Curriculum Vitae

Nikos Kadianakis

Associate Professor
Department of Mathematics
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National Technical University of Athens (N.T.U.A.)

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PERSONAL INFORMATION

Name	Nikolaos Kadianakis
Title	Associate Professor
Date and Place of Birth	6 -12- 1948, Heraclion Crete
Nationality	Greek
Marital Status	Married, two daughters
Office Address	National Technical University of Athens (NTUA), School of Applied Mathematical and Physical Sciences, Department of Mathematics, Zografou campus, 157 80 Zografou, Athens, Greece.
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ACADEMIC POSITIONS(in National Technical University of Athens, Greece (N.T.U.A.)

1998- today Associate Professor in the Department of Mathematics (N.T.U.A.)
1989-1998 : Assistant Professor in the Department of Mathematics (N.T.U.A.
1984-1989 : Lecturer with tenure in the Department of Mathematics (N.T.U.A.)
1982-1984 : Lecturer in the Department of Mathematics (N.T.U.A.)
1974-1982 : Tutor in the Department of Mathematics (N.T.U.A.)

ACADEMIC TITLES

1. Bachelor in Mathematics (1971), Department of Mathematics, National University of Athens (N.U.A.)
2. Master of Science (M.Sc.) (1978) University of Liverpool U.K.
3. Ph.D (1981) University of Liverpool U.K.

EDUCATION

I graduated from High School in Crete in 1966 and the same year I started my studies in the Department of Mathematics of the University of Athens. I graduated in 1971. After completing my military service I started working as a tutor in Mathematics in National Technical University. During this period I attended seminars in Advanced Linear Algebra and Functional Analysis.
In October 1977 I started my postgraduate studies in the department of Applied Mathematics and Theoretical physics in the University of Liverpool (UK) following a Master of Science course.

During my studies I attended and was examined in the following lectures:
Differential equations, Generalized functions, Integral equations, Integral transforms, Tensor Calculus, Compressible flow and heat transfer, General theory of deformation and flow, Theory of Waves, Dynamical Astronomy, Flow of Non-Newtonian fluids.
In 1978 I started my studies for PhD, under the supervision of Prof. P. Appleby in the area of mathematical foundation of Mechanics. At the same period I attended additional lectures in Lie Groups and Mathematical foundations of Elasticity. I also attended seminars in **Dynamical systems, Quantum mechanics, Theory of relativity, Continuum mechanics.** In May 1981 I was awarded the PhD degree. In 1981 I returned to National Technical University, and from 1982 in a Lecturer position.

DISTINCTIONS AND SCHOLARSHIPS

1966: Distinction in the Pan-Hellenic students competition of the Greek Mathematical Society
1967-1969: Scholarship of the Greek State Scholarship Foundation.
1978-1981: Scholarship of the Greek ministry of economy for my postgraduate studies

RESEARCH INTERESTS

Differential Geometry and applications, especially in Continuum Mechanics.

PUBLICATIONS

Theses

1. "Non-Equilibrium Thermodynamical Theories in Continuum Mechanics".

Master of Science Thesis, University of Liverpool 1980.

2. "Dynamical Processes in Classical Space-Time" *PhD thesis, University of Liverpool 1981.*

Published papers

3. "The Characterisation of Spin in Euclidean Space-Time", P. Appleby and N. Kadianakis, *Arch. Rational Mechanics and Anal. Vol.84, N.2, p. 171-188 (1983).*

4. "The Electromagnetic Field in Classical Space-Time", N. Kadianakis, *Il Nuovo Cimento Vol. 89A N.2, p.204-215,* (1985).

5. "Vorticity Preserving Motions in Classical Space-Time", N. Kadianakis, *Il Nuovo Cimento Vo. 95B, N. 1, p.82-98,* (1986).

6. "A Frame-Independent Description of the Principles of Classical Mechanics" P. Appleby and N. Kadianakis, *Arch. Rational Mech. Anal., Vol. 95, N.1 p. 1-22* (1986).

7. "Convected Time-Derivatives in Continuum Mechanics", P. Appleby and N. Kadianakis, *Il Nuovo Cimento Vol. 102B, N. 6, p.593-608,* (1988).

8. "Affine Connections and Frames of reference in Classical Mechanics" N. Kadianakis, *Rep. on Math. Physics, Vol.30, N.1 p.21-32,* (1991).

9. "Disease and Community Structure. The Importance of Self-Regulation in a Host-Host-Pathogen Model", M. Begon, R. Bowers, N. Kadianakis, D. Hodgkinson, *The American Naturalist Vol. 139, N. 6, p.1131,* (1992).

10. "The Kinematics of Continua and the Concept of Connection on Classical Space-Time", N. Kadianakis, *Int. J. Engng. Sci. Vol. 34, N. 3, p. 289-298,* (1996).

11. "Geometrical Aspects of the Co-Rotational Derivative", N. Kadianakis, *ZAMM, Vol. 77, N. 2 p. 137-142,* (**1997**).

12. "Lie-Derivatives of Associated Tensor Fields on a Riemannian Manifold", N. Kadianakis, *Bulletin of the Greek Mathematical Society. 39, p.95-100,* (**1997**).

13. "On the Geometry of Lagrangian and Eulerian Descriptions in the Kinematics of Continua", N. Kadianakis *ZAMM, Vol. 79, N. 2 p. 131-138,* (**1999).**

14. "Frame-independent Forms of the Equation of Continuity", N. Kadianakis. *Far East Journal of Mathematical Sciences 2(5) p.819-831, (**2000**).*

15. "Evolution of Surfaces and the Kinematics of Membranes*"N.* Kadianakis. Journal of Elasticity 99 p.1-17 (**2010**).

16. "Kinematics of Hypersurfaces in Riemannian manifolds" Journal of Elasticity (**2012**).

17. "Variation of the affine connection of a Riemannian Hypersurface" submitted for publication.

<u>Conferences</u>

18. "Local Frames in Euclidean Space-Time", P. Appleby and N. Kadianakis, *22th Polish Solid Mechanics Conference*", Poland (1980).

19. "A frame-independent description of the equations of state in Continuum Mechanics", P. Appleby and N. Kadianakis, *2th Anglo-Polish Mechanics Symposium,* Poland (1983).

20. "The equation of Continuity for surfaces", N. Kadianakis, *5th PanHellenic conference of Analysis, Crete Greece* 1996.

21. "On the Geometry of the Kinematics of Continua", N. Kadianakis, *3th Panhellenic conference of Geometry,* Athens Greece1997.

22. "Kinematics of Hypersurfaces in Riemannian manifolds" 10th *Panhellenic conference of Geometry,* Athens Patra Greece 2011.

23. "Variations of certain geometrical objects in the kinematics of Hypersurfaces" N. Kadianakis, F. Travlopanos,11^{o} *Panhellenic conference of Geometry,* Athens, Greece 2013. (member of the scientific committee).

CITATIONS

Total: 122
Analytically, per publication:

3 . "The Characterisation of Spin in Euclidean Space-Time", P. Appleby and N. Kadianakis, Arch. Rational Mechanics and Anal. Vol.84, N.2, p. 171-188 (1983).

1. Matolcsi, T. "Spacetime without reference frames: an application to synchronizations on a Matolcsi, T., and T. Gruber. "Spacetime without reference frames: An application to the kinetic theory." *International Journal of Theoretical Physics* 35.7 (1996): 1523-1539.

2. Matolcsi, T., and T. Gruber. "Spacetime without reference frames: An application to the kinetic theory." *International Journal of Theoretical Physics* 35.7 (1996): 1523-1539.

4. "The Electromagnetic Field in Classical Space-Time", N. Kadianakis, Il Nuovo Cimento Vol. 89A N.2, p.204-215, (1985).

Matolcsi, T., and T. Gruber. "Spacetime without reference frames: An application to the kinetic theory." *International Journal of Theoretical Physics* 35.7 (1996): 1523-1539.

6. "A Frame-Independent Description of the Principles of Classical Mechanics" P. Appleby and N. Kadianakis, Arch. Rational Mech. Anal., Vol. 95, N.1 p. 1-22 (1986).

1. C. Truesdell: A First Course in Rational Continuum Mechanics, p.68 Academic Press 1991.
2. Svendsen, B., and A. Bertram. "On frame-indifference and form-invariance in constitutive theory." *Acta Mechanica* 132.1 (1999): 195-207.
3. Matolcsi, Tomás, and A. Goher. "Spacetime without reference frames: An application to the velocity addition paradox." *Studies In History and Philosophy of Science Part B: Studies In History and Philosophy of Modern Physics* 32.1 (2001): 83-99.
4. Muschik, W., and L. Restuccia. "Systematic remarks on objectivity and frame-indifference, liquid crystal theory as an example." *Archive of Applied Mechanics* 78.11 (2008): 837-854.
5. Svendsen, B., and A. Bertram. "On material objectivity and reduced constitutive equations" *Archive of Mechanics* 53, 6, (2001): 653-675.
6." Spacetime without reference frames: An application to the kinetic theory" T Matolcsi, T. Gruber - International Journal of Theoretical Physics, 1996
7. "Continuum Mechanics and Thermodynamics" BE Tadamor, ER Miller, SR Elliott e library.matf.bg.ac.rs–Cambridge University Press2012

8. "Affine Connections and Frames of reference in Classical Mechanics" N. Kadianakis, Rep. on Math. Physics, Vol.30, N.1 p.21-32, (1991).

1. Pasquero, Stefano. "Ideality criterion for unilateral constraints in time-dependent impulsive mechanics." *Journal of mathematical physics* 46 (2005): 112904.
2. Matolcsi, T., and T. Gruber. "Spacetime without reference frames: An application to the kinetic theory." *International Journal of Theoretical Physics* 35.7 (1996): 1523-1539.
3. Pasquero, Stefano. "On the Concepts of Frame of Reference and Connection in Space-Time Bundles of Classical Mechanics." *Physics Essays* 17.4 (2004): 526-535.
4. Farkas, Sz, Z. Kurucz, and M. Weiner. "Poincaré Covariance of Relativistic Quantum Position." *International Journal of Theoretical Physics* 41.1 (2002): 79-88.

9. "Disease and Community Structure. The Importance of Self-Regulation in a Host-Host-Pathogen Model", M. Begon, R. Bowers, N. Kadianakis, D. Hodgkinson, The American Naturalist Vol. 139, N. 6, p.1131, (1992).

This paper has a total of 102 citations

10. *"The Kinematics of Continua and the Concept of Connection on Classical Space- Time", N. Kadianakis, Int. J. Engng. Sci. Vol. 34, N. 3, p. 289-298, (1996).*

1. Pasquero, Stefano. "On the Concepts of Frame of Reference and Connection in Space-Time Bundles of Classical Mechanics." *Physics Essays* 17.4 (2004): 526-535.
2. Farkas, Sz, Z. Kurucz, and M. Weiner. "Poincaré Covariance of Relativistic Quantum Position." *International Journal of Theoretical Physics* 41.1 (2002): 79-88.

13. "On the Geometry of Lagrangian and Eulerian Descriptions in the Kinematics of Continua", N. Kadianakis ZAMM, Vol. 79, N. 2 p. 131-138, (1999).

1. Fiala, Zdeněk. "Geometrical setting of solid mechanics." *Annals of Physics* 326.8 (2011): 1983-1997.
2. Fiala, Z. "Novel Objective Time Derivative Obtained from Applying Riemannian Manifold of Riemannian Metrics to Kinematics of Continua." *Journal of the Mechanical Behavior of Materials* 15.6 (2004): 391-400.
3. The geometry of nonlinear elasticity G Romano, R Barretta, M Diaco, Acta Mechanica2014.

***15.* "Evolution of Surfaces and the Kinematics of Membranes"*N.* Kadianakis. Journal of Elasticity 99 p.1-17 (2010).**

Foucard, Louis, et al. "The Role of the Cortical Membrane in Cell Mechanics: Model and Simulation." Multiscale Simulations and Mechanics of Biological Materials Wiley (2013): 241-265.

IMPACT FACTORS

Ενδεικτικά:

1. Journal of elasticity 2011 ……………….....1.111
2. Reports on Mathematical Physics 0.643
3. ZAMM - Journal of Applied Mathematics and Mechanics 0.863
4. International Journal of Engineering Science 1.508
5. Archive for Rational Mechanics and Analysis.......2.054
6. Il nuovo cimento. 0.310

RESEARCH PROGRAMMS

1. EU: "A New Approach in Quantum Mechanics and Field Theory: Deformation and Quantum Groups". Section DG12. Initialized 1-3-1995. Scientific Coordinator: Prof. E. Aggelopoulos.

2. General Secreteriat For Research and Technology (GSRT) "Integrated Mathematical models in the global operation of manufacture systems". Initialized 1-3-1996. Scientific Coordinator: Prof. E. Galanis.

OTHER SCIENTIFIC ACTIVITIES

- Visiting fellow in the University of Liverpool, (May 1990 to August 1990).
- Contribution to seminars in the department of Mechanics of NTUA..

CONFERENCE ATTENTANCE

- "Singularities and Dynamical Systems". Crete, 1983.
- "7o Balkan Mathematical Conference ", Athens, 1983.
- "Topical meeting on Variational problems in Analysis", *Trieste* Italy August 1989.
- "Mathematical Analysis and Applications", Athens 1996.

PRESENT RESEARCH INTERESTS

1. Continuing the study of the variation of submanifolds in two directions: a) Extension to second order variations of their geometric quantities. B) Variation of geometric quantities of submanifolds of codimension greater than one. This subject has many applications to the moving interfaces, deformation of membranes etc.
2. Application of the structure of classical space - time to Lagrangian and Hamiltonian Mechanics.

SCIENTIFIC UNIONS

Member of the Greek Mathematical Society
Member of the American Mathematical Society (in the past).

THESES SUPERVISION

PhD Theses (1)

F. Travlopanos., "Kinematics of Submanifolds and applications" (completed July 2013).

MSc Theses Supervision (1)

Graduate Diploma Theses Supervision (3)

TEACHING EXPERIENCE

Total teaching experience: 36 years, Total autonomous teaching: 33 years.

Undergraduate Courses:
1974-1977 and 1981-82: Tutorials in the department of Mathematics in N.T.U.A. Subjects: Linear Algebra, Analytic Geometry, Calculus, Differential equations, Vector Analysis, Differential Geometry.
1982- today: Lectures mainly in the first 4 semesters in the department of Mathematics in N.T.U.A Subjrcts: Linear Algebra, Analytic Geometry, , Advanced Calculus, Complex Analysis, Ordinary and Partial Differential Equations, Differential Geometry of curves and surfaces.

Postgraduate Courses: Differential Geometry, Tensor calculus and applications, Differential equations and Dynamical systems.

CONTINUING EDUCATION

I was involved in the program of continuing education "Mathematical infrastructure in the contemporary technology" of the Department of Mathematics of NTUA.

BOOKS

1. N. Kadianakis - S. Karanasios. **Linear Algebra and Elementary Analytic Geometry** (in Greek) 1998 (431 pages) in Greek.
2. N. Kadianakis - S. Karanasios. **Linear Algebra, Analytic Geometry and Applications**. (in Greek) 4rth Ed. 2008 (565 pages). ISBN 960-91725-0-4. in Greek.
3. N. Kadianakis - S. Karanasios - A. Fellouris. **Analysis II Functions of several variables.** (in Greek) 6th Ed. 2004 (564 pages). ISBN 960-90120-0-0 in Greek.

LECTURE NOTES

"**Notes of Tensor Calculus**", N. Kadianakis Postgraduate lecture notes (Editor: NTUA).

«Notes on Differential Geometry of Curves and Surfaces». Undergraduate lecture notes (Editor: NTUA).

ADMINISTRATION

- Head of the Department of Mathematics of the School of Applied Mathematics and Physical Sciences, of the National Technical University, for two years (2001-2003).
- Member of various committees in the department of Mathematics of N.T.U.A.

SHORT DESCRIPTION OF PUBLISHED PAPERS

1. ***"Non-Equilibrium Thermodynamical Theories in Continuum Mechanics".***

   Thesis for the Master of Science, University of Liverpool 1980.

   The classical equilibrium thermodynamic is inadequate for a description of thermo-mechanical processes of continuous media having a structure more complex than that of simple fluids. There have been various thermodynamic theories to describe situations away from the state of equilibrium. In this work we present a review of two such theories: the theory of Onsager and the theory of Coleman. We compare the two theories on the basis of results they give when applied to specific classes of materials. The classes are distinguished by various norms defined in a suitable space of functions.

2. ***"Dynamical Processes in Classical Space-Time" PhD Thesis, University of Liverpool 1981.***

   The goal of the thesis is the Mathematical foundation of classical mechanics, especially the mechanics of continuous media, expressing its basic principles in a frame-independent way. This problem is related to the study of differential manifolds with an affine connection and the construction of an appropriate differential geometric structure on classical space-time manifold. The original idea for addressing the problem this way appeared just after the theories of relativity and is due to E. Cartan (1922). In this approach the gravitational field is described by an appropriate affine connection in the differential manifold of classical non relativistic space-time. The geodesic curves of this connection describe the trajectories of the particles that move under influence of the gravitational field only. This idea was developed later in different directions by Dombrowski Horneffer (1964), Trautman (1965), Kunzle (1972) and Appleby (1978). On the other hand, Noll (1963, 1972, 1973) and Truesdell (1977) began an effort for a Mathematical foundation of Mechanics of continuous media, based on a system of axioms, definitions and propositions. Although in these works there was some limited use of the concept of classical space-time, the idea of E. Cartan was absent. This thesis combines the original idea of E. Cartan with an attempt towards a mathematical foundation of mechanics. Thus, the gravitational field should play a much more important role than in the classical foundations. This is so because the affine connection of E. Cartan is the one that gives in the classic space-time the geometric structure, necessary for the formulation of the principles of mechanics in a frame-independent way. The classical foundations of Mechanics relative to a frame of reference are based on a trivial space-time $M = T \times E$, where T and E are Euclidean spaces of dimension 1 (the "time") and 3 (the "space") respectively. In this study, we assume that M is a 4-dimensional differential manifold (space of events) endowed with a function $\tau: M \to T$ that gives the time τ (x) of the event x. The set $M_t = \{x \in M, \tau(x) = t\}$, t $\in$ T contains all simultaneous events at time t. More precisely, we assume that space-time is an affine fiber bundle (M, T, τ) with structural group the isometry group of a 3-dimensional Euclidean space E. The fibers M_t, t $\in$ T are 3-dimensional Euclidean spaces with metric tensor g_t. In this context, a reference system is an injection $\Theta : M \to T \times E$. Then a singular metric tensor field g is defined on M such that at each point $x \in M$, $g(x) = g(\tau(x))$. The geometrical structure of M is characterized by the differential 1-form $\boldsymbol{\tau} = d\tau$, and the singular metric tensor field g. Vector fields u for which $\boldsymbol{\tau}(u) = 0$ are called spatial (space-like). The space M with this structure is called Euclidean space-time. Since the metric g is singular, more than one compatible with g affine connections can be defined on M .

This dissertation can be divided into three parts:

I. In this part we study in detail the differential geometry of classical space-time M . For this purpose we introduce the concept of Spin and examine its properties. Then we prove that every compatible affine connection on M defines a Spin which is used to express the difference between two compatible connections. The properties of the Cartan's connection are studied in this framework.

II This part is a mathematical foundation of kinematics of continuous media in space-time M . A continuum is defined as a flow φ_s, $s \in \mathbb{R}$ on the manifold M . The concept of material manifold is then defined as the quotient space M / φ_s and it is used to construct the classical derivatives that "follow" the flow. These derivatives are classified and generalized with the help of a class of affine connections, more general than those studied in Part I.

III In this part we give the mathematical foundations of the basic principles of continuum mechanics and derive from them the equations of motion. We also formulate the constitutive equations for continuous media in a frame independent way.

3. ***"The Characterisation of Spin in Euclidean Space-Time", P. Appleby and N. Kadianakis. Arch. Rational Mechanics and Anal. Vol.84, N.2, pp. 171-188 (1983).***

In this paper the concept of Spin is defined, as a derivation on space-like vectors in differential manifold M of classical space-time and its properties are studied. While a covariant derivative is based on the parallel transport of tangent vectors, the Spin is defined as a derivation based on the parallel transport of a special class of vectors, the space-like vectors. This concept is defined locally and then as a uniform field on M. It turns out that:

1. The set of Spins is an affine fiber bundle with vector bundle the bundle of second order antisymmetric tensors.
2. Each section of the bundle of Spins gives to M a principal bundle structure, defining a canonical isomorphism between the vector spaces $V_t, t \in T$ corresponding to the affine instantaneous spaces $M_t, t \in T$.
3. Each compatible affine connection defines a Spin. In particular it turns out that the connection of Cartan describing gravity, is compatible. The corresponding Spin defines a section of the bundle of Spins and the corresponding resulting principal bundle structure is called "inertial".
4. The Spin participates in the expression of the difference between two compatible connections.
5. Every continuum (a flow $\varphi_s, s \in \mathbb{R}$) defines a Spin.

From these results it is concluded that the concept of Spin helps in a "natural" study of the geometry of M. In addition, the Spin is the basic component of geometric component of the connection of Cartan giving the necessary (as was proved by P. Appleby) "inertial" principal structure to M for formulating the laws of motion.

This work stems from the first part of the thesis.

4. ***"The Electromagnetic Field in Classical Space-Time", N. Kadianakis, Il Nuovo Cimento Vol. 89A N.2, p. 204-215, (1985).***

In this paper we show that an appropriate differential geometric structure of classical space-time manifold M can describe the problem of motion of a charged particle in an electric field E and a magnetic field B, in the context of non-relativistic physics. This structure is given by a compatible connection Γ whose Riemann tensor satisfies four conditions. It turns out that when the equation of motion of the particle is considered as the equation of geodesics, the conditions that satisfy the Riemann tensor give the Maxwell equations for the E and B. It is also demonstrated that when another compatible connection Γ΄ is already defined on M, then the tensor field Γ΄-Γ is defined in terms of a differential 2-form which is closed (dh = 0).

5. ***"Vorticity Preserving Motions in Classical Space-Time", N. Kadianakis, Il Nuovo Cimento Vo. 95B, N. 1, p. 82-98, (1986).***

The motion of a continuous medium is defined by a flow on the manifold M of classical space-time and its vorticity is defined by the restriction of a differential 2-form on the spatial vectors. In this paper:
(i)We formulate and prove necessary and sufficient conditions for the motion to preserve its vorticity. These conditions reduce to the known conditions for the trivial structure $M = T \times E$.
(ii) We prove, on the manifold M, a suitable generalization of the theorem of Kelvin in the differential and integral forms. In order to prove this theorem we prove the following: The velocity field of the motion defines a family of differential 1-forms (because the metric g is singular). The exterior derivatives of all these forms restricted to space-like vectors are equal to the vorticity.

6. ***"A Frame-independent description of the principles of Classical Mechanics" P. Appleby and N. Kadianakis, Arch. Rational Mech. Anal., Vol. 95, N.1 p. 1-22 (1986).***

The aim of this work is the formulation of the basic principles of mechanics in the form of relations between geometrical quantities defined on the differential manifold M of classical space-time. As a consequence, this formulation is independent of reference systems. The work consists of two parts:
In Part I the concept of mass is defined as a positive Borel measure on M, which is characterized by a generalized function, its density. The concepts of the material universe and material body are also defined. Then: (i) We give an axiomatic theory of the affine connections describing the gravitational field due to random mass distributions. For any Borel set A, such a connection Γ is defined on the exterior of A satisfying certain axioms. It turns out that Γis uniquely analyzed into two components. (ii) We construct an axiomatic theory of material interactions in order to describe systems of forces. These forces are described by means of vector measures in M. With the help of (i) and (ii) we formulate the basic principles of conservation of mass, momentum and angular momentum in a quite general level, so that these principles should be applicable in random distributions of matter (discrete or continuous).
In Part II we demonstrate how the general principles set out in Part I give the equations of continuity and equations of motion for a continuum. Next, we formulate the conservation of energy and the constitutive equations for a continuum.
In Part III of this work we have embedded the results of Section III of the PhD thesis.

7. ***"Convected time-derivatives in Continuum Mechanics, P. Appleby and N. Kadianakis, Il Nuovo Cimento Vol. 102B, N. 6, p.593 (1988).***

Continuum mechanics often use some specific time derivatives, such as material and co-rotational, which measure the rate of change of a quantity, as measured by an observer who follows, either the entire motion of the continuum, or only its rotational component. In this paper we use an affine connection defined by the motion for the definition of a general convected derivative which in turn gives all the particular derivatives. This is achieved by extending the concept of (rigid) Spin defined in previous work to a derivation not compatible with the inner product of space-like vectors. We prove that such a generalized Spin decomposes into a sum of a rigid Spin and a 2^{nd} order symmetric tensor field (expressing a "deformation" of the derivation).

In this paper we embodied the results of the part II of the PhD thesis.

8. ***"Affine Connections and Frames of reference in Classical Mechanics" N. Kadianakis, Rep. on Math. Physics, Vol.30, N.1 p. 21-32, (1991).***

The concept of the affine connection is often used in physical theories. Recent efforts on the foundation of mechanics in a frame independent way are based on the notion of classical space-time equipped with an affine connection. This connection usually describes the gravitational field in the sense that a material point moving under the influence of gravity alone, follows a geodesic of the connection. Because the metric of the classical space-time is singular and we do not assume a frame of reference, the role of the connection is crucial since it enables comparison of vectors at different times and therefore enables the derivation of vector and tensor fields. Therefore, the concept of connection in space-time is closely related to the concept of the frame of reference.

In this paper we give a purely mathematical proof of this relation. We define the concept of the compatible affine connection and the concept of the frame of reference in classical space-time M. Then:

(a). We classify the set C of all rigid compatible affine connections into classes of zero relative spin. (b) We classify the set F of all frames of reference into classes of zero spin, and each such class, into classes of zero relative acceleration. (c) We prove the existence of a natural bijective mapping between the set F of frames of reference and the set C of compatible affine connections which maps classes Σ of connections with zero relative spin τo classes S of frames with zero relative spin. Further, the map induces a bijective map C←→S such that a flat affine connection in C corresponds to class of frames in S, having zero relative acceleration.

Hence a flat affine connection on M can be considered as a class of frames with zero relative spin and zero relative acceleration.

9. ***"Disease and Community Structure. The Importance of Self-Regulation in a Host-Host-Pathogen Model", M. Begon, R. Bowers, N. Kadianakis, D. Hodgkinson, The American Naturalis Vol. 139, N. 6, 1992.***

This paper is a study of a population model consisting of two competing species having a common and directly transmitted disease. The disease divides each species into two populations (patients and non patients), thus introducing a complex dynamics in the original system. The model is described by a system of four differential equations (one for each population category of each kind). The difficulty in the study of such a system is the existence of 12 parameters that control its behavior.

The study of the system was done in two stages: first we studied the behavior of a simplified system with one species (two equations), and then studied the behavior of the complete system.

Initially there was a study of the number of critical points of the system for different regions of parameter space defined by relations between parameters. Then we studied the kind of stability of these points. Finally, we did a numerical simulation for various values of the parameters.

Areas of parameter space with ecological interest where: (a) The two species coexist eventually blocking the disease. (b) The two species coexist with the common disease. (c) One of the species eliminates the other using the disease.

10. ***"The Kinematics of Continua and the Concept of Connection on Classical Space-Time", N. Kadianakis, Int. J. Engng. Sci. Vol. 34, N. 3, p. 289-298, (1996).***

This paper studies the relationship between two different kind of mathematical concepts defined on the classical space-time manifold: the concept of affine connection and the concept of flow. The connection is used to describe physical concepts such as the gravity field, and the flow is used to describe the motion of a continuous medium. The study includes the following steps:

A. We classify the set of compatible, in a very broad sense, affine connections Γ on M into classes of connections with zero relative deformation (Δ-classes). Next, each such class is classified into classes of zero relative spin(R-classes).

B. We classify the set of flows similarly into classes of zero relative deformation (δ-classes) and each such class into classes of zero relative spin (r-classes). Then each r-class is divided into classes of zero relative acceleration.

C. It is shown that there exists a mapping between the set of flows and the set of compatible connections. We show that (i) two flows belong to the same δ-class if and only if the corresponding connections belong to the same Δ-class. (ii) Two flows from the same δ-class belong to the same r-class if and only if the corresponding connections belong to the same R-class. (iii) Two flows from the same δ-class and the same r-class will be in the same a-class if and only if the corresponding connections coincide.

11. ***"Geometrical Aspects of the Co-Rotational Derivative", N. Kadianakis, ZAMM, Vol. N. , p. 137-142, (1997).***

In this paper we study the co-rotational derivative defined by a continuum, equivalent by a flow in the classical space-time manifold M. The study is done in the broader context of a particular class of derivatives, called Spins, with properties like those of co-rotational derivative. We show that each Spin supplies the classical space-time M with a geometric structure similar to that of connection. In particular, we make the distinction between uniform and non-uniform Spin and prove that:

1. Every Spin defines an isometric parallel transfer of space-like vectors. We give an explicit expression of the Spin in terms of this parallel transport. 2. The parallel transfer is independent of the path, if and only if the Spin is uniform. 3.The Spin defined by a continuous motion is uniform if and only if the motion is homogeneous.

12. ***"Lie-Derivatives of Associated Tensor Fields on a Riemannian Manifold", N. Kadianakis, Bulletin of Greek Mathematical Society (1997).***

The operations rising or lowering of indices of a tensor field on a Riemannian manifold, produce associated tensor fields but they do no commute with the Lie derivative. In the applications all the associated fields are related to the same physical quantity, while the Lie derivative describes its rate of change. It is therefore interesting to know how the derivatives of associated fields are related. We prove formulas relating the Lie derivatives of associated vector fields, differential forms and tensor fields of 2^{nd} order. These formulas contain kinematic of continuum mechanics.

13. ***"On the Geometry of Lagrangian and Eulerian Descriptions in the Kinematics of Continua", N. Kadianakis ZAMM, Vol. 79, N. 2 p. 131-138, (1999).***

In this work we present a frame-independent and coordinate-free approach to the Lagrangian and Eulerian descriptions of the motion of a continuum. Working on manifolds gives us the coordinate-free setting, while the use of classical space-time as the ambient space where the continuum moves gives the frame-independent description. This space-time has the minimum possible geometric structure, incorporating only the principle of absolute simultaneity. It does not assume any frames of reference given a priori. Any concept defined is therefore frame-independent. It is shown that many of the kinematical concepts can be defined, in this context. We present both Lagrangian and Eulerian descriptions and show that many of the formulas concerning the classical relations between the tensor fields in these two descriptions, hold in this more general framework.

14. ***"Frame-independent Forms of the Equation of Continuity", N. Kadianakis. Far East Journal of Mathematical Sciences 2(5) p.819-831, (2000).***

The principle of conservation of mass and the induced equation of continuity are usually given with respect to a frame of reference. Moreover, the form of the equation depends on the dimension of the continuous.

In this paper:

(I) We give the principle of conservation of mass and the equation of continuity in a form independent of frames of reference and the dimension of the continuum. (II) We show that on an appropriate submanifold of classical space-time, the equation of continuity takes the form $\mathrm{div}\rho u=0$, regardless of the dimension of the continuum. (III) We produce, using the geometry of the submanifold, forms of the equation for material surfaces and curves. (IV)We consider the additional structure in classical space-time given by a frame of reference and prove that these forms of the equation give the well known forms relative to a frame of reference, thus they present a generalization.

15. ***"Evolution of Surfaces and the Kinematics of Membranes", N. Kadianakis. Journal of Elasticity 99 p.1-17 (2010).***

In this work we study a general form of motion (deformation) of a surface and produce formulas for variation of basic quantities that characterize its internal and external geometry. These formulas concern the first and second fundamental form, the unit normal vector field, the Gauss curvature and mean curvature. The problem is approached as model of the kinematics of a continuous medium of dimension 2 (a film, a membrane or an interface), following the works of Truesdell and Noll for an axiomatic foundation of mechanics for a 3-dimensional continuum

(Arch. Rat. Mech. Anal. 2:197–226, 1958), Truesdell and Noll (The Non-linear Field Theories of Mechanics, 3rd edn., Springer, Berlin, 2004), Truesdell (A First Course in Rational Continuum Mechanics, vol. 1, Academic Press, San Diego, 1977). For this purpose we use a generalized version of the of polar decomposition theorem for surfaces (Chi-Sing Man and H. Cohen (J. Elast. 16:97–104, 1986)) and apply methods and concepts from the mechanics of continuous media. The variations of the geometrical quantities are expressed in terms of other geometrical quantities, as well as in terms of kinematic quantities, thus obtaining a physically richer and often a simpler form. The results are then specialized to the case of parallel surfaces.

16. ***"Kinematics of Hypersurfaces in Riemannian manifolds" N. Kadianakis, F. Travlopanos, Journal of Elasticity (2012).***

In this work we give a generalization of the results of the paper 15, maintaining the co-dimension of the geometrical object and the approach in terms of continuum mechanics. Specifically, we consider a hypersurface of dimension m moving in an ambient space of dimension m +1 which is a Riemannian manifold. The approach is based on a generalization of the polar decomposition theorem to hypersurfaces. The variation formulae contain terms involving the Riemann curvature tensor of the ambient manifold. We give formulas expressing the variation of the geometric objects either in geometrical or in kinematical terms. The results are applied to special cases of motions such as normal motion and tangential motion as well as to special dimensions such as curves moving on a surface.

17. ***«A note on the variation of the Levi Civita Connection of a Riemannian hypersurface» N. Kadianakis, F. Travlopanos (submitted for publication).***

The aim of this work is to study how the Levi-Civita affine connection of a hypersurface *M* is varied when the hypersurface is moving in an ambient Riemannian manifold *N*. We prove formulas for the variation of the connection in various equivalent forms and study special cases of motions. This problem contributes to the general study of the variation of the geometry of a hypersurface, some aspects of which are presented in the paper 16. We use this study as a model in continuum mechanics for the kinematics of an m-dimensional continuum or interface, moving in an (m+1)-dimensional ambient space like curves moving on surfaces, surfaces moving in a 3-dimensional space or hypersurfaces moving in a Riemannian space of arbitrary dimension. Although the variation of the connection have been studied in the literature before, more often for special motions, or special ambient spaces, here we focus on the most general motion, in an ambient Riemannian manifold, using kinematical quantities from continuum mechanics and a coordinate-free language. These kinematical quantities come from a generalized version of the polar decomposition theorem for hypersurfaces. We show that the variation of the connection can be expressed in terms of the single kinematical quantity of stretching. We derive conditions for infinitesimal affine motions and apply our results to important special cases like normal or tangential motions. We show that an infinitesimally affine motion in a Euclidean space can give parallel hypersurfaces if and only if it has a parallel (covariantly constant) second fundamental form. Further, we give some specific examples illustrating our method.

18. ***"Local Frames in Euclidean Space-Time", P. Appleby and N. Kadianakis. 22th Polish Solid Mechanics Conference", September 1980.***

This paper studies all local covariant derivatives that are compatible with the structure of classical space-time. Particular emphasis is given to expressing the difference between two such derivatives which is a tensor of type (1,2). It turns out that this tensor is completely characterized by a spatial antisymmetric tensor field of second order and a spatial vector field.

The study was done in a way completely independent from the one in part I of the PhD thesis as well as from the paper 3 which is based on the concept of Spin.

Next we study those covariant derivatives for which the velocity of a continuum has zero covariant derivative.

19. "A frame-independent description of the equations of state in Continuum Mechanics", P. Appleby and N. Kadianakis. ***2nd Anglo-Polish Mechanics Symposium,*** **1983.**

This work is contained in Part II of paper 6.

20. "The equation of Continuity for surfaces", N. Kadianakis, ***5th Conference on Mathematical Analysis Crete 1996.***

This work is part of paper 14.

21. "On the Geometry of the Kinematics of Continua", N. Kadianakis, ***2nd Panhellenic conference on Geometry, Athens (*****1997).**

This paper presents some of the results of work 12 in combination with the results of work 13.

22. "Kinematics of Hypersurfaces in Riemannian manifolds" , N. Kadianakis, F. Travlopanos, 10th ***Panhellenic conference on Geometry,*** **Patra 17-19 May 2011.**

This paper presents some of the results of work 16.

23. "Variations of certain geometrical objects in the kinematics of Hypersurfaces" N. Kadianakis, F. Travlopanos,11° *Panhellenic conference of Geometry,* Athens, Greece 2013. (member of the scientific committee).

This paper presents some more of the results of work 16 as well as, some newer results..