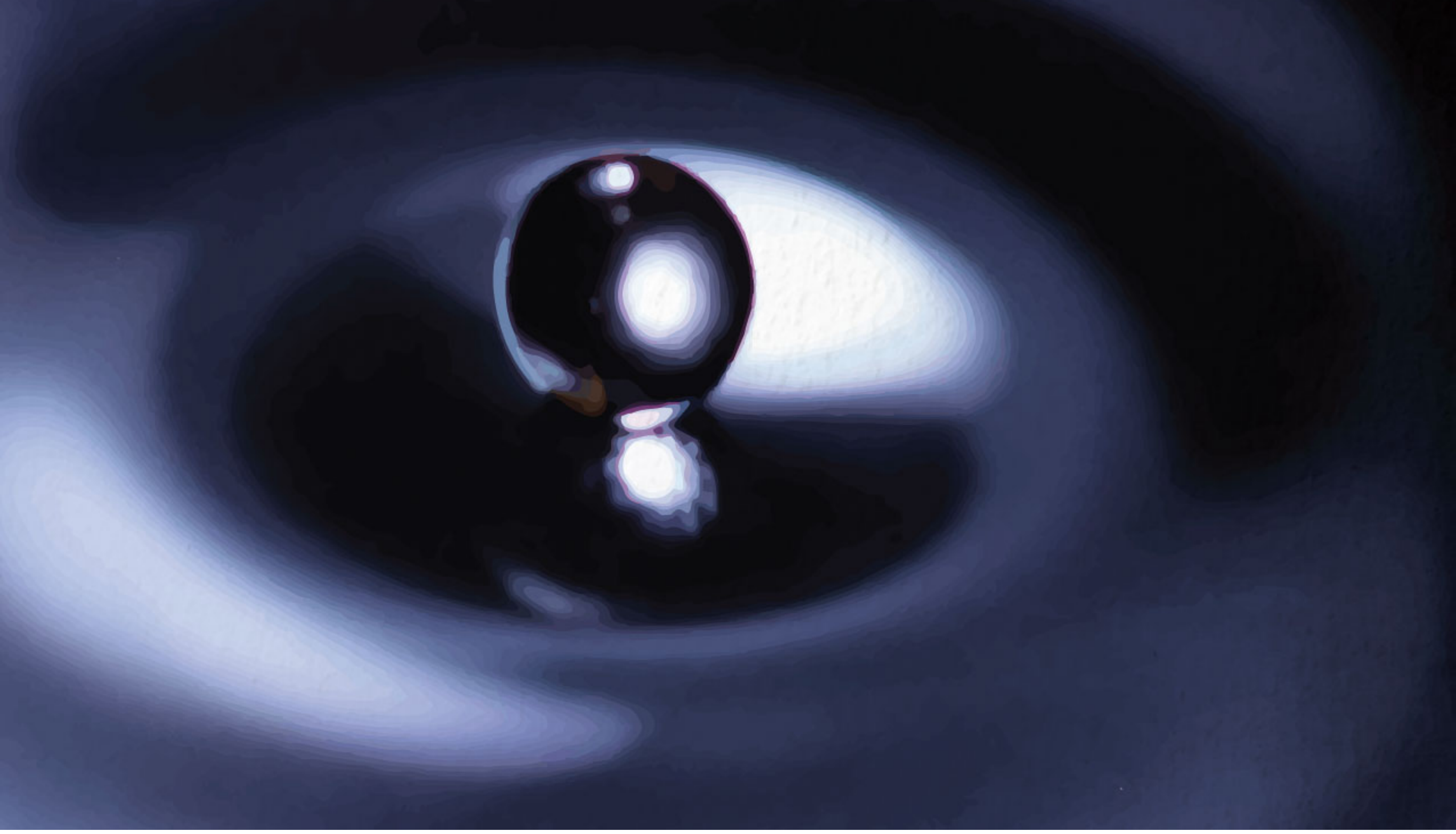
International Conference on Advances in Pilot Wave Theory

From experiments to foundations
Seeking more intelligible explanations for Quantum Phenomena

CONCURRENTLY HOSTING
HYDRODYNAMIC QUANTUM ANALOGS (HQA-2021)

26 - 30 July 2021 // Online

BOOK OF ABSTRACTS



ADVANCES IN PILOT WAVE THEORY

From experiments to foundations. Seeking more intelligible explanations for Quantum Phenomena

CONCURRENTLY HOSTING
HYDRODYNAMIC QUANTUM ANALOGS (HQA-2021)

INTERNATIONAL CONFERENCE
26-30 JULY 2021
ONLINE

Organization:
Centro de Filosofia das Ciências da Universidade de Lisboa (CFCUL) / RG2-Philosophy of Natural Sciences, with the collaboration of MIT'S HQA Research Group.

Scientific Committee:
Paulo Castro (CFCUL/GI2), John W.M. Bush (MIT), José Croca (CFCUL/GI2)

Organizing Committee:
Paulo Castro (CFCUL/GI2), Silvia Di Marco (CFCUL)

Website:
http://pilotwave.campus.ciencias.ulisboa.pt

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// PRESENTATION

At the inception of quantum mechanics, almost a century ago, Louis de Broglie proposed his pilot-wave theory as the basis of a realist quantum dynamics. While both Einstein and Schrödinger championed a similar philosophical viewpoint, the Copenhagen interpretation was instead to prevail. Although the standard quantum mechanics formalism has been very successful in predicting the statistical behavior of quantum systems, it yields little insight into the nature of quantum dynamics.

The first quarter of the 21st Century has seen both a resurgence of pilot-wave theory and a demand for a clearer physical picture of the microscopic, quantum realm. New experimental and theoretical evidence for the plausibility of pilot-wave dynamics in Quantum Mechanics has emerged from the nascent field of hydrodynamic quantum analogs. This conference will try to reignite the debate over pilot-wave theory from both physical and philosophical viewpoints.

The conference will cover three themes: 1. Hydrodynamic quantum analogs, 2. Theoretical advances in pilot wave physics, and 3. Philosophical foundations of pilot wave theory.

// PROGRAMME

The time of the programme is Lisbon time (GMT+1/UTC)

DAY 1 – Monday, 26 July

Chairs: Paulo Castro & Aurelien Drezet

14:00 – 14:20	Opening
14:20 – 15:10	**John W. M. Bush** (MIT, USA) **// keynote speaker** *Hydrodynamic quantum analogs*
15:10 – 15:40	**Matthieu Labousse** (ESPCI Paris, CNRS, PSL University, France) *Mechanisms of macroscopic eigenstates*
15:40 – 16:10	**Guido Bacciagaluppi**[1] **& Maaneli Derakhshani**[2] ([1]Ultrecht University, The Nederlands / [2]Department of Mathematics at Rutgers university, New Brunswick, USA) *On Multi-Time Correlations in Stochastic Mechanics*
16:10 – 16:40	Break
16:40 – 17:30	**Ana María Cetto** (UNAM, Mexico) **// keynote speaker** *On the origin and nature of the wave element in quantum mechanics according to stochastic electrodynamics*

DAY 2 – Tuesday, 27 July

Chairs: José Croca & Ana María Cetto

14:00 – 14:30	**Yuval Dagan** (Faculty of Aerospace Engineering, Technion, Israel) *A Hydrodynamically-inspired relativistic pilot-wave theory*
14:30 – 15:00	**Augusto Garuccio**[1] **& Angela Laurora**[2] ([1]University of Bari, Italy / [2]University of Basilicata-Matera Campus, Italy) *John Bell's unpublished notes about de Broglie's Pilot Wave*
15:00 – 15:30	**Maxime Hubert** (PULS group, Friedrich-Alexander Universität Erlangen-Nürnberg, Germany *Overload wave-memory induces amnesia of a self-propelled particle*
15:30 – 16:00	**Valeri Frumkin** (MIT, USA) *Superradiant droplet emission and hydrodynamic non-separability*
16:00 – 16:30	Break
16:30 – 17:20	**José Croca** (CFCUL/GI2, Portugal) **// keynote speaker** *The Quest for the Ontic Nature of the Quantum Waves*
17:20 – 17:50	**Philipp Roser** (Western Washington University, USA) *Unquantizing quantum physics: dynamics without the quantisation condition*

DAY 3 – Wednesday, 28 July

Chairs: John W. M. Bush & Gildo Magalhães

14:00 – 14:30	**André Nachbin** (Instituto Nacional de Matemática Pura e Aplicada, Brazil) *Wave-mediated Kuramoto-like synchronization for droplets interacting at a distance*
14:30 – 15:00	**Paul Milewski** (University of Bath, UK) *Faraday Pilot Wave Dynamics in One Dimension: where did the memory go?*
15:00 – 15:30	**Harold "Sonny" White** (The Limitless Space Institute, USA) *Dynamic Vacuum Model Development*
15:30 – 16:00	**Loic Tadrist** (Aix-Marseille University, France) *Realisation of a beam splitter for walking droplets*
16:00 – 16:30	Break
16:30 – 17:20	**Thomas Durt** (Ecole Centrale de Marseille · Institut Fresnel, France) // **keynote speaker** *De Broglie's double solution program, nearly one century later: a survey*
17:20 – 17:50	**Herman Batelaan** (University of Nebraska-Lincoln, USA) *Decoherence and Degeneracy in Electron Matter Wave Experiments*

DAY 4 – Thursday, 29 July

Chairs: André Nachbin & João L. Cordovil

14:00 – 14:30	**Tapio Simula** (Swinburne University of Technology, Australia) *Droplets and superfluids*
14:30 – 15:00	**Anand Oza** (New Jersey Institute of Technology, USA) *Exploring diffraction with a pilot-wave model*
15:00 – 15:30	**Pedro Saenz** (University of North Carolina, USA) *Hydrodynamic Spin Lattices*
15:30 – 16:00	**Aurelien Drezet** (Univ. Grenoble Alpes, CNRS, Institut Néel, France) *A mechanical analog of the Bohr and de Broglie atomic model*
16:00 – 16:30	Break
16:30 – 17:20	**Valia Allori** (Philosophy Dept, Northern Illinois University, USA) // **keynote speaker** *"What If?" Speculations about the Best of All Possible Quantum Worlds*
17:20 – 17:50	**Gildo Magalhães** (University of S. Paulo, Brazil) *Form and function as expressions of the historical and epistemological problem of continuity*

DAY 5 – Friday, 30 July

Chairs: Tapio Simula & Valia Allori

14:00 – 14:50	**Lee Smolin** (Perimeter Institute for Theoretical Physics, Canada) // **keynote speaker** *Views, variety and the quantum*
14:50 – 15:20	**Louis Vervoort** (University of Tyumen, Russia) *Probability theory as a physical theory points to superdeterminism; and implications for hidden-variable theories*
15:20 – 15:50	**João L. Cordovil** (CFCUL/GI2, Portugal) *An emergentist perspective of the QM's measurement problem*
15:50 – 16:20	Break
16:20 – 16:50	**Jonathan Tennenbaum** (CFCUL/GI2) *The Douboschinski pendulum – a paradigm for quantization through nonlinear interactions*
16:50 – 17:40	**Paulo Castro** (CFCUL/GI2, Portugal) // keynote speaker *A strong nomological interpretation of Quantum Mechanics. Towards a theory of physical encoded information*
17:40 – 18:00	Closing remarks

// KEYNOTE SPEAKERS

Valia ALLORI, Philosophy Department at Northern Illinois, USA

John W. M. BUSH, MIT, USA

Paulo CASTRO, CFCUL/GI2, Portugal

Ana María CETTO, UNAM, Mexico

José CROCA, CFCUL/GI2, Portugal

Thomas DURT, Ecole Centrale de Marseille – Institut Fresnel, France

Lee SMOLIN, Perimeter Institute for Theoretical Physics, Canada

// ABSTRACTS

Valia ALLORI (keynote speaker)
Philosophy Department at Northern Illinois University, USA

"What If?" Speculations about the Best of All Possible Quantum Worlds

Standard quantum mechanics, the theory we find in physics book, is said to be incompatible with scientific realism, the view that scientific theories can give us an approximately true description of the world. Usually, realists claim that this is due to the measurement problem, namely the problem of the unobserved macroscopic superpositions predicted by the theory, and that by solving the measurement problem one can have at least three realist quantum theories: the pilot-wave theory, the many-worlds theory, and the theory of spontaneous collapse. In this paper I argue that the measurement problem is the wrong problem to look at, if someone is a realist. First, I show how this problem was proposed to convince the positivists, rather than the realists: quantum theory had indeed a problem, first and foremost, of empirical adequacy. Then I show how, starting from the 1920s, what was identified as the problem of quantum theory had nothing to do with measurements but rather it was a problem of incompleteness. For reasons with little scientific merit, these worries had been taken to imply that no possible completion of quantum theory was possible, which in turn pushed for instrumentalism. When realists re-examined quantum mechanics later in the 20th century, they either went back to the incompleteness problem and shut down again (like Bohm), or they focused on the measurement problem (like Everett as well as Ghirardi, Rimini and Weber). In this paper I speculate on what would have happened if instrumentalists had not won, and people actually realized that quantum theory can be completed, even if nonlocally. Had this happened, then it would have been straightforward to see how: 1) no one would have ever looked at the wavefunction as the ontology of the theory; 2) no one would have ever looked at the measurement problem, 3) two out of the three quantum solutions of the measurement (the many-worlds theory and the theory of spontaneous collapse) would have never been considered. Since the reasons why people did not take completions of quantum theory seriously are devoid of any scientific value, in the best of all possible worlds the only option for a realist quantum theory would have been the pilot-wave theory.

Guido BACCIAGALUPPI[1] **& Maaneli DERAKHSHANI**[2]
[1]Ultrecht University, Nederlands / [2]Department of Mathematics at Rutgers university, New Brunswick, USA

On Multi-Time Correlations in Stochastic Mechanics

As pointed out by Nelson himself, stochastic mechanics appears to fail to recover the multi-time correlations predicted by quantum theory. In standard quantum theory, in order to calculate the correlations between the position of a particle at multiple times, one considers a series of position measurements, which localise the particle at the given times. Straightforward application of the Born rule yields the multi-time correlations. In Nelson's mechanics, the particle has a well-defined position at all times, and the stochastic process determines the correlations in position at multiple times. The quantum mechanical calculation and the stochastic mechanical calculation, however, lead to different results. In order to recover the standard predictions, as shown explicitly by Blanchard et al., one would have to use collapsed wavefunctions also in stochastic mechanics. The question is how to justify this move, especially since in Nelson's theory the wavefunction is not even a fundamental object.

We show that the answer consists in importing into stochastic mechanics certain techniques used in pilot-wave theory, specifically the notion of `effective collapse' of the universal wavefunction, which is the tool that was developed by Bohm to describe measurements. We argue that this strategy is in fact especially natural in stochastic mechanics, precisely because the wavefunction is not a fundamental object in this theory.

Herman BATELAAN
University of Nebraska, USA

Decoherence and Degeneracy in Electron Matter Wave Experiments

Modelling quantum decoherence and degeneracy for electron waves is challenging and may benefit from being considered within different approaches to quantum mechanics. Within this context our experimental efforts are reported.
Quantum decoherence is often considered to be an important part of understanding the classical to quantum boundary. Finding physical systems in which decoherence can be studied in a controlled fashion is hard. In particular, finding a system where dissipation and decoherence can both be measured together to test the Caldeira-Leggett equation is an outstanding problem. We report on our efforts to find such systems for electron matter wave-to-wall interactions.
Quantum degenerate electron beams that can be used do not exist. The problem is to distinguish Coulomb pressure from Pauli pressure. Our experimental attempts to do this are reported. Ultimately, we are working towards a test of non-locality for the Pauli Exclusion Principle.

John W. M. BUSH (keynote speaker)
Department of Mathematics, Massachusetts Institute of Technology, USA

Hydrodynamic quantum analogs

I provide an overview of the field of hydrodynamic quantum analogs initiated in 2005 by the seminal experiments of Yves Couder and Emmanuel Fort. Particular attention is given to enumerating the dynamical mechanisms responsible for the emergence of robust, structured statistical behavior, and to exploring the potential and limitations of the walking-droplet system as a quantum analog.
A primary focus is demonstrating how the non-Markovian nature of the droplet dynamics, as results from the persistence of its pilot wave field, may give rise to behavior that appears to be spatially nonlocal. Finally, we describe recent theoretical explorations of a generalized pilot-wave framework that allows us to capture quantum-like features inaccessible to the walking-droplet system. This framework provides a mathematical bridge between the hydrodynamic pilot-wave system and various realist models of quantum dynamics, including the pilot-wave theories of Louis de Broglie and David Bohm.

Paulo CASTRO
Center for Philosophy of Sciences of the University of Lisbon, Portugal

A strong nomological interpretation of Quantum Mechanics. Towards a theory of physical encoded information

Since 1927, the year Niels Bohr idealism prevailed over Louis de Broglie realistic insights, that Quantum Mechanics has been the object of several interpretations to understand atomic behavior. However, any effort to reinstate our rational way of thinking about quantum phenomena seems to fall back into an idealistic way of portrait the wave entity. In recent years, a nomological interpretation (*nomos* meaning law-like in Nature) has been proposed by the Bohmian School. Although particles are to exist at all times, their law-like guiding wave is still an elusive entity, only acting in the theory as a mathematical object, devoid of any real physical existence.
In my talk I wish to challenge the unavoidability of this separation between a nomological approach to quantum nature and the realistic existence of quantum waves. In short, I will propose that a quantum wave, as the particles within it, do exist at all times and that the wave encodes all possible cinematic behaviors of its guided particles. I will thus suggest that Quantum Mechanics is a second order physical theory about Nature. A theory about encoded physical information, where the regular behaviors commonly summarized in the "laws of Nature" are an emergent result from the information encoded in quantum waves.

***Anna María CETTO** (keynote speaker)
Instituto de Física, Universidad Nacional Autónoma de México, Mexico

On the origin and nature of the wave element in quantum mechanics according to stochastic electrodynamics

Stochastic electrodynamics (SED) is a fundamental theory for quantum mechanics constructed from first physical principles, revealing quantization as an emergent phenomenon that arises from a deeper stochastic process. The basis of SED is the interaction of the electron – considered as an otherwise classical particle – with the electromagnetic zero-point radiation field. The permanent action of this random wave field on the electron impresses wavelike properties on its statistical behavior, without the particle ever losing its corpuscular nature; the de Broglie wave assigned to the moving particle is thus seen to have an electromagnetic origin. A comparison of the quantum-mechanical system with the hydrodynamic analog reveals some interesting commonalities as well as differences. A deeper analysis of these may help in achieving a better comprehension of the emergence of quantization and in determining the extent of the analogies.

João L. CORDOVIL
Center for Philosophy of Sciences of the University of Lisbon and University of Lisbon, Portugal

An emergentist perspective of the QM's measurement problem

As it is well known, the measurement problem is a long-standing problem regarding Quantum Mechanics or, at least, of its interpretation. Roughly speaking, the measurement problem arises from the transition of a system in Quantum Mechanics from a superposition state to a definitive state. That is, how a system transforms from being in a quantum state to be on a classic state. As is also well known, there are several attempted solutions to the measurement problem. Despite the vast array of options, most of the solutions presented assume that classic entities or properties are metaphysically reducible (or identical, in some cases) to quantum entities or properties. But maybe we can question this assumption. Maybe we can explore the idea that classic entities are not ontologically reducible but emergent from quantum entities. Thus, perhaps we can reformulate the measurement problem as: how a classic entity emerges from quantum entities? This presentation aims to explore if and how the theory of emergence could be applied to the measurement problem and if this approach can clarify the problem.

José CROCA (keynote speaker)
Center for Philosophy of Sciences of the University of Lisbon and University of Lisbon, Faculty of Sciences, Department of Physics, Portugal

The Quest for the Ontic Nature of the Quantum Waves

In the history of physics, the quest for the ontic nature of some theoretically proposed entities has a long tradition. In the end, the question was and is, whether some of these proposed entities do have a real physical nature or, on the contrary, are mere conceptual helpful tools. It is common knowledge, for those familiar with the history of science, that the more pragmatic research traditionally maintains that the question for the elucidation of the nature of the proposed theoretical entities is not a relevant issue. From the advent of modern science to present times these rough controversies have played an important role in the development of science. Presently we are faced with another of these controversies, related with ontic nature of the quantum waves. Orthodox quantum mechanics, claims that quantum waves, solution to the Schrödinger equation, are conceptual tools, mere probability waves devoid of any physical reality. De Broglie and his nonlinear causal school sustain that quantum waves, or as they may now be named, subquantum waves, guiding waves, pilot waves, empty waves, zero-point field waves, theta waves, de Broglie waves, stand for the description of something having real physical existence.
Now, just as before, to the great majority of physicists, having a more practical pragmatic attitude before science, this controversy, on the ontic nature of the quantum waves, whether they are mere probability waves or, on the contrary, do have physical reality, is without any sense. They say that they don't care, because the issue is not relevant to do the actual quantum calculations.
We believe that the clarification of the nature of the quantum waves is a very important issue. If indeed quantum waves do have real physical existence, as some experiments seem to indicate, then a whole new universe of theoretical and technological possibilities will open.

Yuval DAGAN
Faculty of Aerospace Engineering - Technion – Israel Institute of Technology, Haifa, Israel

A Hydrodynamically-inspired relativistic pilot-wave theory

In 2005, Yves Couder discovered that millimetric droplets could walk across a vibrating fluid bath surface, self-propelling through a resonant interaction with their own wave field. These walking droplets exhibit several features previously thought to be exclusive to the microscopic quantum realm. As such, they represent a macroscopic realization of the double-solution pilot-wave theory of de Broglie, who envisaged microscopic particles as having an internal vibration at the Compton frequency, interacting with a monochromatic guiding wavefield with the de Broglie wavelength.
Several authors have attempted to develop theoretical quantum dynamics models based on insights gained from the walker system. In our recent study (Dagan & Bush, 2020), we revisited de Broglie's double-solution theory and suggested a new theoretical quantum dynamic model, the 'hydrodynamic quantum field theory' (HQFT). In this computational framework, inspired by insight gained from the hydrodynamic analog, dynamic interactions of waves and particles on the Compton scale are realized, including the mechanism for particle-induced wave generation, by incorporating insights from the hydrodynamic system. We model the particle as a localized periodic disturbance in the Klein-Gordon (KG) field at twice the Compton frequency. In this model, particles are self-propelled, gradient-driven by pilot waves generated by the oscillating particle and evolve according to a one-dimensional KG equation. Resonance is achieved between the particle and its pilot wave, leading to self-excited motion of the particle. The particle locks into quasi-steady motion characterized by a mean momentum $p = \hbar k$, where k is the wavenumber of the surrounding matter waves. Speed modulations along the particle path arise with the de Broglie wavelength and frequency ck. The emergent dynamics are strongly reminiscent of that arising in the hydrodynamic pilot-wave system.
Here, we proceed by assessing the viability of HQFT and the extent to which the hydrodynamic system may be used as a rational model for relativistic quantum dynamics. To this end, we propose a new variant of HQFT, in which classical non-relativistic particle dynamics are modeled instead of the relativistic dynamic model originally suggested. Markedly, some quantum features such as the relativistic modulation frequency and de Broglie's wavelength are captured by the theoretical model. Hence, we propose a new mechanism for the emergence of the relativistic quantum signature of free particles, suggesting a new non-relativistic model for relativistic quantum dynamics.

Aurelien DREZET
Univ. Grenoble Alpes, CNRS, Institut Néel, Grenoble, France

A mechanical analog of the Bohr and de Broglie atomic model

We provide a relativistic model for a classical particle coupled to a scalar wave-field through a holonomic constraint. In presence of an external Coulomb field, we define a regime where the particle is guided by the wave in a way similar to the old de Broglie phase-wave proposal. Moreover, this dualistic mechanical analog of the quantum theory is reminiscent of the double-solution approach suggested by de Broglie in 1927 and is able to reproduce the Bohr-Sommerfeld semiclassical quantization formula for an electron moving in an atom.

Thomas DURT (keynote speaker)
Ecole Centrale de Marseille, Institut Fresnel, France

De Broglie's double solution program, nearly one century later: a survey

In 1927, Louis de Broglie took part to the 5th Solvay Physics Council in Brussels ("Electrons et photons"') where he proposed a non-standard interpretation of the quantum theory in which particles follow well-defined trajectories governed by the Schrödinger wave function (also called "pilot wave" in this context), in accordance with the so-called "guidance equation". This dynamic is classical in the sense that it reintroduces at the quantum level the concept of continuous and deterministic trajectory but it also departs from the classical intuition by several aspects. Although it remained somewhat confidential, the de Broglie-Bohm interpretation played a prior role in the recognition of the non-classical (contextual and non-local) features of the quantum theory. It can be seen as an ultimate attempt to interpret this theory in a realistic fashion. The objective of our talk is to discuss the relevance and shortcomings of recent developments related to de Broglie's double solution program, which are semi-classical gravity, quantum equilibrium, and bouncing oil droplets or "walkers", putting into light their paradoxical implications as well as their intrinsic limitations.

Valeri FRUMKIN
Department of Mathematics, Massachusetts Institute of Technology, USA

Superradiant droplet emission and hydrodynamic non-separability

Superradiance was proposed theoretically by Robert Dicke in 1954 to describe a 'cooperative', spontaneous emission of photons from a collection of atoms. When the separation between the atoms is much smaller than the emission wavelength, superradiance can be understood classically, by picturing each atom as a tiny antenna emitting electromagnetic waves. A more interesting type of superradiance occurs when the separation between the atoms is comparable to the emission wavelength, in which case quantum mechanical treatment is needed to explain the phenomenon. According to the quantum mechanical picture, this type of superradiance occurs when at each absorption event, a single photon is stored in a cloud of N atoms of the same kind. The atoms interact with each other through the *E/M* field, creating collective non-separable states that can radiate the photon faster or slower than if it were stored in a single atom.
In this work we demonstrate superradiant emission of droplets from parametrically excited hydrodynamic cavities. The cavities consist of deep circular wells in a liquid bath, and are spanned by a thin layer of oil, that allows for coupling of the cavities through their common wavefield. We show that the amplified emission rate oscillates sinusoidally as a function of the distance between the cavities, as does the emission rate of photons from a pair of trapped ions. We thus establish a hydrodynamic analog of superradiance. We show that the emission events at both cavities are strongly anti-correlated, allowing us to define non-separable emission states in this hydrodynamic system. The resulting hydrodynamic non-separability

allows us to change the state of the entire superradiating system by acting on a single cavity. Unlike its quantum counterpart, hydrodynamic non-separability is not subject to quantum decoherence, and so may have potential for applications in non-classical computing, and other quantum technology-inspired applications.

Augusto GARUCCIO[1] & Angela LAURORA[2]
[1]University of Bari, Italy / [2]University of Basilicata-Matera Campus, Italy

John Bell's unpublished notes about de Broglie's Pilot Wave

In this contribution we present and discuss an unpublished note of Joh Bell on the De Broglies's Pilot Wave. The note is the result of the analysis of the scientific correspondence and other original documents made available by Mrs. Mary Bell, wife and colleague of John, made by one of us (A.L.) in a PhD project devoted to the historical reconstruction of the scientific thought of John Bell and confirms the highly original character in theoretical research. Bell's original documents, a manuscript entitled "Notes for a history of the pilot wave", confirms that the Irish researcher considered central the idea of the pilot wave. We will present, moreover, a comparison between the unpublished note and the short writing published in 1988 in memory of de Broglie, that suggest that Bell had in mind to write a more elaborate work on this subject. Unfortunately, his sudden and untimely disappearance has put the end word to this project.

Maxime HUBERT
PULS group, Department of Physics and Interdisciplinary Center for Nanostructured Films, Friedrich-Alexander Universität Erlangen-Nürnberg, Germany.

Overload wave-memory induces amnesia of a self-propelled particle

The role of memory is at the core of biological active matter with examples in ants and termites dynamics resulting in complex structures formation. While essential in understanding animal behavior, the effects of memory are still poorly understood, mainly because of the lack of model systems allowing to investigate memory-driven dynamics. More specifically, the consequences of the inclusion of an increasing amount of memories in active matter are not understood. In recent years, a candidate for this investigation appeared with walking droplets. Indeed, the droplet is propelled thanks to the standing waves left on the liquid by previous impacts. The droplet is able to read and react to its own memory here encoded on the surface, and the amount of memories is continuously and externally controllable.
In this presentation, we discuss the dynamics of both the wave field and the walker from a statistical point-of-view as the memory is continuously increased. We show that the walker is submitted to a bifurcation from a steady motion at constant speed and low memory to a chaotic diffusive-like trajectory at high memory. We show that the wavefield encodes all the correlations within the dynamics. Indeed, the successive impacts of the droplet on the liquid are correlated in such a way that destructive interferences are observed, mimicking a minimization process in the wavefield construction. Despite the correlations in the wavefield, we show that the increasing memory leads to a Markovian dynamic for the walker, that we

can discuss through an effective thermal energy mainly independent of the memory parameter.

Matthieu LABOUSSE
Gulliver, CNRS, ESPCI & PSL Université, Paris, France

Mechanisms of macroscopic eigenstates

Waves and particles are distinct objects at a macroscopic scale. The existence of *walkers*, drops bouncing on a vertically vibrated fluid bath is a surprising case of dual objects at our scale. The drop is self-propelled, piloted by the standing surface waves generated by its previous rebounds. These objects exhibit a rich dynamic relying on the concept of *path memory*. In this talk, I will give a theoretical understanding of the temporal non local structure of *walkers*. We will explore the dynamics of walkers in a confined situation. I will review some of the most striking results that have been experimentally observed so far and rationalize theoretically with classical arguments. Finally, we will discuss a classical mechanism leading to the buildup of classical macroscopic wave eigenstates.

Gildo MAGALHÃES
University of S. Paulo, Brasil

Form and function as expressions of the historical and epistemological problem of continuity

During historical processes, transformations are collectively achieved after a certain time and looked from afar they seem to be a continuous development. Likewise natural processes also exhibit an appearance of continuity. Wave-like descriptions have unveiled how aspects of continuity can be integrated with discontinuity in the domains of human history and natural history, including chemistry, physics, geology, and cosmology. This matter may be also approached from the biological standpoint. Although few biologists continue supporting a genetically functional, i.e. causal morphology, the evolution of form cannot be isolated from the evolution of function, thereby an emphasis on teleology is not only demanded but altogether necessary for bridging the chasm between the several human sciences.

Paul MILEWSKY
University of Bath, UK

Faraday Pilot Wave Dynamics in One Dimension: where did the memory go?

We shall discuss Faraday pilot-wave dynamics in one dimension. In this case it has been shown that the trajectory equation (obtained through a "stroboscopic approximation") which is commonly used by many groups may be recast as a local-in-time system of ordinary differential equations equivalent to the Lorenz system. This is unusual, as it indicates that the approximation appears to lose the "path memory" of the original system, which is not the case in two-dimensional dynamics. Starting with the discrete-time formulation of the problem we will discuss various results and compare the behavior of the discrete system to that of the continuous time system with a stroboscopic approximation. This is joint work with Eileen Russel.

André NACHBIN
Instituto Nacional de Matemática Pura e Aplicada, Brasil

Wave-mediated Kuramoto-like synchronization for droplets interacting at a distance

We present a computational study using a simplified one-dimensional model for pilot-wave hydrodynamics in the presence of submerged barriers.
A droplet is confined to a fluid cavity, as a particle confined by a potential. Two bouncing droplets confined within fluid cavities can interact separated by a large distance. As first displayed in our tunneling study (Nachbin, Milewski & Bush, PRF 2017), single pilot-wave dynamics can be affected by a vacant nearby cavity. This non-local wave effect is further reported in Nachbin (Fluids 2020). In the case of two oscillators, the wave-mediated droplet-interaction persists even at a distance. In Chaos (Nachbin, 2018) we examined the correlated phase-space dynamics of two droplets confined to separate cavities. Through cycles in phase-space we found regimes where oscillators spontaneously synchronized, as in the celebrated Kuramoto model. We also discovered a regime which led to the statistical indistinguishability of two droplets. In this talk we will review these results and present our current findings regarding the interplay between droplets at a distance.

Anand OZA
New Jersey Institute of Technology, USA

Exploring diffraction with a pilot-wave model

The seminal experiments of Yves Couder and Emmanuel Fort demonstrated that a droplet walking on the surface of a vibrating fluid bath may exhibit behavior thought to be peculiar to the quantum realm. One of their experiments suggested that single-particle diffraction and interference may be obtained when a walker crosses a single or a double-slit between submerged barriers (Couder & Fort, Phys. Rev. Lett. 2006). Later experiments with finer control of experimental parameters yielded different results, thus reopening the question of the extent of the analogy between walkers and quantum particles (Andersen et al., Phys. Rev. E 2015; Pucci et al., J. Fluid Mech. 2018; Rode et al., Phys. Rev. Fluids 2019). Here we use the hydrodynamic pilot-wave model developed by Oza et al. (J. Fluid Mech. 2013) to explore numerically the diffraction of a wave-driven particle by barriers, which are represented as an array of reflecting point sources of waves. The statistical distribution of the particle's deflected position generally exhibits multiple peaks, the number of which depends on the obstacle geometry and the bath's forcing acceleration. We will discuss the similarities and differences between these statistical distributions and the Fresnel and Fraunhofer diffraction patterns in optics.

*This is joint work with Antoine Bellaigue (Institute of Physics, University of Rennes) and Giuseppe Pucci (National Research Council of Italy, Institute of Nanotechnology)

Philipp ROSER
Western Washington University, US

Unquantizing quantum physics: dynamics without the quantisation condition

The single-valuedness of the wave function is crucial to making quantum mechanics "quantized", forcing discrete angular-momentum eigenvalues in hydrogen-like atoms, for example. Quantum dynamics may, however, also be formulated without a wave function in terms of the fluid-like dynamics of an ensemble, where the law of evolution explicitly depends on the local configuration-space density. In order to fully recover the solutions of quantum mechanics in such a framework, the quantisation condition must be added "by hand" and appears, arguably, ad hoc. I review a few ideas designed to justify the introduction of the quantisation condition. Then, using theoretical considerations and numerical simulations with specific examples, I ask, what does "quantum" dynamics look like without that condition?

Pedro SÁENZ
Department of Mathematics, University of North Carolina at Chapel Hill, USA

Hydrodynamic Spin Lattices

In this talk, we will introduce a hydrodynamic analog system that allows us to investigate simultaneously the wave-mediated self-propulsion and interactions of effective spin degrees of freedom in inertial and rotating frames. Millimetric liquid droplets can walk across the surface of a vibrating fluid bath, self-propelled through a resonant interaction with their own guiding wave fields. By virtue of the coupling with their wave fields, these walking droplets, or 'walkers', extend the range of classical mechanics to include certain features previously thought to be exclusive to the microscopic, quantum realm. A walker may be trapped by a submerged circular well at the bottom of the fluid bath, leading to a clockwise or counterclockwise angular motion centered at the well. When a collection of such wells is arranged in a 1D or 2D lattice geometry, a thin fluid layer between wells enables wave-mediated interactions between neighboring walkers. Through experiments and mathematical modeling, we demonstrate the spontaneous emergence of coherent droplet rotation dynamics for different types of lattices. For sufficiently strong pair-coupling, wave interactions between neighboring droplets may induce local spin flips leading to ferromagnetic or antiferromagnetic order. Transitions between these two forms of magnetic order can be induced through variations in non-equilibrium driving, lattice geometry and Coriolis forces mimicking an external magnetic field. Theoretical predictions based on a generalized Kuramoto model derived from first principles rationalize our experimental observations, establishing HSLs as a generic paradigm for active phase oscillator dynamics.

Tapio SIMULA
Swinburne University of Technology, Australia

Droplets and superfluids

In the experimentally focused part of this presentation, I will provide an update on the progress of the construction of a new droplets laboratory at Swinburne University of Technology in

Australia. This includes an outline of the key capabilities of the new instrument, and plans for the near term experiments. In the theoretically focused part, I will discuss how a Bose-Einstein condensation phase transition of a laboratory superfluid gives rise to an emergent analog spacetime with `fundamental' particles and interactions. By contrast, quantum mechanics in such a spacetime is not emergent and is inherited from the underlying layer of constituent particles such as atoms.

Lee SMOLIN (keynote speaker)
Perimeter Institute for Theoretical Physics, Waterloo, Canada

Views, variety and the quantum

A non-local hidden variables theory for non-relativistic quantum theory is presented, which gives a realist completion of quantum mechanics, in the sense of a complete description of individual events. The proposed fundamental theory is an extension of an energetic causal set theory, which assumes that time, events, causal structure, momentum and energy are fundamental. But space and the wave function are emergent. The beables of the theory are the views of the events, which are a subset of their causal pasts. Thus, this theory asserts that the universe is a causal network of events, which consists of partial views of itself as seen by looking backwards from each event. The fundamental dynamics is based on an action whose potential energy is proportional to the variety, which is a measure of the diversity of the views of the events, while the kinetic energy is proportional to its rate of change. The Schrodinger equation is derived to leading order in an expansion in density of the events of the fundamental histories.
To higher order, there are computable corrections, non-linear in the wave function, from which new physical effects may be predicted.

Loic TADRIST
Aix-Marseille University, France

Realisation of a beam splitter for walking droplets

The analogy between quantum particles and walking droplets raised the possibility to explain quantum phenomena from deterministic but chaotic equations. Several experimental works on walking droplets were dedicated to testing the limits of the quantum analogy. Their results were surprisingly close to the predictions of quantum mechanics (quantized orbital radii in a potential well for instance). However, little is known about the nature of the wavy interactions between walking droplets. The Hong-Ou-Mandel experiment reveals different interactions between quantum particles depending if they are fermions or bosons: when two quantum particles are sent on each side of a beam splitter, they may gather (bosons) or be sent in opposite directions (fermions). The reproduction of this experiment (as well as many others, e.g. entanglement) with walkers requires the design of a physical beam splitter. In this talk, we propose an experimental configuration that may represent a beam splitter for walking droplets. The beam of droplets (a single droplet repeatedly sent to the beam splitter) is separated thanks to a standing wave. The experimental results show that our set-up effectively

separates the droplet beam, with a high sensitivity to variations of standing wave amplitude and impact parameters.

Jonathan TENNENBAUM
Center for Philosophy of Sciences of the University of Lisbon, Portugal

The Douboschinski pendulum – a paradigm for quantization through nonlinear interactions

So-called argumental interactions are characterized by the property, that the exchange of energy is regulated by phase-frequency-amplitude fluctuations in the participating oscillating systems, while each of them operates at very nearly its own proper frequency and retains (in the mean) its characteristic dynamic parameters. The simplest and most famous example is known as Doubochinski's Pendulum: a classical pendulum (1 Hz) interacting with an alternating-current electromagnet (30-1000 Hz), and possessing a discrete series of stable amplitudes. The presentation will discuss the phenomenology and mechanism of emergence of "quantized" amplitudes in this system, including some newer results of interest. Some ideas will be presented concerning the general principles by which quantum mechanical laws might ultimately be derived from the properties of nonlinear processes on the subquantum level.

Louis VERVOORT
University of Tyumen, Russia

Probability theory as a physical theory points to superdeterminism; and implications for hidden-variable theories

Probability theory as a physical theory is, in a sense, the most general physics theory available, more encompassing than relativity theory and quantum mechanics, which comply with probability theory. Taking this simple fact seriously, I argue that probability theory points towards superdeterminism, a principle that underlies, for instance, 't Hooft's Cellular Automaton Interpretation of quantum mechanics. Specifically, I argue that superdeterminism offers a solution for 1) Kolmogorov's problem of probabilistic dependence; 2) the interpretation of the Central Limit Theorem; and 3) Bell's theorem. Superdeterminism's competitor, indeterminism ('no hidden variables'), remains entirely silent regarding 1) and 2), and leaves 3) as an obstacle rather than a solution for the unification of quantum mechanics and general relativity. I will discuss the implications for hidden-variable theories. (Reference: Entropy 2019, 21(9), 848.)

Harold "Sonny"WHITE
The Limitless Space Institute, US

Dynamic Vacuum Model Development

This talk will summarize a pilot wave interpretation of quantum mechanics known as the dynamic vacuum model which claims the quantum vacuum can vary both spatially and temporally. Recently published findings for this dynamic vacuum model approach are discussed along with their implications which lead to possible new insights associated with the Casimir force phenomenon. The findings suggest that there is structure to the perturbed vacuum state that exists in a Casimir cavity, and two notional custom Casimir cavity geometries are presented and discussed. One notional micro/nano geometry consists of a standard parallel plate Casimir cavity equipped with pillars arrayed along the cavity mid-plane with the purpose of detecting a transient electric field arising from vacuum polarization conjectured to occur along the midplane of the cavity. A second micro/nano geometry consists of a tapered cavity geometry similarly equipped with pillars along the mid-plane with the purpose of generating a longitudinal wave pulse in the dynamic vacuum. An analytic technique called worldline numerics was adapted to numerically assess vacuum response to these custom Casimir cavity geometries. Some of the analysis results are presented and discussed, preliminary experimental approaches and equipment identified, and early manufacturing prototypes are presented.

// BIOGRAPHICAL NOTES

***Valia ALLORI** is Professor of Philosophy at Northern Illinois University. She has studied both physics (in Italy, her home country) and philosophy (in the United States), and she is interested in metaphysics, philosophy of science, especially philosophy of physics and the foundations of quantum theory. She has been a 2017– 2018 National Humanities Center Fellow.

Guido BACCIAGALUPPI is Associate Professor of Foundations of Physics at Utrecht University. He specialises in the history and foundations of quantum mechanics and has worked on a variety of topics, including pilot-wave theories and stochastic mechanics. He is the author of 'Quantum Theory at the Crossroads' with A. Valentini, a monograph on the 1927 Solvay conference.

Herman BATELAAN studied physics at the University of Leiden and obtained the Ph.D. at the University of Utrecht. He is a professor at de University of Nebraska and a fellow of the American Physical Society for “outstanding contributions to electron matter optics, in particular the measurements of the Kapitza-Dirac effect and elucidation of the Aharonov-Bohm effect.“

***John W. M. BUSH** is a Professor of Applied Mathematics at MIT. Having completed his BSc in Physics at University of Toronto, he went on to Harvard for his PhD in Geophysics, then the University of Cambridge for postdoctoral research at DAMTP. He joined the faculty of MIT in 1998, was tenured in 2004 and is now the Director of the Applied Mathematics Laboratory. His research began in geophysics, but then shifted towards surface-tension-driven phenomena and their applications in biology. For the past decade, his research has been focused on hydrodynamic quantum analogs.

***Paulo CASTRO** studied Physics at the Faculty of Sciences of the University of Lisbon. Three years later he moved to the Humanities where he graduated in Anthropology at University Nova de Lisboa in 1996. He holds a PhD in the philosophy of contemporary thought from the University Lusófona of Humanities and Technologies. In 2015 he joined the Philosophy of Natural Sciences Research Group, at the Center for the Philosophy or Sciences of the University of Lisbon, where he presently works on the philosophy of nonlinear Quantum Mechanics.

***Anna María CETTO** is Research Professor at the Institute of Physics and lecturer at the Faculty of Sciences, Universidad Nacional Autónoma de México (UNAM). She holds an M.A. degree in Biophysics from Harvard University and M.Sc and Ph.D degrees in Physics from UNAM. Her main field of research is theoretical physics (foundations of quantum mechanics), where she has made substantial contributions to the understanding of quantization as an emergent phenomenon. She has published 14 books and 130 research articles. Prof. Cetto is former Dean of the Faculty of Sciences and UNESCO consultant for the World Conference on Science. From 2003 to 2010 she was Deputy Director General of the International Atomic Energy Agency (Nobel Peace Prize 2005). She is founding president of LATINDEX, online information system for Ibero-American and Caribbean scholarly journals. She has served on the Boards of a number of international organisations, including the the Third World Organisation for Women in Science

(TWOWS, Co-Founder), International Council for Science (ICSU), International Foundation for Science (IFS), United Nations University (UNU), International Network of Engineers and Scientists (INES) and the Pugwash Conferences (Nobel Peace Prize 1995). She is currently President of the Mexican Physical Society and science advisor to the Ministry of Foreign Affairs in Mexico.

João L. CORDOVIL has a PhD in History and Philosophy of Science from the Faculty of Sciences of the University of Lisbon. In July 2019 he became a researcher in the Department of History and Philosophy of Science at that same University. Presently he is the Scientific Coordinator of the Centre for the Philosophy of Sciences of the University of Lisbon.

***José CROCA** is Head of the Research Group on the Foundations of Quantum Physics at the Center for the Philosophy of Sciences of the University of Lisbon (CFCUL). Held a teaching position at the Department of Physics of the University of Lisbon. Did its PhD in 1985 at the University of Lisbon under the supervision of J. Andrade e Silva, one of the most direct collaborators of Louis de Broglie. Did postgraduate research at the University of Bari with Professor Franco Selleri. He is the author of innumerous scientific books, papers and talks in international conferences about nonlinear causal quantum physics. He has proposed several experiments to detect quantum waves, a non-linear Schrödinger equation and its wavelet-based set of generalized uncertainty relations, from which Heisenberg's result as a particular case. Founding member of the Center of Philosophy of Sciences of the University of Lisbon and Head of the Research Group on the Foundations of Quantum Physics. Received two International Prizes: the 2008 Santilli-Galileu 2008 Gold Medal, for The Crusading Work Towards the Demise of the Prevailing Scientific Obscurantism and the FIR Prize 2008, for his Work in promoting Reason, from the Federação Internacional Racionalista.

Yuval DAGAN has a PhD in Aerospace Engineering (2016) from the Technion - Israel Institute of Technology. In 2017 received the MIT-Technion Postdoctoral Fellowship and joined the Reacting Gas Dynamics Laboratory in the Department of Mechanical Engineering at MIT. In 2018 joined the Applied Mathematics Laboratory at MIT as a Postdoctoral Research Associate under the supervision of Prof. John Bush. Since 2019, assistant Professor in the department of Aerospace Engineering at the Technion.

Maaneli DERAKHSHANI is currently a Postdoctoral researcher in the foundations of physics at Rutgers University -- New Brunswick, Department of Mathematics. He obtained his PhD in the foundations of physics from Universiteit Utrecht in 2017, under the supervision of Prof. Guido Bacciagaluppi.

Aurélien DREZET is a physicist at the Institut Néel-CNRS, Grenoble-France. His current research topics and interests include: 1) Quantum-nano-photonics and plasmonics (topological meta-materials, near-field optics). 2) Foundation of quantum mechanics (Bohmian mechanics, de Broglie double solution, mechanical analogs).

***Thomas DURT** teaches quantum physics at the Ecole and Centrale de Marseille and is researcher at the Institut Fresnel. He is also member of the scientific committee of the Fondation de Broglie. His main interests are quantum foundations, quantum optics and quantum information. Recent research topics include de Broglie's double solution program, the possibility to break the superposition principle due to a non-linear self-interaction of gravitational origin (Schrödinger-Newton equation), the onset of quantum equilibrium and the possibility to derive the Born rule from the hidden quantum dynamics, the photon wave-function and the associated de Broglie-Bohm trajectories.

Valeri FRUMKIN is postdoctoral fellow at the Massachusetts Institute of Technology, studying Hydrodynamic Quantum Analogs with John W. M. Bush. Previously he was postdoctoral fellow at Technion – Israel Institute of Technology (Israel), worked with Moran Bercovici on Fluidic Shaping of Optical Components and on developing novel microfluidic technologies. PhD Thesis: Technion – Israel Institute of Technology (Israel) on Nonlinear Dynamics of Bilayer Fluid Systems Subjected to Thermocapillarity, under the supervision of Alexander Oron.

Augusto GARUCCIO is Honorary Professor at University of Bari, Italy. Past Full Professor of History and Didactics of Physics. The primary research interests are on Foundations of Quantum Mechanics and its Applications (Einstein, Podolsy, Rosen paradox and Bell's inequality; State vectors of first and second type; Wave-Particle duality and de Broglie's theory of Pilot Wave; Experimental problems of polarization correlation of photon pairs; Bohm theory of quantum potential; Quantum optics and complementarity; Parametric down-conversion sources of correlated photon pairs; Quantum technologies based on entangled states; Correlation Plenoptic Imaging; Didactics and History of Modern Physics). Over the past several years he collaborated with Prof. Franco Selleri in Bari, Prof. Jean Pierre Vigier in Paris, Prof. Leonid Mandel in Rochester, Proff. Yanhua Shih and Morton Rubin in Baltimore. From 1980 he is referee of Foundation of Physics and Physics Letters A. Author of more than 200 scientific papers in international journal with peer review. Editor with A. van der Merwe of the book *Waves and Particles in Light and Matter*, Plenum, New York, 1994. Member of organizing committee of 14 conferences on Foundations and Applications of Quantum Mechanics. Member of the Italian Society of Physics and Astronomy Historians and a member of the Italian Physics Society.

Maxime HUBERT obtained his PhD thesis at the University of Liège (Belgium) in 2018, working numerically and theoretically on active transport phenomena along interfaces. He studied the physical principles of self-propulsion and micro-swimming, and he developed memory kernels to understand bimodal diffusive dynamics. Willing to switch his skills and knowledge to biological problems, He joined the PULS group at the Friedrich-Alexander University Erlangen-Nuremberg (Germany). He is now investigating the collective migration of epithelial cells and its relation to the mechanical environment of the tissue, the maintenance of tissue homeostasis and the topological properties of epithelial tissues.

Matthieu LABOUSSE is a theoretical physicist and works at ESPCI Paris -PSL as a CNRS researcher. His research is carried out in the laboratory Gulliver. He combines numerical, theoretical and even sometimes experimental approaches to investigate the physics of self-organization in complex systems including Programmable active matter, Metamaterials, Design of polymer systems, Waves and memory.

Angela LAURORA is contract professor in Didactics and History of Physics, Primary Education Sciences at Department of Humanities, University of Basilicata in Matera Campus since 2017. After graduating in Physics with the thesis "An interactive didactic approach to the photoelectric effect", she obtained a PhD in History of Science at the University of Bari, deepening from a historical point of view the contributions of John Bell to research about the paradox of Einstein, Podolsky and Rosen; the thesis results were presented at Congresses of the Italian Society for the History of Physics and Astronomy. Her research activity also involved the design and experimentation of didactic paths at school, combining the laboratory approach based on easy-to-find and low-cost materials with the use of the history of physics as a qualifying element for teaching physics. She is a member of the Italian Society of Physics and Astronomy Historians and a member of the Italian Physics Society.

Gildo MAGALHÃES is electrical engineer at Polytechnical School, University of São Paulo; Ph.D. in History, University of São Paulo; Visiting Scholar, Dibner Library of Rare Books and Manuscripts, Smithsonian Institution (Washington, D.C); Fellow, Chemical Heritage Foundation, now Science History Institution (Philadelphia); Associated Member, Center for the Philosophy of Science, University of Lisbon. Currently Full Professor of History of Science and Technology, Department of History, Faculty of Philosophy, Letters, and Human Sciences, and Director, Center for the History of Science, University of São Paulo.

Paul MILEWSKI is Professor of Applied Mathematics at the University of Bath. Prior to that he held positions at Stanford and Wisconsin-Madison. He completed his PhD in Applied Mathematics at MIT in 1993. He has worked in modelling, computation and asymptotics of a variety of problems in fluid dynamics, often involving nonlinear geophysical waves. He has published over 75 papers on a variety of topics, has supervised over 15 PhD students, is on the editorial board of several Applied Mathematics Journals and is the Head of the Department of Mathematical Sciences.

André NACHBIN is full professor at IMPA (Institute of Mathematics Pure and Applied/Brazil). Undergraduate and MSc in Civil Engineering from the Federal University of Rio de Janeiro. PhD in Mathematics from the Courant Institute of Mathematical Sciences, New York University. Member of the Brazilian Academy of Sciences.

Anand U. OZA is an Assistant Professor in the Department of Mathematical Sciences at the New Jersey Institute of Technology (NJIT). He received his bachelor’s degree from Princeton University, master’s degree at DAMTP, University of Cambridge, and PhD in mathematics from MIT. He was an NSF postdoctoral fellow at the Courant Institute, New York University, and then joined the NJIT faculty in 2017. His research is concerned with physical applied mathematics, with a focus on fluid mechanics and soft matter physics. His work uses a combination of mathematical modeling, asymptotic analysis, and numerical simulation, and is typically motivated by laboratory experiments.

Philipp ROSER received his PhD under the supervision of Antony Valentini at Clemson University in 2016. Following a series of short-term teaching positions, he joined Western Washington University in 2018. His research encompasses questions in quantum gravity and cosmology, and in the foundations of quantum mechanics.

Pedro SÁENZ is an Assistant Professor and the director of the Physical Mathematics Laboratory (www.pml.unc.edu) in the Department of Mathematics at UNC. From 2015 to 2019, he was an Instructor in the Department of Mathematics at MIT. Pedro received his Ph.D. from the University of Edinburgh in 2014 and pursued brief post-doctoral studies at Imperial College London in 2015. His research blends experiments, numerical simulations and theory, to address fundamental problems that find motivation in Physics and Engineering.

Tapio SIMULA is a physicist with an interest in theory, experiments, and computation. He obtained his D.Sc. in 2003 from the Helsinki University of Technology, Finland. His research has focused on quantised vortices in superfluid Bose-Einstein condensates, topological quantum computation with non-abelian vortex anyons, and most recently on bouncing, walking, and superwalking droplets and their hydrodynamical quantum analogs. Tapio is a Australian Research Council (ARC) Future Fellow at Optical Sciences Centre, Swinburne University of Technology in Melbourne, Australia.

***Lee SMOLIN** is a theoretical physicist who has done most of his work on quantum gravity. He has founded a number of approaches including loop quantum gravity and relative locality. He has broad interests and has contributed new ideas to cosmology (Cosmological Natural Selection), foundations of quantum mechanics (non-local hidden variables theories, energetic causal sets etc). He is the author of 5 semi-popular books that explore the philosophical ramifications of the big open questions in physics, plus co-authoring a book with Roberto Mangabeira Unger. SInce 2001 he is a founding and senior faculty member of Perimeter Institute.

Loic TADRIST Is associate professor at Aix-Marseille University in biomechanics and complex systems. Previously he was postdoctoral fellow at FNRS researcher at University of Liège, mentored and supervised by Tristan Gilet. Experimental and theoretical study of walking droplets interactions, capillary phenomena. PhD Thesis : Ecole Polytechnique (France), on plant biomechanics under the supervision of Emmanuel de Langre. Foliage-wind interactions.

Jonathan TENNENBAUM is Collaborator of CFCUL. Ph.D. in mathematics (University of California at San Diego), research in complex analysis and analytical number theory, former editor of German-language science magazine "FUSION" and author of several books on the history and applications of nuclear energy, Chief Science Editor for Asia Times, co-author together with Danil Doubochinski of "The macroscopic quantum effect in nonlinear oscillating systems: A possible bridge between classical and quantum physics" and "On the General Nature of Physical Objects and their Interactions, as Suggested by the Properties of Argumentally - Coupled Oscillating Systems".

Louis VERVOORT studied physics at the Un. Ghent, Un. Aix-Marseille and Ecole Normale Supérieure, Paris, and philosophy at the Un. Montréal. His main current interests are in the foundations of (quantum) physics and of artificial intelligence, and their philosophical correlates. His present affiliation is School of Advanced Studies, University of Tyumen, Russian Federation.

Harold "Sonny" WHITE has accumulated over 19 years of experience working in the aerospace industry with Boeing, Lockheed Martin, NASA, and now with the Limitless Space Institute. He currently serves as the Director of Advanced Research and Development at LSI. In this role, he leads all research and development work for LSI, establishes priorities and recommendations for investigations and expenditures. Dr. White obtains grants and other resources in support of R&D efforts, markets LSI to major benefactors to increase resources and related R&D efforts, and conducts, arranges, and schedules events and ensures appropriately related well-known individuals are involved.

**** keynote speakers***

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