ΑΝΑΛΥΤΙΚΟ ΥΠΟΜΝΗΜΑ ΔΗΜΟΣΙΕΥΣΕΩΝ

Phoonix

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Morphology-dependent resonances in a large dielectric sphere: An asymptotic calculation using local coordinates (1993)

In this dissertation, an asymptotic calculation for the electromagnetic fields, at frequencies near low order high-Q morphology-dependent resonances in a large dielectric sphere, is presented. Employing local coordinates in the radial and angular directions, the present method takes advantage of the special field distribution within the sphere.

Closed-form formulas for the resonant frequencies are derived. The results turn out to be consistent with the exact Mie solution, with a relative error of a small fraction of a percent.

In addition, the approach employed here, renders more physical insight and simplifies the results of the conventional Mie Theory. The more interesting part of this method is that it does not require the knowledge of the exact solution to the entire problem and can be extended to fully nonlinear cases.

Πρόκειται για μία εξ' ολοκλήρου αναλυτική εργασία που εντάσσεται στην Οπτική Φυσική υγρών μικροσωματιδίων, όπου με τη μέθοδο τοπικών συντεταγμένων το ηλεκτρομαγνητικό πρόβλημα της σκέδασης Mie σε μία διηλεκτρική σφαίρα απλουστεύεται σε μία αναλυτική σχέση υπολογισμού των συντονισμών Mie για τις δύσκολες περιπτώσεις με μήκος κύματος της ΗΜ ακτινοβολίας πολύ μικρότερο του σκεδαστή (περίπου 1% της διάστασης της διηλεκτρικής σφαίρας). Η μέθοδος αυτή σε πολλά σημεία θυμίζει τη μέθοδο inverse-WKB, που χρησιμοποιείται στην μη-γραμμική κβαντική οπτική, αλλά ακολουθεί τη δική της ιδιαίτερη παραμετροποίηση. Παρόμοιες σχέσεις, την ίδια χρονική περίοδο, εμφανίστηκαν μετά στη διεθνή βιβλιογραφία αλλά με λιγότερη ακρίβεια και κυρίως χωρίς την ανάλογη αιτιολογία των φυσικών φαινομένων που οδήγησαν στο αποτέλεσμα της αναλυτικής σχέσης που παρουσιάζεται στη διατριβή. Επίσης η μέθοδος είναι έτοιμη για την περιγραφή μη-γραμμικών οπτικών φαινομένων.

Μέχρι και σήμερα η αναλυτική σχέση αυτή χρησιμοποιείται μέσω ειδικού software για τους συντονισμούς Mie που χρησιμοποιούν στις συσκευές τους στο Microparticle Photophysics Lab (MP^3L) του NYU Polytechnic Institute για την οπτική μελέτη υγρών και αερίων (aerosol) μικροσωματιδίων για βιολογικές και περιβαλλοντικές εφαρμογές. Ιδιαίτερα όμως χρησιμοποιείται για τη βαθμονόμηση συσκευών στις τεχνικές laser-burning και dye-fluorescence.

Δημοσιευμένες Εργασίες σε επιστημονικά περιοδικά με κριτές (19)

A01. I. E. Psarobas and K. M. Leung: *Morphology-dependent resonances in a large dielectric sphere: An asymptotic calculation using local coordinates*, Phys. Rev. A **46**, 2111-2116 (1992).

An asymptotic calculation for the electromagnetic fields at frequencies near low-order high-Q morphology-dependent resonances in a large dielectric sphere is reported. Employing local coordinates in the radial and angular directions, our method takes advantage of the special field distribution within the sphere. Closed-form formulas for the resonance frequencies are derived. Our results turn out to be identical with those obtained in recent independent studies in which these formulas are extracted from Mie's exact solution. Our method is interesting in that it does not require the knowledge of the exact solution to the entire problem and can be extended to fully nonlinear cases.

A02. I. E. Psarobas, N. Stefanou, and A. Modinos: *Photonic crystals of chiral spheres*, J. Opt. Soc. Am. A **16**, 343-347 (1999). Ετεροαναφορές (**10**)

We examined the properties of photonic crystals that consist of nonoverlapping chiral spheres in a dielectric medium. We considered the effect of the chiral property of the spheres on the frequency band structure of the electromagnetic field in the crystal and on the transmittance properties of a slab of the crystal, and we estimated the optical activity of the crystal.

A03. I. E. Psarobas: *Effective-medium description of dielectric-chiral photonic crystals*, Opt. Commun. **162**, 21-25 (**1999**). Ετεροαναφορές (**4**)
Using exact results of the properties of photonic crystals consisting of chiral spheres in conjunction with an existing Maxwell–Garnett-like model for chiral composites we examine the possibility of describing such a crystal as a homogeneous
chiral entity.

A04. I. E. Psarobas, N. Stefanou, and A. Modinos: *Scattering of elastic waves by periodic arrays of spherical bodies*, Phys. Rev. B **62**, 278-291 (**2000**). Ετεροαναφορές (**0.1**)
We develop a formalism for the calculation of the frequency band structure of a phononic crystal consisting of nonoverlapping elastic spheres, characterized by Lamé coefficients which may be complex and frequency dependent, arranged periodically in a host medium with different mass density and Lamé coefficients. We view the crystal as a sequence of planes of spheres, parallel to and having the two-dimensional periodicity of a given crystallographic plane, and obtain the complex band structure of the infinite crystal associated with this plane. The method allows one to calculate, also, the transmission, reflection, and absorption coefficients for an elastic wave (longitudinal or transverse) incident, at any angle, on a slab of the crystal of finite thickness. We demonstrate the efficiency of the method by applying it to a specific example.

A05. I. E. Psarobas, N. Stefanou, and A. Modinos: *Phononic crystals with planar defects*, Phys. Rev. B **62**, 5536-5540 (**2000**). Ετεροαναφορές (**52**)
We study the effect of planar defects in phononic crystals of spherical scatterers. It is shown that a plane of impurity spheres introduces modes of vibration of the elastic field localized on this plane at frequencies within a frequency gap of a pure phononic crystal; these show up as sharp resonances in the transmittance of elastic waves incident on a slab of the crystal. A periodic arrangement of impurity planes along a given direction creates narrow impurity bands with a width which depends on the position of these bands within the frequency gap of the pure crystal and on the separation between the impurity planes. We show how a slight deviation from periodicity (one impurity plane is different from the rest) reduces dramatically the transmittance of elastic waves incident on a slab of the crystal.

A06. A. Modinos, N. Stefanou, I. E. Psarobas, V. Yannopapas: *On wave propagation in inhomogeneous systems*, Physica B **296**, 167-173 (**2001**). Ετεροαναφορές (**24**)
We present a theory of electron, electromagnetic, and elastic wave propagation in systems consisting of nonoverlapping scatterers in a host medium. The theory provides a framework for a uni»ed description of wave propagation in three-dimensional periodic structures, finite slabs of layered structures, and systems with impurities: isolated impurities, impurity aggregates, or randomly distributed impurities. We point out the similarities and differences between the different cases considered, and discuss the numerical implementation of the formalism.

A07. I. E. Psarobas: *Viscoelastic response of sonic band-gap materials*, Phys. Rev. B **64**, art. no. 012303 (**2001**). Ετεροαναφορές (**12**)
The effect of viscoelastic losses in a high-density contrast sonic band-gap material of close-packed rubber spheres in air is discussed. The scattering properties of such a material are computed with an on-shell multiplescattering method, properties which are compared with the lossless case. The existence of an appreciable omnidirectional gap in the transmission spectrum, when losses are present, is also reported.

A08. I. E. Psarobas, R. Sainidou, N. Stefanou, and A. Modinos: *Acoustic properties of colloidal crystals*, Phys. Rev. B **65**, art. no. 064307 (**2002**). Ετεροαναφορές (**01**)
We present a systematic study of the frequency band structure of acoustic waves in crystals consisting of nonoverlapping solid spheres in a fluid. We consider colloidal crystals consisting of polystyrene spheres in water, and an opal consisting of close-packed silica spheres in air. The opal exhibits an omnidirectional frequency gap of considerable width; the colloidal crystals do not. The physical origin of the bands are discussed for each case in some detail. We also present results on the transmittance of finite slabs of the above crystals.

A09. R. Sainidou, I. E. Psarobas, N. Stefanou, and A. Modinos: *Scattering of elastic waves by a periodic monolayer of spheres*, Phys. Rev. B **65**, art. no. 024303 (**2002**). Ετεροαναφορές (**14**)
Using the multiple-scattering formalism we developed in a previous work, and extended here, we analyze available experimental data on the transmission of longitudinal waves in the system: water-slab of polyesterwater, the slab of polyester having a plane of glass or lead or steel spheres in the middle. The theoretical results reproduce accurately the measured spectra and provide a transparent physical picture of the underlying processes.

A10. <u>I. E. Psarobas</u> and M. M. Sigalas: *Elastic band gaps in a fcc lattice of mercury spheres in aluminum*, Phys. Rev. B **66**, art. no. 052302 (**2002**). Ετεροαναφορές (**11**)

Elastic waves propagating in a periodic system consisting of mercury spheres arranged in a fcc lattice and surrounded by aluminum have been studied using the layer-multiple-scattering method. The band structure shows wide elastic band gaps along certain high-symmetry directions. For filling ratios of mercury spheres around 8.2%, there is a narrow full band gap with maximum width of the gap over mid-gap frequency of 2.5%. The full band gap can be further enhanced by using a heterostructure containing seven slabs of different sizes of mercury spheres and can be as wide as 14.4%.

A11. R. Sainidou, N. Stefanou, <u>I. E. Psarobas</u> and A. Modinos: *A layer-multiple-scattering method for phononic crystals and heterostructures of such*, Comput. Phys. Commun. **166**, 197-240 (**2005**). Ετεροαναφορές (**3.**)

We present a computer program to calculate the frequency band structure of an infinite phononic crystal, and the transmission, reflection and absorption of elastic waves by a slab of this crystal. The crystal consists of a stack of identical slices parallel to a given surface; the slice may consist of multilayers of non-overlapping spheres of given periodicity parallel to the surface and homogeneous plates. The elastic coefficients of the various components of the crystal may be complex functions of the frequency.

A12. M. Sigalas, M. S. Kushwaha, E. N. Economou, M. Kafesaki, <u>I. E. Psarobas</u> and W. Steurer: *Classical vibrational modes in phononic lattices: theory and experiment*, Z. Kristallogr. **220**, 765-809 (**2005**). Ετεροαναφορές (**57**)

We present a review, through selected illustrative examples, of the physics of classical vibrational modes in phononic lattices, which elaborates on the theory, the formalism, the methods, and mainly on the numerical and experimental results related to phononic crystals. Most of the topics addressed here, are written in a self-consistent way and they can be read as independent individual parts.

A13. R. Sainidou, N. Stefanou, <u>I. E. Psarobas</u> and A. Modinos: *Rfcj_wcp ksjrgnjc+qa_rrcpgle kcrfmb_nnjgcb rm nfmlmlga apwqr_jq*, Z. Kristallogr. **220**, 848-858 (**2005**). Ετεροαναφορές (**7**)

After a brief description of the layer multiple-scattering method as applied to phononic crystals, we present some results obtained by this method, relating to: crystals of polystyrene spheres in water; crystals of silica spheres in air; and crystals of steel spheres in polyester. We relate the transmission characteristics of slabs of these materials to the complex band structure of the corresponding infinite crystals. We emphasize aspects of the underlying physics which have not been discussed previously.

A14. <u>I. E. Psarobas</u>: *Phononic crystals - Sonic band-gap materials (editorial)*, Z. Kristallogr. **220**, IV (R4) (**2005**). Ετεροαναφορές (**3**)

It comes as no surprise that the study of quantum mechanics in a periodic potential contains direct parallels to the study of classical waves, i.e. electromagnetic (EM) and elastic (EL) waves, propagating in periodic composites of respective nature. This is profoundly demonstrated by macroscopic artificial structures with strong spatial periodic modulation in their EM or EL properties. Although, periodic elastic and dielectric composites have been studied for a long time by the applied mechanics and the electrical engineering communities, respectively, it was the past two decades that these structures attracted the interest of research in physics. Such novel structures are identified as classical spectral gap materials, because of the possibility of having frequency regions, known as absolute frequency gaps, over which there can be no propagation of classical waves. On the other hand, because of the conceptual impact of crystalline matter in condensed matter physics (i.e the geometric forms of atom arrangements in a crystal), classical spectral gap materials, depending on the type of the classical waves (EM or EL) they associate, are also well-known as photonic (EM waves) and phononic (EL waves) crystals. On the basis of the deeper physical understanding on wave phenomena and the experience gained from other areas of physics, photonic and phononic crystals have accelerated in recent years the means to control and manipulate classical waves, namely light and sound (vibrations). What follows is a collective attempt of innovative ways to manipulate sound and vibrations, with profound influence on science and technology.

This special issue of Zeitschrift für Kristallographie aims to capture the essential developments related to Phononic Crystals – Sonic Band-Gap materials, which are presented mainly by the leading experts in the field. Most of the 14 articles in this issue, report new developments in the field and they illustrate the importance for further advancing the knowledge of elastic wave transport in periodic media and consequently the potential of phononic device applications. There is a fine balance between experiment and theory, while the first two articles are reviews, in order to better serve the purpose of an extended introduction to the field.

This special issue covers a wide variety of special topics, such as phononic waveguides, locally resonant sonic materials, ultrasonic scanning, filtering and demultiplexing of acoustic signals, phononic quassicrystals, numerical methods, elastic band-gap optimization, Anderson localization of elastic waves, and tunneling.

A15. N. Papanikolaou, <u>I. E. Psarobas</u>, and N. Stefanou: *Elastic Absolute spectral gaps for infrared light and*

hypersound in three-dimensional metallodielectric phoXonic crystals, Appl. Phys. Lett. **96**, art. no. 231917 (**2010**). Ετεροαναφορές (**/6**)
By means of full electrodynamic and elastodynamic multiple-scattering calculations we study the optical and acoustic properties of three-dimensional lattices of metallic nanospheres implanted in a dielectric host. Our results show that such structures exhibit omnidirectional spectral gaps for both telecom infrared light and hypersound, with relatively low absorptive losses. This class of dual phoxonic band-gap materials is an essential step toward the hypersonic modulation of light and could lead to the development of efficient acousto-optical devices.

A16. I. E. Psarobas, N. Papanikolaou, N. Stefanou, B. Djafari-Rouhani, B. Bonello, and V. Laude: *Enhanced acousto-optic interactions in a one-dimensional phoXonic cavity*, Phys. Rev. B **82**, art. no. 174303 (**2010**). Ετερο-αναφορές (**//**)
We report on the occurrence of strong nonlinear acousto-optic interactions in a one-dimensional model phoxonic cavity that supports, simultaneously, photonic and phononic localized resonant modes, by means of rigorous electrodynamic and elastodynamic calculations. We show that these interactions can take place when photons and phonons of long lifetime are confined in the same region of space and lead to enhanced modulation of light by acoustic waves through multiphonon exchange mechanisms.

A17. N. Papanikolaou, I. E. Psarobas, N. Stefanou, B. Djafari-Rouhani, B. Bonello, and V. Laude: *Light modulation in phoXonic nanocavities*, Microelectron. Eng. **90**, 155-158 (**2012**). εʉɼ Ɉ ʆɸʆɸʊ ʆ Ɉ ȥʏ &**3**'
We report on the occurrence of strong nonlinear acousto-optic interactions in phoxonic structures, that support, simultaneously, acoustic and optical localized resonant modes, under the influence of acoustic losses. Deploying a detailed theoretical investigation of the acousto-optic coupling in the specific case of a one-dimensional phoxonic cavity, realized by homogeneous SiO_2 and Si layers, we demonstrate the possibility for an enhanced modulation of light with sound through multi-phonon exchange mechanisms. A full electrodynamic and elastodynamic multiple scattering approach is employed to describe the optical and acoustic modes, and to account for their mutual interaction and the underlying effects both in time and frequency domains. In particular, we discuss the influence of hypersonic attenuation on the acousto-optic interaction by considering typical acoustic losses in the GHz regime.

A18. V. Yannopapas and I. E. Psarobas: *Lasing action in multilayers of alternating monolayers of metallic nanoparticles and dielectric slabs with gain*, J. Opt. A **14**, 035101 (**2012**). εʉɼ Ɉ ʆɸʆɸʊ ʆ Ɉ ȥʏ &**/**'
By employing a rigorous multiple-scattering electrodynamic approach we study the loss compensation and lasing action in photonic crystals formed as alternating layers of active dielectric slabs and two-dimensional planes of plasmonic (metallic) spheres. The strong dispersion of the plasmonic bands and the efficient trapping of light among the dielectric slabs (the cavity effect) triggers lasing action for thin slabs of the photonic crystal and for a moderate amount of gain, with quality factors of the order of 103. Below and above the lasing threshold, gain compensates losses, promising significant improvement of the imaging properties of plasmonic photonic crystals.

A19. V. Yannopapas and I. E. Psarobas: *Ordered arrays of metal nanostrings as broadband super absorbers*, J. Phys. Chem. C **116**, 15599 (**2012**). εʉɼ Ɉ ʆɸʆɸʊ ʆ Ɉ ȥʏ &**1**'
We study the absorption spectrum of ordered arrays of strings of gold nanoparticles within a nematic liquid crystal by a rigorous electrodynamic approach. We find, in particular, that, as the length of the strings increases, light absorbance can be very high over the entire visible regime. The ordinary modes of the nematic liquid crystal allow the nanoparticle strings to absorb light much more efficiently than the extraordinary modes. Overall, absorption does not depend on the lattice type of the string array due to the subwavelength functionality of the system. Such a structure operates as a grey body exhibiting an absorption efficiency of 79% within the entire visible regime, averaging over all angles of incidence and polarization modes.

Συγγραφή κεφαλαίων σε επιστημονικά βιβλία (3)

B01. I. E. Psarobas, N. Stefanou, and A. Modinos, NATO-ASI Science Series: Photonic crystals and light localization in the 21st Century, ed. by C. M. Soukoulis, *Band Structure and Transmittance Calculations for Phononic Crystals by the LKKR Method* pgs. 519-526, Kluwer Academic, Dordrecht-Netherlands (APR **2001**). Ετεροαναφορές (**1**)

We developed a multiple-scattering method for the calculauon of the frequency band structure of a phononic crystal consisttng of non·overlapping elastic spheres arranged periodically in a host medium of different elastic properties. Using a variation of the same method we can also calculate, with the same ease and accuracy, the coefficients of transmission, reflection and absorption of elastic waves incident on a slab of the material of finite thickness. The leastic coefficients for the spheres and/or the host medium can be complex and frequency dependent. We demonstrate the effectiveness of the method by applying it to specific examples.

B02. I. E. Psarobas, *Versatile phononic slabs* pgs. 175-185, IUTAM Bookseries Volume **26**, **Recent Advances of Acoustic Waves in Solids**, Part 3, Springer (**2010**).
Phononic slabs of an fcc phononic crystal consisting of close-packed (glued) rubber spheres in air, under the influence of mild dissipation in rubber, exhibit large absolute transmission gaps. Proper size variation of the spheres in a sequence of crystal slabs can shift and enlarge the frequency gap readily to comply with a variety of filtering needs in a phononic application. The aspects of such a versatile phononic slab are presented in a realistic theoretical approach, by means of the layer multiple-scattering method developed for phononic crystals.

B03. B. Assouar, R. Sainidou, and I. E. Psarobas, Ch. 7: *The Three-dimensional Phononic Crystals*.
PHONONIC CRYSTALS: FUNDAMENTALS & APPLICATIONS, eds. A. Khelif and A. Adibi (GeorgiaTech, U.S.A.) Kluwer Academic Publishers, Boston (in press **2012-13**).
A three-dimensional phononic crystal is a classical analogue of the well-known behavior of crystalline matter. As a classical spectral gap material possesses all relevant features from frequency gap formation, symmetry properties as well as interesting physical phenomena as tunneling, disorder and classical Anderson localization of acoustic waves. In this chapter, we also present a physical approach to phononic defects, multi-component phononic structures with locally resonant constituents and we give a brief outline for related acoustic metamaterials and their appealing applications. Mostly with the view of Layer-Multiple-Scattering method, we address the subjects of complex phononic band structure, scattering from finite slabs of the crystal as well as matters of distinct physical importance to next-generation applications of dual spectral-gap materials, namely the phoXonic crystals.

Πρακτικά Συνεδρίων υψηλής επιστημονικής απήχησης με κριτές (5)

C01. N. Papanikolaou, I. E. Psarobas, G. Gantzounis, E. Almpanis, N. Stefanou, B. Djafari-Rouhani, B. Bonello, V. Laude, and A. Martinez: *PhoXonic architectures for tailoring the acousto-optic interaction*, Proc. SPIE **8071**, 80710Z (**2011**).
Periodic media offer impressive opportunities to manipulate the transport of classical waves namely light or sound. Elastic waves can scatter light through the so-called acousto-optic interaction which is widely used to control light in telecommunication systems and, additionally, the radiation pressure of light can generate elastic waves. Concurrent control of both light and sound through simultaneous photonic-phononic, often called phoxonic, bandgap structures is intended to advance both our understanding as well as our ability to manipulate light with sound and vise versa. In particular co-localization of light and sound in phoxonic cavities could trigger nonlinear absorption and emission processes and lead to enhanced acousto-optic effects. In the present communication, we present our efforts towards the design of different phoxonic crystal architectures such as three-dimensional metallodielectric structures, two-dimensional patterned silicon slabs and simple one-dimensional multilayers, and provide optimum parameters for operation at telecom light and GHz sound. These structures can be used to design phoxonic cavities and study the acousto-optic interaction of localized light and sound, or phoxonic waveguides for tailored slow light-slow sound transport. We also discuss the acousto-optic interaction in onedimensional multilayer structures and study the enhanced modulation of light by acoustic waves in a phoxonic cavity, where a consistent interpretation of the physics of the interaction can be deduced from the time evolution of the scattered optical field, under the influence of an acoustic wave.

C02. I. E. Psarobas, N. Papanikolaou, and N. Stefanou: *Multi-phonon Processes in PhoXonic Cavities*, Phononics 2011: First International Conference on Phononic Crystals, Metamaterials and Optomechanics, Santa Fe, New Mexico, U.S.A, pgs. 300-301 (**2011**).
Long lifetime photons and phonons, confined in the same region of space, inside a phoXonic cavity, can interface with each other via strong nonlinear acousto-optic interactions. We unveil physics of distinct importance as the hypersonic modulation of light is substantially enhanced through multi-phonon exchange mechanisms.

C03. I. E. Psarobas and V. Yannopapas: *Dynamically tuned zero-gap phoXonic systems*, Proc. SPIE **8346**, 83460K (**2012**).

A full electrodynamic and elastodynamic multiple scattering approach is employed to describe the optical and acoustic modes, and to account for their mutual interaction both in time and frequency domain in one-dimensional phoXonic crystal slabs. We report on the occurrence of nonlinear acousto-optic interactions and demonstrate the effect of the hypersonic tuning of photonic Dirac points in the optical and telecom frequencies. Potential sensing capabilities are examined under moderate acousto-optic interactions in the proximity of crossing photonic bands enabling light to slow down, stop or reverse. Quarter-wave stack arrangements are considered in the optical (polymeric-based slab) and IR (Si-based slab) frequencies. Such structures support two bands that cross symmetrically, without forming a photonic gap. In the vicinity of the Dirac point (crossing bands), dynamic tuning achieves efficient transfer of energy between the bands using weak and slow modulations of the wave velocity. Finally, through hypersonic light modulation, we may achieve efficient electromagnetic pulse reversal and switching.

C04. I. E. Psarobas and V. Yannopapas: *Topological photonic structures*, Proc. SPIE **8346**, 83460Q (**2012**).

We show that in chiral metamaterials of resonant spheres Dirac points occur in the photon dispersion relation. As a result, the introduction of a time reversal symmetry-breaking term such as a Faraday term in the constituent materials can realize the physics of the quantum Hall effect in metamaterials. We show in particular that the electromagnetic modes of a chiral medium with the inclusion of a Faraday term are topological states possessing non-zero Chern numbers.

C05. I. E. Psarobas and V. Yannopapas: *Rmnmjmew ?pes k c l rq g l C l eg l ccpg l e 1B N f mVm l ga Qwqrc k q*,
Phononics 2013: 2nd International Conference on Phononic Crystals/Metamaterials, Phonon Transport and Optomechanics, Sharm El-Sheikh, Egypt, pg. 03 . (**2013**).

Δημοσιεύσεις ανά θεματική επιστημονική περιοχή (6)

1. Υπολογιστική Μηχανική-Φυσική και σχεδιασμός υλικών (Computational Mechanics-Physics & materials by design): Εργασίες (**A02-19, B01-3, C01-4, D01-5**). Υπολογιστικές τεχνικές που έχουν αναπτυχθεί στη θεωρία περίθλασης ηλεκτρονίων χαμηλής ενέργειας από κρυστάλλους (Low Energy Electron Diffraction) έχουν μεταφερθεί με πλήρη επιτυχία στην επίλυση προβλημάτων πολλαπλής σκέδασης κλασσικών κυμάτων (ΗΜ και ελαστικά-ακουστικά) από μη-ομογενή ελαστικά ή/και οπτικά μέσα-υλικά. Ο φορμαλισμός της επίλυσης προβλημάτων περιοδικότητας, περασμένων πλακιδίων πολυστρωματικών ετεροδομών (1-3 διαστάσεις), περιοδικές δομές με ατέλειες και αταξία, καθώς και άτακτες δομές σκεδαστών, παρουσιάστηκε στην δημοσίευση **A06** με μία ενοποιημένη μορφή για ηλεκτρόνια (κβαντική μηχανική), ΗΜ κύματα (οπτική) και για ελαστικά-ακουστικά κύματα (κλασσική μηχανική). Η μέθοδος αυτή είναι η πολυστρωματική πολλαπλή σκέδαση (Layrer-Multiple Scattering, LMS) και είναι από τις πιό ακριβείς και ολοκληρωμένες μεθόδους που υπάρχουν σήμερα για τα φωτονικά και κυρίως φωνονικά υλικά. Ο κώδικας της μεθόδου για την ακουστική και ελαστικότητα έχει δημοσιευθεί (**A11**) και αποτελεί το πιο ολοκληρωμένο εργαλείο για τον σχεδιασμό φωνονικών υλικών με μεγάλη ακρίβεια από ελαστικά κύματα σεισμικών δονήσεων μέχρι ήχους εκατοντάδων GHz (hypersound). Ο κώδικας MULTEL έχει σχεδιαστεί με πολύ επιμέλεια, είναι πολύ πιο γρήγορος σε σχέση με την ανταγωνιστική μέθοδο FDTD (Finite Difference Time Domain), αλλά και κάθε άλλη μέθοθο πεπερασμένων στοιχείων (finite element) για τους φωνονικούς κρυστάλλους. Χρησιμοποιεί τεχνικές άθροισης Kampe και Ewald όπως χρησιμοποιούνται από την υπολογιστική φυσική συμπυκνωμένης ύλης για πλύ γρήγορη σύγκλιση. Η ακρίβειά του έχει ελεγχθεί πειραματικά πολλές φορές και προσεγγίζει το όρια του πειραματικού σφάλαματος (**A09**), ενώ επειδή λειτουργεί από πρώτες αρχές έχει τη δυνατότητα να εμβαθύνει ουσιαστικά στη φυσική σημασία των εμπλεκομένων ανά περίπτωση φυσικών φαινομένων. Ο κώδικας υπολογίζει τη φωνονική δομή των ζωνών συχνότητας του ελαστικού πεδίου, τα φάσματα απορρόφησης, ανάκλασης και διέλευσης του ελαστικού πεδίου σε πεπερασμένες δομές, ενώ συνδέεται άμεσα με τεχνικές Green για τον υπολογισμό συνθέτων αλληλεπιδράσεων. Τέλος αποτελεί ένα πολυχρηστικό εργαλείο για το σχεδιασμό, βελτίωση και κατασκευή φωνονικών υλικών και μεταϋλικών.

2. Φωτονικοί κρύσταλλοι & Φωτονικά μεταϋλικά (Photonic Crystals & Photonic Metamaterials): Εργασίες (**A02, A03, A18, A19, C04, D04**). Σ' αυτή την ομάδα δημοσιεύσεων ξεχωρίζει η εργασία **A02** που αναλύει τη συμπεριφορά φωτονικών κρυστάλλων με χειρόμορφη συμπεριφορά (chiral photonic crystals). Κι αυτό γιατι παρουσίασε ένα θέμα πολύ μπροστά από την εποχή του. Τα τελευταία 2 χρόνια οι ερευνητές στο πεδίο των φωτονικών κρυστάλλων σε νανοδομές και συστάδες νανοσωματιδίων μέσα σε υγρούς κρυστάλλους έχουν τη δυνατότητα και πειραματικά πλέον να μελετούν και να αξιοποιούν τις δυνατότητες αυτών των μεταϋλικών.

3. Φωνονικοί κρύσταλλοι & ακουστικά υλικά φωνονικού χάσματος (Phononic Crystals & Acoustic spectral-gap materials): Εργασίες (**A04-14, B01-3, D01-2, D05**). Οι εργασίες αυτές αποτελούν κεφάλαιο, η κάθε μία με το δικό της τρόπο, στο πεδίο των φωνονικών κρυστάλλων με εξέχουσα την εργασία **A04** η οποία μαζί με την εργασία των φωνονικών υλικών τοπικών συντονισμών (locally resonant phononic crystals) της ομάδας του Καθ. Ping Sheng στο Hong Kong, αποτελούν τις βάσεις στη φαινομενολογία, φορμαλισμό και φυσική εξήγηση της λειτουργίας αυτών των τεχνητών περιοδικών δομών.

4. Φωξονικοί κρύσταλλοι & κλασσικά υλικά διπλού χάσματος συχνοτήτων (PhoXonic Crystals & Dual classical spectral-gap materials): Εργασίες (**A15-17, C01-3, D03-4**). Πρόκειται για νέας γενιάς υλικά με διπλό φασματικό χάσμα, όπου εκτός από την ενδιαφέρουσα περίπτωση αλληλεπίδρασης του ΗΜ και του ελαστικού-ακουστικού πεδίου, συμπεριφέρονται είτε ως φωτονικοί, είτε ως φωνονικοί κρύσταλλοι, ή και τα δύο

5. Οπτική Φυσική Μικροσωματιδίων (Microparticle Photophysics): Εργασίες (**A01**).
6. Θεωρητική Φυσική Συμπυκνωμένης Ύλης (Theoretical Condensed Matter Physics): Εργασίες (**A02-19**).

ΣΥΓΚΕΝΤΡΩΤΙΚΗ ΕΚΤΙΜΗΣΗ ΔΗΜΟΣΙΕΥΜΕΝΟΥ ΕΡΓΟΥ

Ιωάννη Ψαρόμπα (Ph.D)

Peer Review Journals

ΠΗΓΗ: ISI WEB OF SCIENCE 5.4 + SCOPUS

	ΠΕΡΙΟΔΙΚΟ	ΕΤΟΣ	Αναφορές	Ετερ/ρές	Συμμετοχή	Impact Factor
1	Physical Review A	1992	0	0	A, I	2.861
2	J. Opt. Soc. Am. A	1999	14	10	A, I	1.936
3	Optics Commun.	1999	8	4	A, I, O	1.517
4	**Physical Review B**	**2000**	**230**	**203**	**A, I**	**3.772**
5	Physical Review B	2000	83	74	A, I	3.772
6	Physica B	2001	31	26		1.056
7	Physical Review B	2001	22	14	A, I, O	3.772
8	Physical Review B	2002	29	23	A, I	3.772
9	Physical Review B	2002	20	16	I	3.772
10	Physical Review B	2002	36	33	A, I	3.772
11	Comput. Phys. Commun.	2005	62	50	I	2.300
12	Z. fur Kristallographie	2005	105	79	I	1.255
13	Z. fur Kristallographie	2005	12	9	I	1.255
14	Z. fur Kristallographie	2005	3	3	A, I, O	1.255
15	Applied Physics Letters	2010	22	18	I	4.281
16	Physical Review B	2010	17	11	A, I	3.772
17	Microelectr. Engineering	2012	5	5	I	1.569
18	Journal of Optics A (IOP)	2012	1	1		1.862
19	Journal of Phys. Chem. C	2012	3	3		2.161
	ΣΥΝΟΛΙΚΑ		**704**	**582**		**49.712**

ΣΤΑΤΙΣΤΙΚΑ	
ΣΥΝΟΛΟ ΑΝΑΦΟΡΩΝ	**704**
ΣΥΝΟΛΟ ΕΤΕΡΟΑΝΑΦΟΡΩΝ	**582**
ΣΥΝ. ΣΥΝΤ. ΑΠΗΧΗΣΗΣ	**49.7**
ΣΥΝΤΕΛ. h ΕΤΕΡ. (ΑΝΑΦ)	**14 (20)**
ΜΕΣΟΣ ΑΡΙΘΜΟΣ ΕΤΕΡ/ΡΩΝ	**31**
ΜΕΣΟΣ Impact Factor	**2.62**
1ος Συγγραφέας (Α)	**10**
Κύριος Ερευνητής (Ι)	**16**
Μόνος Συγγραφέας (Ο)	**3**