DOS) of a quasi two-dimensional-electron-gas (2DEG), when it is subjected to an in-plane magnetic field, B. The DOS diverges significantly from the famous step-like form and this introduces changes to the pertinent electronic properties. In order to calculate the DOS it is indispensable to use a self-consistent approach. The eigenvalue problem has to be solved for each subband index \(i\) and in-plane wavevector, \(k_x\), when the quasi 2DEG is parallel to the xy-plane and B is applied along the y-axis. Although the modification of the DOS is usually ignored, we show here that not only the general shape of the DOS varies, but this effect is also quantitative.

A11) Local optical absorption by confined excitons in single and coupled quantum dots
C. D. Simserides*, U. Hohenester, G. Goldoni and E. Molinari
Heterocitations 3
Proceedings of QD-2000 (International Conference on Semiconductor Quantum Dots)
We investigate optical near-field spectra of single and coupled semiconductor quantum dot. An enhanced role for the Coulomb correlations is predicted, and it is shown that the spectra depend crucially on the spatial resolution of the “local” probe. The intensity of certain optical peaks as a function of the resolution exhibits an unexpected non-monotonic behavior, which is identified as a fingerprint of Coulomb interactions in zero-dimensional nanostructures.

A10) Local absorption spectra of artificial atoms and molecules
C. D. Simserides, U. Hohenester, G. Goldoni and E. Molinari
Heterocitations 20 (+1), From Collaborators 10
We investigate theoretically the spatial dependence of the linear absorption spectra of single and coupled semiconductor quantum dots, where the strong three-dimensional quantum confinement leads to an overall enhancement of Coulomb interaction and, in turn, to a pronounced renormalization of the excitonic properties. We show that - because of such Coulomb correlations and the spatial interference of the exciton wavefunctions - unexpected spectral features appear whose intensity depends on spatial resolution in a highly non-monotonic way when the spatial resolution is comparable with the excitonic Bohr radius. We finally discuss how the optical near-field properties of double quantum dots are affected by their coupling.

A9) Local absorption spectra of single and coupled semiconductor quantum dots
C. D. Simserides*, U. Hohenester, G. Goldoni and E. Molinari
Materials Science and Engineering B 80 (2001) 266-269
doi: 10.1016/S0921-5107(00)00652-8
Heterocitations 3
We study theoretically the local absorption spectra of single and double semiconductor quantum dots, in the linear regime. The three-dimensional confinement leads to an enhancement of the Coulomb correlations, while the spectra depend crucially on the size of the «local» probe. We show that because of such Coulomb correlations the intensity of certain optical peaks as a function of the resolution can exhibit an unexpected non-monotonic behavior for spatial resolutions comparable with the excitonic Bohr radius. We finally discuss the optical near-field properties of coupled double quantum dots for different coupling strengths.

A8) Optical Spectra of Single Quantum Dots: Influence of Impurities and Few-Particle Effects
A. Hartmann, Y. Ducommun and E. Kapon, U. Hohenester, C. Simserides and E. Molinari
doi: 10.1002/1521-396X(200003)178:1<283::AID-PSSA283>3.0.CO;2-M
Heterocitations 5, From Collaborators 5
The evolution of photoluminescence (PL) spectra of single GaAs/AlGaAs quantum dots (QD) is studied as a function of laser excitation power and temperature. At very low powers, where multi-exciton occupation of the QD can be excluded, an unexpected and pronounced spectral evolution is observed (large energy shifts and appearance of multiple emission lines). A similar evolution is observed at low excitation powers with increasing temperature. A model, taking into account the influence of the shallow, residual impurities in the environment of each QD, explains the observed spectral evolutions in terms of photo-depletion of the QD and hopping of impurity-bound carriers back into the QD. Theoretical calculations of the PL due to N electrons + 1 hole (Ne+1h) QD states allow us to attribute the 2 meV spaced lines in the experimental spectra to the different charge states Ne + 1h, (N-1)e + 1h, ... of the QD.
The density of states and the electron concentration of a double-heterojunction system subjected to an in-plane magnetic field

C. D. Simserides*

We calculate the electronic states of AlGaAs/GaAs/AlGaAs double heterojunctions subjected to a magnetic field parallel to the quasi two-dimensional electron gas layer. We study the energy dispersion curves, the density of states, the electron concentration and the distribution of the electrons in the subbands.

The parallel magnetic field induces severe changes in the density of states, which are of crucial importance for the explanation of the magnetocconductivity in these structures. However, to our knowledge, there has been no systematic study of the density of states under these circumstances. We attempt a contribution in this direction.

For symmetric heterostructures, the depopulation of the higher subbands, the transition from a single-layer to a bilayer electron system and the domination of the bulk Landau levels in the centre the wide quantum well, as the magnetic field is continuously increased, are presented in the «energy dispersion picture» as well as in the «electron concentration picture» and in the «density of states picture».

Electron scattering by optical phonons in AlGaAs/GaAs/AlGaAs double quantum wells

X. Zianni, C. D. Simserides and G. P. Triberis

The scattering of a quasi two-dimensional electron gas by optical phonons in selectively doped AlGaAs/GaAs/AlGaAs quantum wells is systematically studied in order to determine the effect of phonon confinement. The electron states are calculated solving self-consistently Schroedinger and Poisson equations to obtain an accurate dependence upon the structure parameters and the temperature. We study the way the scattering is affected by the form of the phonons calculating the mobility using three models for the phonons. They are considered: (a) as 3d (b) as a set of confined and interface phonons and (c) as the normal modes of the heterostructure. The relaxation times for the electron energy subbands are calculated solving the system of Boltzmann equations. The effect of the temperature and the well width variation is also investigated. The results are in a good agreement with experimental measurements. The agreement is only slightly dependent on the model used for the phonons and becomes best when the effect of the heterostructure on the phonon modes is taken into account.

Looking for the maximum low-temperature conductivity in selectively-doped AlGaAs/GaAs/AlGaAs double heterojunctions

C. D. Simserides and G. P. Triberis

We use self-consistent numerical calculations to study the sheet electron concentration and the mobility as functions of the doping concentration, the spacer thickness, the well width and the Al mole fraction of a selectively doped AlGaAs/GaAs- AlGaAs double heterojunction, using no arbitrary, a priori, assumptions, at low temperatures. For the first time we take into account two kinds of donor (shallow and deep) that coexist in the Si-doped AlGaAs. We study all the significant scattering mechanisms. The model, based exclusively upon the knowledge of the material and structural parameters involved, allows as to obtain the maximum conductivity for any specific structure. Our results are in a very good agreement with experiment.

A study on the temperature dependence of the quasi-two-dimensional electron concentration and mobility in AlGaAs/GaAs selectively doped heterostructures

C. D. Simserides and G. P. Triberis

From the early eighties, experiments based on the Hall effect, in various AlGaAs/GaAs selectively doped heterostructures, showed that up to a certain temperature the sheet electron concentration remains almost constant and then continuously increases up to room temperature. Conventional Hall experiments cannot separate the contribution of the bulk electrons from that of the quasi-two-dimensional electron gas (Q2DEG), not only as far as the Hall sheet electron concentration, n_H, is concerned but also the Hall mobility, μ_H. However, the determination of the Q2DEG concentration and mobility, is an essential parameter for all these high-speed devices. Although experimental results on the mobility of the Si-doped bulk AlGaAs have been reported, there is a lack of such reports for the mobility of the Q2DEG. Only recently Schacham et al presented an experimental technique to separate the Q2DEG from the bulk contribution at room temperature.
Here, we present a quantitative analysis to interpret the temperature dependence of the Q2DEG sheet electron concentration versus the bulk sheet electron concentration, taking into account the fact that in the Si-doped Al$_x$Ga$_{1-x}$As two types of donors coexist, i.e. deep and shallow, which independently, and by different mechanisms, provide electrons to the bulk Al$_x$Ga$_{1-x}$As different conduction band minima (Γ, L, X) and to the Q2DEG. We calculate the electronic states, the ionized- donor concentrations, the Q2DEG and the bulk electron concentrations and the corresponding mobilities as a function of temperature. Our numerical results are in very good agreement with the experimental data.

A3) On the temperature dependence of the electronic states and the mobility in AlGaAs/GaAs heterostructures

C. D. Simserides and G. P. Triberis

Heterocitations 3, From collaborators 2
Proceedings of ICSMM-7 (7th International Conference on Superlattices, Microstructures and Microdevices)

Experiment shows that in AlGaAs/GaAs heterostructures the sheet electron concentration remains almost constant up to a certain temperature, while it increases at higher temperatures. We attempt an interpretation of this temperature dependence, taking into account the fact that in the bulk n-AlGaAs deep and shallow donors exist, which independently and by different mechanisms provide electrons to the different conduction band minima of the bulk n-AlGaAs, and contribute to the formation of the Q2DEG. We calculate the electronic states of this structure, the Q2DEG and the bulk concentrations, and the corresponding mobilities as a function of temperature. Our numerical results are in an excellent agreement with experimental data.

A2) Comments on the efficiency of Selectively-Doped Double-Heterojunction Structures

C. D. Simserides and G. P. Triberis

Heterocitations 1, From collaborators 2

We present the form of the electron concentration during the transition from a “perfect” square well to a system of “two separated heterojunctions”, in Selectively Doped Double Heterojunction structures. We also present a cartography of the surface $N_s = N_s(N_d,D_s)$, that is, of the dependence of the sheet electron concentration, $N_s$, from the doping concentration, $N_d$ and the spacer thickness, $D_s$. We project the iso-$N_s$ curves on the ($N_d,D_s$) plane. The iso-$N_s$ map allows us to choose the most suitable combination of the ($N_d,D_s$) values to obtain the desired $N_s$.

A1) A systematic study of electronic states in n-Al$_x$Ga$_{1-x}$As/GaAs/n-Al$_x$Ga$_{1-x}$As selectively-doped double-heterojunction structures

C. D. Simserides and G. P. Triberis,

Heterocitations 18, From collaborators 4

The electron concentration, the wavefunctions and the energy levels of a n-Al$_x$Ga$_{1-x}$As/GaAs/n-Al$_x$Ga$_{1-x}$As double heterojunction are evaluated by solving Schroedinger and Poisson equations self-consistently. We investigate, at zero temperature, the dependence of the sheet electron concentration, and the subband populations on the well width, spacer thickness and doping concentration, for Al mole fraction x = 0.3. We give physical interpretations to some interesting characteristics observed. The transition from a “perfect” square well to a system of “two separated heterojunctions” is systematically studied. Our results are in excellent agreement with previous experiments.
B. Books (3), and
Invited Chapter (Monograph) in a Book (1)
Invited Review Article with referees (1)

B5) BOOK:
(States of Matter, Constantinos Simserides) Αθήνα 2015 (Athens 2015)
271 pages
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B4) BOOK:
(Quantum Optics and Lasers, Constantinos Simserides) Αθήνα 2015 (Athens 2015)
324 pages
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Eudoxus ID: 320166
One of the suggested textbooks of Courses
[2] “Special Topics on Physics”, Technological Education Institute of Piraeus, Department of Mechanical Engineering

B3) INVITED REVIEW ARTICLE with referees:
“Near-Field Optical Properties of Quantum Dots, Applications and Perspectives”
Recent Patents on Nanotechnology 5 (2011) pp. 188-224 (ISSN: 1872-2105)
Bentham Science Publishers
A. Zora, G. P. Triberis, C. Simserides
Heterocitations 9
Abstract:
Recent years have witnessed tremendous research in quantum dots as excellent models of quantum physics at
the nanoscale and as excellent candidates for various applications based on their optoelectronic properties. This
review intends to present theoretical and experimental investigations of the near-field optical properties of these
structures, and their multimodal applications such as biosensors, biological labels, optical fibers, switches and
sensors, visual displays, photovoltaic devices and related patents.
Book Description:
Under the influence of different external stimuli condensed matter reveals its magnificent properties. The electric field, the temperature, the concentration gradients and the light are the basic "forces" responsible for processes such as the electrical, the thermal, the diffusion transport or optical phenomena. The action of the magnetic field brings about the galvanomagnetic or the thermomagnetic effects.

New alloy semiconductors and the development of artificial semiconductor heterostructures led to the confinement of carriers in two, one or zero dimensions, opening a new window in condensed matter research.

The application of a perpendicular magnetic field upon two-dimensional carriers, led to the discovering of astonishing phenomena, namely, the integer or the fractional quantum Hall effects and inspired radical theoretical interpretations.

The reduced symmetry of low dimensional structures enhances decisively the role of the magnetic field orientation, bringing to light novel and unexpected phenomena. In the present book the effect of the application of an in-plane magnetic field upon low dimensional carriers, giving rise to impressive novel phenomena, is presented and discussed.

Specifically, whenever a quantum well is subjected to an in-plane or tilted magnetic field, the elegant concept of Landau levels must be modified, because the carriers move under the competing influence of the Lorentz force and the force due to the quantum well confining potential. Under these conditions, the equal-energy surfaces or equivalently, the density of states (DOS), are qualitatively and quantitatively modified. The DOS diverges significantly from the ideal step-like two-dimensional carrier form.

The book discusses various physical properties which are affected by the DOS modification.

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B1) INVITED CHAPTER in the BOOK:
"Quantum Wells: Theory, Fabrication and Applications",
Editors: Alfred Ruyter and Harper O'Mahoney, Pub. Date: 2009, Pages: pp.540
Chapter title: “Quantum wells under in-plane magnetic field: Density of states and novel phenomena in thermodynamic properties, magnetization and spin-
polarization.” Pages 37.

**Author:** C. Simserides*

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- Preface
- Photodectors Based on Quantum-Well Structures: Theory, Properties and Novel Concepts (Carlos Rivera, ISOM and Dpto. Ingenieria Electronica, ETSI de Telecommunicacion, Univ. Politecnica de Madrid, Ciudad Univ., Madrid, Spain)
- Recent Developments of PbSe-Based IV-VI Semiconductor Quantum Well Structures (Shaibal Mukherjee, Shelly L. Elizondo, Lee A. Elizondo, Zhisheng Shi, Univ. of Oklahoma, Norman, OK)
- Coupled Quantum Well Structures (LiLi Yang, Q.X. Zhao, and M. Willander, Dept. of Science and Technology (ITN), Campus Norrkoping, Linkoping Univ., Norrkoping, Sweden)
- Collective Electronic Excitations in Systems Exhibiting Quantum Well States (Antonio Politano, Univ. degli Studi della Calabria, Dipartimento di Fisica, Rende, Italy)
- Magneto-Optical Study of Semimagnetic Single and Double Quantum Well Structures based on Cd(Mn)Se/CdMgSe Material System (I.I. Reshina, S.V. Ivanov, Ioffe Physical Technical Institute, Russian Academy of Sciences, St. Petersburg, Russia)
- Optical Gain in InGaAsN Quantum Well Structures. Summary of Various Approaches (M.S. Wartak, Dept. of Physics and Computer Science, Wilfrid Laurier Univ., Waterloo, Ontario, Canada)
- Magnetoexciton Dispersion in GaAs - (Ga, Al) As Single and Coupled Quantum Wells (Z.G. Koinov, St. Petersburg Electrotechnical University, Russia)
- Bonding and Antibonding States in Natural Molecules and Double Quantum Wells (R. Gutierrez, Centro de Investigaciones, A. Castaneda, Centro de Investigaciones, Dept. de Fisica, Univ. Antonio Narino, Bogota, Colombia)
- Spin Slitting in Modulation-Doped Semiconductor Quantum Wells (U. Ekenberg and D.M. Gvozdi, School of Information and Communication Technology, Royal Institute of Technology, Kista, Sweden, Faculty of Electrical Engineering, Univ. of Belgrade, Belgrade, Serbia)
- Infinite Quantum Well: On the Quantization Problem (P. L. Garcia de Leon, J. P. Gazeau, D. Gitman and J. Queva, (Laboratoire Astroparticules et Cosmologie, Universite Paris Diderot Paris, Paris Cedex 13 France, Universite Paris Est - Institut Gaspard Monge (IGM-LabInfo), 5 Bd. Descartes, Champs-sur-Marne, Marne-la-Vallee Cedex 2, France, Instituto de Fisica, Universidade de Sao Paulo, Caixa Postal Sao Paulo, SP, Brazil)
- Elementary Excitations in Artificially Disordered Electron Systems: Random Multi-layers (Yu A. Pusep, Instituto de Fisica de Sao Carlos, Univ. de Sao Paulo, Carlos, SP, Brazil)
- Quantum Wells Under In-Plane Magnetic Field: Density of States and Novel Phenomena in Thermodynamic Properties, Magnetization and Spin-Polarization (Constantinos Simserides, Institute of Materials Science, National Center of Scientific Research Demokritos, Athens, Greece)
- Short Communication: Effects of Weak Magnetic Field on Rashba Spin Orbit Interaction in Spin Dependent Resonant Transmission in A ZeSe/Zn1-xMnxSe Heterostructure (A. John Peter, Govt. Arts College, Melur, India)

**Heterocitations to the book as a whole 2**
C. Publications in International Conference proceedings with editorial-type refereeing and/or referees (21)

C21) Frequency Content of Carrier Oscillations along B-DNA Polymers
K. Lambropoulos, M. Mantela, C. Simserides*
Volume 2018-November, 2018, Pages 186-193. DOI: 10.1109/PIERS-FALL.2017.8293134
URL: http://ieeexplore.ieee.org/stamp/stamp.jsp?tp=&arnumber=8293134&isnumber=8293079

We study the frequency content of an extra carrier oscillation along characteristic periodic B-DNA polymers made of $N$ monomers. We employ two variants of the Tight-Binding approach, a wire model and an extended ladder model including diagonal hoppings. In the former, the site is a monomer, i.e., a base pair, while, in the latter, the site is a base. Initially, we focus on the Fourier Spectra of the probabilities to find the extra carrier at each monomer, having placed it at time zero at a specific monomer. Using the Fourier amplitude of each component of the frequency spectrum, we define the *weighted mean frequency* (WMF) for each site, a measure of its frequency content. To obtain a measure of the overall frequency content of carrier oscillations in the polymer, we define the *total weighted mean frequency* (TWMF), averaging the WMFs of all sites weighting over the probabilities of finding the extra carrier at each site. The frequency content is generally in the THz domain. Finally, we also give an example of an aperiodic sequence, the (A,T) Cantor dust.

C20) THz oscillations in DNA monomers, dimers and trimers
36th PIERS (Progress in Electromagnetics Research Symposium) Proceedings, 6-9 July 2015, Prague, pp 879-883

We call *monomer* a B-DNA base-pair and study electron or hole oscillations in *monomers, dimers and trimers*. We employ two Tight Binding (TB) approaches: (I) at the base-pair level, using the on-site energies of the base-pairs and the hopping parameters between successive base-pairs and (II) at the single-base level, using the on-site energies of the bases and the hopping parameters between neighboring bases. With (I), for monomers, we predict oscillations with frequency $f \approx 50$-550 THz. With (II), for dimers, we predict oscillations with $f \approx 0.25$-100 THz, for trimers made of identical monomers $f \approx 0.5$-33 THz. In other cases, the oscillations may be not strictly periodic, but Fourier analysis shows similar frequency content. For dimers, we compare approaches (I) and (II). Finally, we present calculations with (III) *Real-Time Time-Dependent Density Functional Theory* (RT-TDDFT) for the adenine-thymine (A-T) and the guanine-cytosine (G-C) base-pairs. It seems that a non conventional source or receiver of electromagnetic radiation with $f$ from fractions to THz to just below PHz could be envisaged.

C19) Theory of ferromagnetism driven by superexchange in dilute magnetic semiconductors
C. Simserides*, J.A. Majewski, K.N. Trohidou, T. Dietl
European Physical Journal Web of Conferences 75, 01003 (2014)
http://dx.doi.org/10.1051/epjconf/20147501003
doi: 10.1051/epjconf/20147501003
On the occasion of JEMS 2013, Rhodes, Greece
Hetero citations 5, From Collaborators 1

Magnetic properties of Ga$_{1-x}$Mn$_x$N are studied theoretically by employing a tight binding approach to determine exchange integrals $J_i$ characterizing the coupling between Mn spin pairs located at distances $R_{ij}$ up to the 16th cation coordination sphere in zinc-blende GaN. It is shown that for a set of experimentally determined input parameters there are no itinerant carriers and the coupling between localized Mn$^{3+}$ spins in GaN proceeds via superexchange that is ferromagnetic for all explored $R_{ij}$ values. Extensive Monte Carlo simulations serve to evaluate the magnitudes of Curie temperature $T_C$ by the cumulant crossing method. The theoretical values of $T_C(x)$ are in quantitative agreement with the experimental data that are available for Ga$_{1-x}$Mn$_x$N with randomly distributed Mn$^{3+}$ ions with the concentrations 0.01 $\leq x \leq$ 0.1.


C18) “Temperature dependence of the emission spectra of individual self-assembled quantum dots”
A. Zora, C. Simserides and G. P. Trubets
On the occasion of Quantum Dot 2010

We have developed a quantum-mechanical theory for the interaction of light and electron-hole excitations in semiconductor quantum dots. Our theoretical analysis results in an expression for the photoluminescence intensity in the non-linear regime. The validity of the theoretical results is tested analyzing experimental data
reported for the temperature dependence of the emission spectra of an individual lens-shaped In0.4Ga0.6As self-assembled quantum dot in a wide temperature range up to 300 K. Our theoretical predictions for the redshift of the emission peak with increasing temperature, in the range 2-300 K, agree with the experiment.

**C17** “Effects of Detuning on Control of Intersubband Quantum Well Transitions with Chirped Electromagnetic Pulses”  
K. Blekos, C. Simserides, A. F. Terzis, E. Paspalakis  

We study the interaction of a chirped electromagnetic pulse with intersubband transitions of a double semiconductor quantum well. We specifically consider the interaction of the ground and first excited subbands with the electromagnetic field and use the nonlinear density matrix equations for the description of the system dynamics. These equations are solved numerically for various values of the electron sheet density for a realistic double GaAs/AlGaAs quantum well, and the efficiency of population transfer is discussed with emphasis given to the effects of the detuning of the central frequency of the electromagnetic field from resonance.

**C16** “Magneto-optics of quantum dots in the near field”  
C. Simserides*, A. Zora, G. Triberis  
doi: 10.1142/S0217979207043361  
Proceedings of the 17th International Conference on High Magnetic Fields in Semiconductor Physics  
Heterocitations 1

We examine a quantum dot (QD) illuminated in the near field with sub-wavelength spatial resolution, while simultaneously it is subjected to a magnetic field of variable orientation and magnitude. The magnetic field orientation can conserve or destroy the zero-magnetic-field (“structural”) symmetry. The asymmetry induced by the magnetic field – except for specific orientations along symmetry axes - can be uncovered in the near-field (NF) but not in the far-field (FF) spectra. We predict that NF magneto-absorption experiments of realistic spatial resolution could reveal the QD symmetry. This exceptional symmetry-resolving power of the near-field optics, is lost in the far field.

**C15** “Controlled Intersubband Population Dynamics in a Semiconductor Quantum Well”  
E. Paspalakis, C. Simserides, A. F. Terzis  
Heterocitations 1

We examine the intersubband transition dynamics of a single semiconductor quantum well when the ground and the first excited subbands are coupled by strong electromagnetic fields, with emphasis given to controlled intersubband population inversion. The system dynamics is described by the nonlinear density matrix equations that include the effects of electron electron interactions. We present analytical results for the electromagnetic field that can lead to high-efficiency population inversion in the system. The validity of the analytical results is tested with numerical solutions of the density matrix equations for various values of the electron sheet density for a realistic GaAs/AlGaAs quantum well.

**C14** “Near-field magneto-optics of quantum dots”  
A. Zora, C. Simserides*, G. Triberis  
28th International Conference on the Physics of Semiconductors, Vienna, Austria, July 24-28 2006

Encouraged by the latest experimental developments as well as by the theoretical interest on the near-field (NF) optics of semiconductor quantum dots (QDs), we present our most recent theoretical results on the NF optical absorption and photoluminescence (PL) of single and coupled III-V QDs subjected additionally to an external magnetic field of variable orientation and magnitude. The zero-magnetic-field “structural” QD symmetry can be destroyed varying the magnetic field orientation. The asymmetry induced by the magnetic field - except for specific orientations along symmetry axes - can be uncovered in the near-field but not in the far-field spectra. Hence, we predict that NF magnetoabsorption experiments, of realistic spatial resolution, will be in the position to bring to light the QD symmetry.

**C13** “The effect of a categorical discrimination task on the auditory M100 peak latency”  
R. König, C. Sielużycki, C. Simserides, H. Scheich,  
Proceedings of BIOMAG 2006 (15th International Conference on Biomagnetism)

Heterocitations 1

The rationale of this magnetoencephalographic (MEG) study was the quest for temporal aspects of the fMRI-characterized hemispheric asymmetries of auditory cortex functions during the processing of simple linearly frequency-modulated (FM) tones. We searched for parameters which distinguish a stimulus-related task condition—the categorical discrimination of direction (upward versus downward) of frequency modulation—from mere exposure to the same FM tones. We found that the M100-peak latency after FM tones was significantly shorter in the task condition than in the exposure condition, in the left but not in the right hemisphere.

C12) “High temperature electrical conductivity due to small polaron hopping motion in DNA molecules”
G. P. Triberis, V. C. Karavolas and C. D. Simserides
doi: 10.1088/1742-6596/10/1/052
Proceedings of the 2nd Conf. on Microelectronics, Microsystems and Nanotechnology 2004

Heterocitations 2

We present a small polaron hopping model to interpret the high-temperature electrical conductivity measured along the DNA molecules. The model takes into account the one-dimensional character of the system and the presence of disorder in the DNA double helix. The experimental data for the lambda phage DNA (A-DNA) and the poly(dA)-poly(dT) DNA follow nicely the theoretically predicted behavior leading to realistic values of the maximum hopping distances supporting the idea of multiphonon-assisted hopping of small polarons between next nearest neighbors of the DNA molecular "wire".

C11) “Spin-polarization and magnetization of conduction-band dilute-magnetic-semiconductor quantum wells with non-step-like density of states”
C. Simserides*
doi: 10.1088/1742-6596/10/1/035
Proceedings of the 2nd Conf. on Microelectronics, Microsystems and Nanotechnology 2004

We study the magnetization, \( M \), and the spin polarization, \( \zeta \), of n-doped non-magnetic-semiconductor (NMS) / narrow to wide dilute-magnetic-semiconductor (DMS) / n-doped NMS quantum wells, as a function of the temperature, \( T \), and the in-plane magnetic field, \( B \). Under such conditions the density of states (DOS) deviates from the occasionally stereotypic step-like form, both quantitatively and qualitatively. The DOS modification causes an impressive fluctuation of \( M \) in cases of vigorous competition between spatial and magnetic confinement. At low \( T \), the enhanced electron spin-splitting, \( U_{\infty} \), acquires its bigger value. At higher \( T \), \( U_{\infty} \) decreases, augmenting the influence of the spin-up electrons. Increasing \( B \), \( U_{\infty} \) increases and accordingly electrons populate spin-down subbands while they abandon spin-up subbands. Furthermore, due to the DOS modification, all energetically higher subbands become gradually depopulated.

C10) “Temperature dependent magnetization and magnetic phases of conduction-band dilute-magnetic-semiconductor quantum wells with non-step-like density of states”
C. Simserides*
ICPS27 (27th International Conference on the Physics of Semiconductors) proceedings published by AIP

We investigate the magnetization of II-VI non-magnetic-semiconductor (NMS) / narrow to wide dilute-magnetic-semiconductor (DMS) / NMS quantum wells. These structures are appropriate for conduction-band spintronics. We employ an in-plane magnetic field, \( B \), in order to induce non-step-like density of states. Finally, we tune the spin polarization by varying the temperature, \( T \), and \( B \), i.e. we investigate the magnetic phases of these NMS/DMS/NMS structures.

C9) “Do stimuli or tasks determine lateralized auditory cortex responses? An MEG study”
C. Sielużycki, R. König, C. Simserides, H. Scheich
International Journal of Bioelectromagnetism, IJBEM 7 (2005) 185-188
[Proceedings of the Joint Meeting of 5th International Conference on Bioelectromagnetism and 5th International Symposium on Noninvasive Functional Source Imaging within the Human Brain and Heart (BEM & NFSI), University of Minnesota, Twin Cities campus in Minneapolis, Minnesota, USA, 12-15/5/2005].

We studied hemispheric differences of the evoked magnetic fields induced by frequency modulated tones (FMs) and pure sinusoidal tones, by means of magnetoencephalography (MEG). Seven subjects were exposed to three conditions: 1) passive listening to sinusoidal 1 kHz tones (sin-e-exposure condition), 2) passive listening to linear FMs (FM-exposure condition), and 3) directional categorization (up versus down) of FMs (FM-task condition).
The underlying question was whether different stimuli determine the hemispheric activation of auditory cortex, or rather the task performed by the subjects. With binaural presentation we observed an N100m-latency difference between hemispheres for FMs and a smaller difference for sinusoidal tones. The right-hemispheric response to FMs was faster than the left one, both during task end exposure. We also observed different frequency content of the raw (non-averaged) data recorded for the three different conditions. Specifically, the FM-task condition produced a distinct spectral content compared to the two exposure conditions with tones and FMs, which induced a similar spectral pattern.

C8) “Near field spectroscopy of quantum dots under magnetic field”
A. Zora, C. Simserides* and G. Triberis
doi: 10.1142/S0217979204027347
We present the basic steps for the study of the linear near field absorption spectra of semiconductor quantum dots under magnetic field of variable orientation. We show that the application of the magnetic field alone is sufficient to induce -increasing the spot illuminated by the near field probe- interesting features to the absorption spectra.

C7) “Magnetization and magnetic phases of conduction-band dilute-magnetic-semiconductor quantum wells with non-step-like density of states”
C. Simserides*
doi: 10.1142/S0217979204027384
We study the magnetization and the magnetic phases of II-VI-based n-doped non-magnetic-semiconductor (NMS) / narrow to wide dilute-magnetic-semiconductor (DMS) / n-doped NMS quantum wells under in-plane magnetic field. The parallel magnetic field is used as a tool, in order to achieve non-step-like density of states in these -appropriate for conduction-band spintronics- structures.

C6) “An MEG study of directional categorization of frequency-modulated tones”
C. Simserides*, R. König, and H. Scheich
Proceedings of the 14th International Conference on Biomagnetism (BIOMAG 2004),

C5) “Task-dependent activation of the auditory cortex by frequency-modulated tones: an MEG study”
C. Simserides*, R. König, and H. Scheich
Biomedizinische Technik 48 (2004) 205-207 (with referee)
Proceedings of NFSI-2003 (4th International Symposium on Noninvasive Functional Source Imaging)
Frequency modulations (FM) play a fundamental role in human speech and likewise in animal vocalization. Moreover, interest in the activation pattern of the human auditory cortex in response to FM tones is due to the fact that processing of FM tones as well as of speech prosodies may be based on common auditory mechanisms. The aim of this study is to provide information about the processing of FM tones as well as the dependence of the corresponding cortical activation on a directional decision task. This is achieved by the use of the MEG technique that, unlike fMRI, is capable of tracking brain dynamics with an unequalled high temporal resolution in the millisecond range along with a yet satisfying spatial resolution.

C4) “Auditory Cortex Response to Frequency-Modulated Tones Investigated with MEG”
R. König, C. Simserides, and H. Scheich

C3) “Conduction band narrow to wide Diluted Magnetic Semiconductor layers under in-plane magnetic field: not step-like Density of States and consequences”
C. Simserides*
(11th International Conference on Modulated Semiconductor Structures, Nara, Japan, 14-18 July 2003)

C2) “Local optical absorption by confined excitons in single and coupled quantum dots”
C. Simserides*, U. Hohenester, G. Goldoni and E. Molinari
“Electronic properties of n-Al_xGa_{1-x}As/GaAs/n-Al_{1-x}Ga_xAs double heterojunctions”

C. D. Simserides and G. P. Triberis
D. Topical conference proceedings or international schools proceedings (8)

In the following list extended or simple abstracts are not included.

D8) K. Lambropoulos, K. Kaklamanis, G. Georgiadis, and C. Simserides, Charge oscillations in the mid-to-far infrared and charge transfer in DNA, 9th Conference of the Hellenic Society for Computational Biology and Bioinformatics (HSCBB14), Agricultural University of Athens in 10-12 October 2014


D5) V. Piazza, C. D. Simserides, W. Wegscheider and F. Beltram, Changing the density of states and the magnetoresistance of double heterojunctions by an in-plane magnetic field, Advanced Materials for Industrial Applications. International summer school organized by the Physics Dept. of the Aristotle University of Thessaloniki, Kavala (20-27/6/1999)


D2) C.D. Simserides and G.P. Triberis, Temperature dependence of the electronic states and the mobility in AlGaAs/GaAs heterostructures, 10th Panhellenic Conference of Solid State Physics, September 1994, Delfi. Proceedings of X ΠΣΦΣΚ.


E. Publications in popular science magazines (1)

We use self-consistent numerical calculations to study the sheet electron concentration and the mobility as functions of the doping concentrations, the spacer thickness, the well width and the Al mole fraction of selectively doped Al$_x$Ga$_{1-x}$As/GaAs/Al$_x$Ga$_{1-x}$As double heterojunctions, using no restrictive, a priori, assumptions. For the first time we take into account two kinds of donors (shallow and deep) that coexist in the Si-doped Al$_x$Ga$_{1-x}$As. We study all the significant scattering mechanisms. The model, based exclusively upon the knowledge of the material and structural parameters involved, allows us to obtain the maximum conductivity for any specific structure. The transition from a “perfect square quantum well” to a system of “two separated heterojunctions” is systematically studied. We also present a quantitative analysis of the temperature dependence of the quasi-two-dimensional electron concentration taking into account that in the Si-doped Al$_x$Ga$_{1-x}$As shallow and deep donors coexist. These donors provide electrons not only to the quasi-two-dimensional electron gas but also to the different conduction band minima of the bulk Al$_x$Ga$_{1-x}$As.

Our numerical results are in very good agreement with the experiment.
ΣΧΕΔΙΑΓΡΑΜΜΑ ΔΙΔΑΚΤΟΡΙΚΗΣ ΔΙΑΤΡΙΒΗΣ
tου Κωνσταντίνου Σιμσερίδη

«Ηλεκτρονιακές καταστάσεις και ευκινησία
eπιλεκτικά εμπλουτισμένων ετεροδομών AlₓGa₁₋ₓAs/GaAs/AlₓGa₁₋ₓAs»

Κεφάλαιο Α : Εισαγωγή.
Α1. Εισαγωγή στη Φυσική των Διατάξεων Ημιαγωγών.
Α2. Θεώρημα Slater (Εξίσωση Περιβάλλουσας Συναρτήσεως) και συνέπειες.
Α3. Από την εξ. Schrödinger μέσω της Προσέγγισης Ενεργού Μάζας στην εξίσωση Ενεργού Μάζας.
Α4. Εφαρμογή της εξίσωσης BenDaniel-Duke.

Κεφάλαιο Β. Ηλεκτρονιακές καταστάσεις διπλής ετεροεπαφής σε θερμοκρασία Τ = 0Κ.
Β1. Εισαγωγή.
Β2. Περιγραφή του συστήματος.
Β3. Θεωρητικοί υπολογισμοί.
Β4. Αποτελέσματα.

Κεφάλαιο Γ. Θερμοκρασιακή εξάρτηση των ηλεκτρονιακών καταστάσεων.
Γ1. Εισαγωγή.
Γ2. Μορφοποίηση του προβλήματος.
Γ3. Εφαρμογή σε ετεροδομή.
Γ4. Αποτελέσματα και συζήτηση.

Κεφάλαιο Δ. Γενική Θεωρία Μεταφοράς. Ευκινησία των ηλεκτρονίων και αγωγιμότητα της δομής.
Δ1. Εισαγωγή στη μελέτη της ηλεκτρονιακής ευκινησίας.
Δ2. Γενική Θεωρία Μεταφοράς - Εξίσωση Boltzmann.
Δ3. Γενική Θεωρία Μεταφοράς - Ευκινησία Υποζώνης και Ευκινησία Δομής.

Κεφάλαιο Ε. Θωράκιση Ψευδο-Διδιαστάτου Αερίου Ηλεκτρονίων.
Ε1. Γενική Θεωρία (μία υποζώνη στο πηγάδι). Αποτελέσματα.
Ε2. Σύγκριση αποτελεσμάτων TF-RPA.
Ε3. Γενική Θεωρία (πολλές υποζώνες στο πηγάδι).
Ε4. Αποτελέσματα με πολλές υποζώνες στο πηγάδι.

Κεφάλαιο ΣΤ. Αταξία Κράματος.
ΣΤ1. Εισαγωγή στη σκέδαση από αταξία κράματος.
ΣΤ2. Στοιχεία πίνακα.
ΣΤ3. Μία υποζώνη στο πηγάδι.
ΣΤ4. Πολλές υποζώνες στο πηγάδι.
ΣΤ5. Σκέδαση από αταξία κράματος. Αποτελέσματα.

Κεφάλαιο Ζ. Ιονισμένοι Δότες.
Ζ1. Εισαγωγή στη σκέδαση από ιονισμένους δότες.
Ζ2. Στοιχεία πίνακα.
Ζ3. Μία υποζώνη στο πηγάδι.
Κεφάλαιο Η. Τραχύτητα Ενδοεπιφάνειών.
Η1. Εισαγωγή στη σκέδαση λόγω τραχύτητας ενδοεπιφάνειων.
Η2. Στοιχεία πίνακα.
Η3. Μία υποζώνη στο πηγάδι.
Η4. Σκέδαση λόγω τραχύτητας ενδοεπιφάνειων. Αποτελέσματα.

Κεφάλαιο Θ. Ακουστικά Φωνόνια και αποτελέσματα με όλους τους μηχανισμούς σκέδασης.
Θ1. Εισαγωγή στη σκέδαση από ακουστικά φωνόνια.
Θ2. Στοιχεία πίνακα.
Θ3. Μία υποζώνη στο πηγάδι.
Θ4. Αποτελέσματα με όλους τους μηχανισμούς σκέδασης.

Παραρτήματα
Π1 Απόδειξη του θεωρήματος Slater.
Π2 Η πυκνότητα ιδιοκαταστάσεων σε κβαντικό πηγάδι δυναμικής ενέργειας \( U(f) = U(z) \).
Π3 Η πυκνότητα ιδιοκαταστάσεων σε κβαντικό πηγάδι δυναμικής ενέργειας \( U(z) \).
Π4 Η χωρική πυκнότητα κεταλημένων καταστάσεων σε θερμοκρασία Τ.
Π5 Απόδειξη της σχέσης (Δ2.14).
Π6 Εξαγωγή της ανάλογης σχέσης με την εξ.(Δ3.6) στις 3 διαστάσεις.
Π7 Η θερμοκρασιακή εξάρτηση της πολωσιμότητας.
Π8 Τα στοιχεία πίνακα για τη σκέδαση από αταξία κράματος.
Π9 Απόδειξη της σχέσης (Π9.1).
Π10 Τα στοιχεία πίνακα για τη σκέδαση από ιονισμένους δότες.

Αναφορές