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Preface

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From the 7th to the 11th of July 1997, workshops on Irreversibility and Cosmology (part I) and on Fundamental Aspects of Quantum Mechanics (part II) were held in Peyresq, Alpes de Haute-Provence, France. Peyresq is a medieval Provencal village, situated 100 km from Nice at an altitude of 1528 m. The village was founded in the early 13th century. At the beginning of the 17th century there were around 50 houses and by 1851 the village counted 208 inhabitants distributed among 53 families. Like many other villages of Haute-Provence, it was almost completely deserted after the Second World War. During the 1950s the village was progressively entirely rebuilt in its original spirit and style by students of Belgian universities, mainly the Université Libre de Bruxelles, under the guidance of Mady and Toine Smets. The aim was to create a "Foyer d' Humanisme," an international humanistic center for cultural, artistic, and scientific pursuits.

The Workshop was financed by the Foundation Peyresq, Foyer d'Humanisme, the Fondation Nicolas Claude Fabri de Peyresq, Olam, the Fondation pour la Recherche Fondamentale of Belgium, the European Community (DG XII) under contracts CII*-CT94-0004 and PSS*0992, and the Flemish and Polish governments (Project of Bilateral Scientific and Technological Cooperation 61). We would like to thank all these institutions for their help as well as Aerolinias Argentinas for their financial support. We would also like to extend our warm appreciation to Madame Mady Smets, who is the guardian angel of Peyresq, and without whom none of this work could have seen the light of the day.

PART I. IRREVERSIBILITY AND COSMOLOGY

This section of the meeting was organized by the RGGR, Research Group in General Relativity, of the Free University of Brussels and by the Quantum-Relativistic Theories and Gravitation Group Buenos Aires University.

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The organizers acknowledge the high level of the contributions of the distinguished researchers of these groups.

As in the 1996 meeting [see *International Journal of Theoretical Physics*, **36** (11)], the main subject was the theory of irreversible processes and its relation to cosmology. Among the issues discussed were the stability of cosmological structures and the production of entropy in the universe. Relativistic quantum mechanics was also considered as in the previous meeting.

After paper [1], which can be considered as a physical and philosophical introduction, several papers are devoted to the definition of irreversibility using Hardy function spaces.

Two approaches are proposed using these spaces:

1. Lax–Philips Scattering Theory

This theory is used in paper [2] to study systems approaching equilibrium and the Loschmidt paradox (also a quantum version of it) and its relation to the theory of nonself-adjoint operators.

2. Rigged Hilbert Spaces (RHS) Formalism

An axiomatic definition of irreversibility using RHS is presented in paper [3]. The corresponding time-reversal operator is defined in paper [4]. A study of resonances in RHS is developed in paper [5]. According to paper [6], the RHS must be further extended to obtain a rigorous version of some formulas used in the literature. An extension of the GNS theorem to RHS is presented in paper [7].

3. Other Approaches to Irreversibility

Alternative formulations of irreversibility (not using Hardy spaces) are introduced in paper [8] using the subdynamics theory and a functional approach (which is closely related to the formalism of RHS) and in paper [9], where Brownian motions are studied using other techniques.

4. Cosmology

Cosmological subjects are developed in papers [10–13]. The generation of entropy in Kaluza–Klein models is studied in paper [10], the stability of cosmic strings and loops, built of fermion modes coupled to vortex-forming Higgs fields, are studied in paper [11]. Paper [12] deals with the Einstein versus Jordan-frame debate in scalar–tensor theories of gravitation. A cosmological toy model containing interesting features that can be used to answer some questions of the theory of irreversible processes is presented in paper [13].

5. Relativistic Quantum Mechanics

Finally, paper [14] presents a covariant formalism for particles and antiparticles of spin 1/2.

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[3] M. Castagnino and E. Gunzig: Minimal Irreversible Quantum Mechanics: An Axiomatic Formalism.

[4] M. Gadella and R. de la Madrid: Resonances and Time Reversal Operators in Rigged Hilbert Spaces.

[5] A. Bohm, H. Kaldass, and P. Patuleanu: Hilbert Space or Gel'Gand Triplet. Time-Symmetric or Time-Asymmetric Quantum Mechanics.

[6] M. Gadella and R. Odóñez: Some Comments on the RHS Formulation of Resonance Scattering.

[7] S. Iguri and M. Castagnino: The Formulation of Quantum Mechanics in Terms of Nuclear Algebras.

[8] R. Laura and R. M. Id Betan: Subdynamics Theory in the Functional Approach to Quantum Mechanics.

]9] F. Gaioli, E. T. Garcia Alvarez, and D. G. Arbó: Quantum Brownian Motion. II.

[10] V. Faraoni and E. Gunzig: Cosmic Entropy from the Bosonic String?

[11] A. Gangui, P. Peter, and E. Gunzig: Fermionic Currents in Cosmic Strings.

[12] V. Faraoni and E. Gunzig: Einstein Frame or Jordan Frame?

[13] A. Korol, L. Lara, and M. Castagnino: What We Can Learn About Irreversibility from a Cosmological Toy Model.

[14] E. T. Garcia Alvarez and F. H. Gaioli: Covariant Hamiltonian Formalisms for Particles and Antiparticles.

PART II. QUANTUM STRUCTURES AND QUANTUM EXPERIMENTS

This section of the meeting was organized by the group FUND, Research Group on the Foundations of Exact Sciences, of the Free University of Brussels, in the framework of a project of bilateral cooperation between Flanders and Poland, entitled "Probing the Structure of Quantum Mechanics: New Probability Models for New Experiments on Quantum Particles," which gathers researchers from the universities of Brussels (VUB). Antwerp (UIA), and Gdansk (GU).

The organizers acknowledge the high level of the contributions of the distinguished researchers who took part in the workshop.

The project in the framework of which this symposium was organized gathers physicsts interested in the fundamental aspects of quantum mechanics, their theoretical as well as experimental aspects, and more specifically the fruitful connection that always exists between them. Theoretical hypotheses suggest new experiments, while new experiments require extensions and reformulations of existing theories. Such recurrent topics as the role of time in quantum mechanics, nonlocality, the measurement problem, the superposition principle, the problem of compound entities, and quantum probability form the background of the research carried out by the participants of the symposium.

Although Erwin Schrödinger claimed that we would never be able to see a single quantum jump, recent decades have seen very sophisticated experiments by which it has been possible to check the validity of quantum predictions during individual measurements. Use of trapped ions, cavity QED, atomic and neutronic interferometry, and Bell-like experiments are among the many examples of high-tech realizations which have confirmed the validity of nonclassical concepts such as nonlocality, wave–particle dualism, the superposition principle, and so one.

Recent decades have also seen interesting new theoretical results concerning the foundations of quantum mechanics. Just to mention the problems connected with the axiomatic description of compound quantum entities: some of the traditional quantum axioms have been identified as being the origin of the problems, and these problems are directly related to the existence of non-product states in the traditional tensor product description of compound systems, and the existence of these non-product states is the origin of the nonlocal effects in EPR-type experiments, now experimentally well confirmed.

The experiment realized in Paris [15], in which interferences are formed by light emitted by delocalized atoms prepared in a longitudinal Stern–Gerlach-like atomic interferometer [16], illustrate perfectly the purpose of the workshop. This experiment forces us to consider seriously questions of the kind: Is light localized? What is the time of emission of a photon during a decay process? Are massive objects such as atoms localized?

The other contributions contain axiomatically oriented work (axiomatic foundations [17–19], quantum probability [20]), work related to the role of time in quantum mechanics (time operator [21], existence of a fundamental spatiotemporal unit of length [22], quantum memory effects [23]), work on nonlinear quantum mechanics [24], and experimental evidences of nonlocality [25]. The philosophy which guided us is very close to the spirit of Peyresq, where for many years regular conferences have been organized on the foundations of quantum mechanics. The title of one such congress, “A New Language for Quantum Technology,” organized 2 years ago in Peyresq by the Foundation de Broglie would also have been very appropriate for the present symposium.

If, in everyday life, to know always means to understand, quantum mechanics has brought us, according to Feynman's words ("nobody understands quantum mechanics"), to a situation where we know things that we do not understand. The hope which underlies all the energy invested in fundamental research about quantum theory is that if we better know quantum mechanics, perhaps we shall better understand it.

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[21] J. Naudts: Off-Shell Relativistic Quantum Mechanics and Formulation of Dirac's Equation Using Characteristic Matrices.
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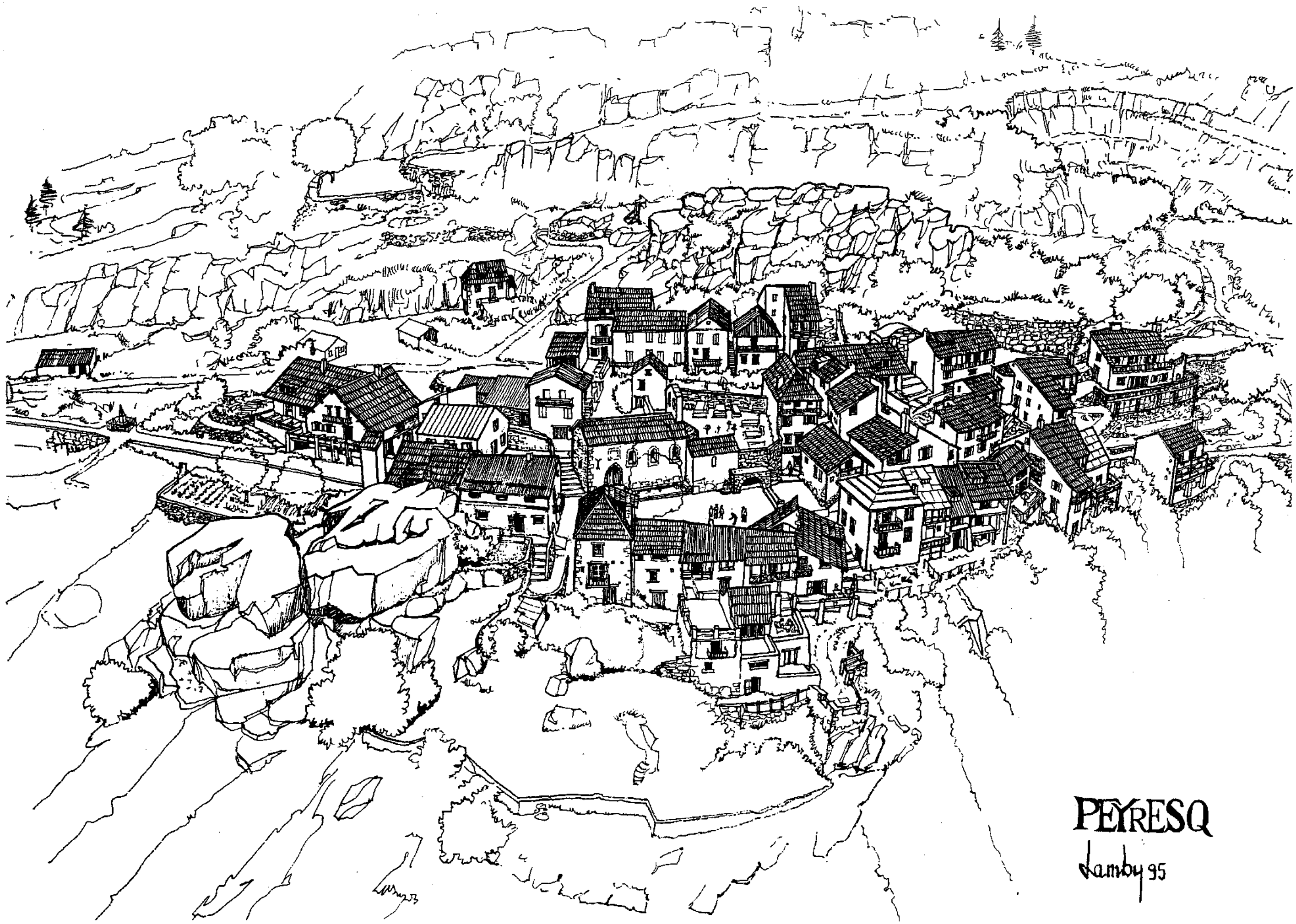
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