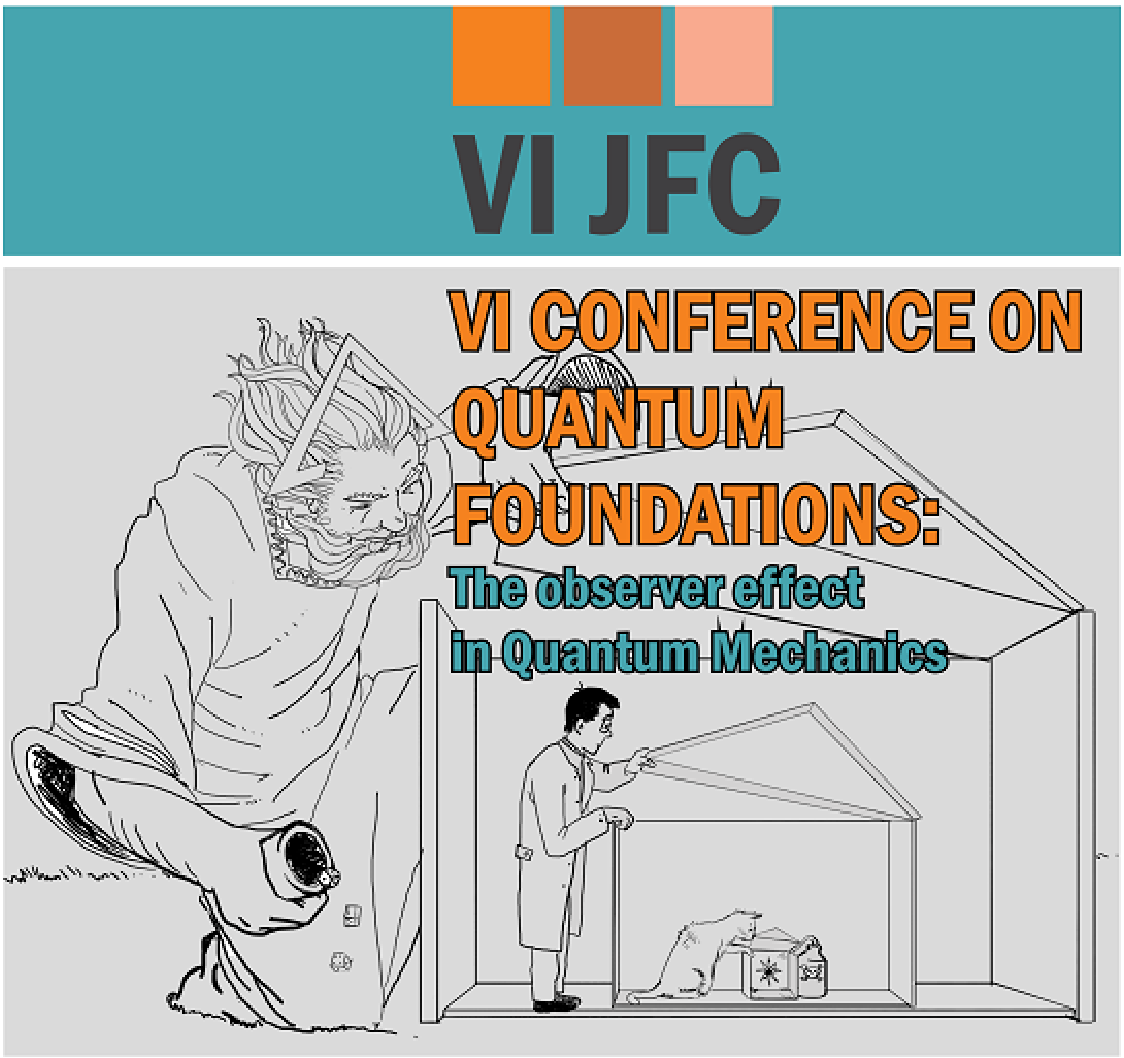
Book of Abstracts



Centro Científico Tecnológico CONICET - La Plata, Argentina
DECEMBER 12-14, 2016

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Program

Program VIJFC

	Monday	Tuesday	Wednesday
09:00 - 10:00	09:00 – 09:30 **Registration**	09:00 – 09:30 **O. Lombardi**	09:00 – 09:30 **A. Hnilo**
	09:30 – 10:00 **J.A. de Barros**	09:30 – 10:00 **C. Lopez**	09:30 – 10:00 **Y. Navarrete**
10:00 - 11:00	10:00 – 10:30 **A.L. Plastino**	10:00 – 10:30 **S. Zozor**	10:00 – 10:30 **D. Gonzalez**
	10:30 – 11:00 **coffee break**	10:30 – 11:00 **coffee break**	10:30 – 11:00 **coffee break**
11:00 - 12:00	11:00 – 11:30 **G. Bellomo**	11:00 – 11:30 **M. Losada**	11:00 – 11:30 **L. Schulman**
	11:30 – 12:00 **M. Cerezo**	11:30 – 12:00 **I.S. Gomez**	11:30 – 12:00 **M. Sanduk**
12:00 - 13:00	12:00 – 12:30 **R. Rossignoli**	12:00 – 12:30 **C. Massri**	12:00 – 12:30 **G. Sergioli**
	12:30 – 15:00 **lunch**	12:30 – 15:00 **lunch**	12:30 – 15:00 **lunch**
13:00 - 14:00			
14:00 - 15:00			
15:00 - 16:00	15:00 – 15:30 **M.L. Espíndola**	15:00 – 15:30 **P.W Lamberti**	15:00 – 15:30 **N. Gigena**
	15:30 – 16:00 **A. de la Torre**	15:30 – 16:00 **F. Holik**	15:30 – 16:00 **J.M. Matera**
16:00 - 17:00	16:00 – 16:30 **coffee break**	16:00 – 16:30 **coffee break**	16:00 – 16:30 **coffee break**
	16:30 – 18:30 **Lecture 1: O. Lombardi and S. Fortin**	16:30 – 18:30 **Lecture 2: A. Hnilo**	16:30 – 17:00 **G.M. Bosyk**
17:00 - 18:00			17:00 – 17:30 **L. Knoll**
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The place and schedule of lectures 3, 4 and 5 will be announced during the meeting.

Contents

Abstracts

Is the consciousness causes collapse hypothesis falsifiable?

Jose Acacio de Barros
San Francisco State University, San Francisco, California, USA

Wigner and von Neumann famously advocated a solution to the measurement problem that postulated the collapse of the wave function by a non-physical mind, what one could call the consciousness causes collapse hypothesis. This is a substance dualist view of the physical world, where matter and mind had different and separate ontologies. Here we will discuss how one could try to test this hypothesis, and show that it is not possible to design an experiment that fits the requirements of such test. Thus, the consciousness causes collapse hypothesis is unfalsifiable.

Exploring quantumness and locality of bipartite quantum system

Guido Bellomo
Instituto de Física La Plata, CONICET, UNLP, Argentina

Quantum correlations in a physical system are usually studied with respect to a unique and fixed decomposition of the system into subsystems, without fully exploiting the rich structure of the state space. Here, we show several examples in which the consideration of different ways to decompose a physical system enhances the quantum resources and accounts for a more flexible definition of quantumness measures. Furthermore, we give a different perspective regarding how to reassess the fact that local operations play a key role in general quantumness measures that go beyond entanglement- as discordlike ones. We propose a family of measures to quantify the maximum quantumness of a given state. For the discord-based case, we present some analytical results for $2 \times d$-dimensional states. Applying our definition to low-dimensional bipartite states, we show that different behaviors can be reported for separable and entangled states vis-à-vis those corresponding to the usual measures of quantum correlations. We show that there is a close link between our proposal and the criterion to witness quantum correlations based on the rank of the correlation matrix, proposed by Dakić, Vedral, and Brukner [Phys. Rev. Lett. 105, 190502 (2010)].

Majorization and entanglement transformations

Gustavo M. Bosyk
Instituto de Física La Plata, CONICET, UNLP, Argentina

First, I will briefly introduce the concept of majorization between probability vectors and its main properties [1]. In particular, I will present the *majorization lattice* obtained by Cicalese and Vaccaro [2]. Then, I will address the problem of entanglement transformations by using *local operations and classical communications* (LOCC). More precisely, the problem consists in two parties, Alice and Bob, that share an entangled pure-state $|\psi\rangle$ (initial state) and their goal is to transform it in another entangled pure-state $|\phi\rangle$ (target state), by using only LOCC. A celebrated result of Nielsen gives the necessary and sufficient condition that makes possible this entanglement transformation process [3]. Indeed, this process can be achieved if and only if the majorization relation $\psi \prec \phi$ holds, where ψ and ϕ are probability vectors obtained by taking the squares of the Schmidt coefficients of the initial and target states, respectively. In general, this condition is not fulfilled. However, one can look for an *approximate* entanglement transformation. Vidal *et. al* have proposed a deterministic transformation using LOCC in order to obtain a state most approximate to target in terms of maximal fidelity between them [4]. In this talk, I will present an alternative proposal by exploiting the fact that majorization is indeed a lattice for the set of probability vectors [5].

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From factorization to quantum information protocols, or: how we proposed a method to engineer separable ground states in spin systems

Marco Cerezo
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In this work we discuss ground state factorization schemes in spin S arrays with general quadratic couplings under general magnetic fields, not necessarily uniform or transverse. We show that if some control over the couplings or the fields is feasible, then completely separable exact ground states can be engineered in general spin systems. These results enable to devise separable ground state engineering methods which could be used as initial states in quantum information protocols and quantum annealing. Finally, we show that pairwise entanglement reaches full range in the immediate vicinity of factorization, indicating that even in the present general setting factorization can still be considered as an entanglement critical point.

Do we finally understand Quantum Mechanics?

Alberto Clemente de la Torre
Universidad Nacional de Mar del Plata

The ontology emerging from quantum field theory and the results following from Bell's theorems allowed the development of an intuitive picture of the microscopic world described by quantum mechanics, that is, we can say that we understand this theory. However there remain several aspects of it that are still mysterious and require more work on the foundations of quantum mechanics.

The Linearization of the Schrödinger Equation

Maria Lewtchuk Espindola
Departamento de Matemática - Centro de Ciências Exatas e da Natureza - Universidade Federal da Paraíba

A new foundation to Hamiltonian Analytical Mechanics, named two fold or alternative Hamiltonization, furnishes two Hamiltonian functions, a linear in the momenta and the usual one. As one of the consequences of this Hamiltonization procedure in quantum mechanics there is the possibility of the linearization of the Schrödinger equation. In this procedure the Hamiltonian function must be a solution to the PDE obtained by the substitution of the first set of Hamiltonian canonical equations of motion in the Hamiltons definition of a Hamiltonian function. The canonical momenta are provided by second set of Hamiltonian canonical equations of motion. The main change proposed in this procedure is that the conjugate momenta should not be postulated a priori, but instead of this, they are determinate as a consequence of a canonical description of the mechanical system. It is also proved that Hamilton's definition of the conjugate momenta is obtained by the imposition of the envelope condition in the solution of the PDE that defines the Hamiltonian function. Therefore in the singular mechanics the usual definition cannot be used as the PDE is linear in the momenta. It must be noted that the Hamiltonian yielded is identical to that obtained by Dirac, but with an additional advantage as there is no constraints, no need of new definitions as "weak equalities" or "super phase space" nor a new variational procedure. Then this procedure can be applied to Singular (Dirac), Nambu, or Non Holonomic Mechanics, and can be used to the linearization of the Hamilton-Jacobi equation or to the determinate constants of motion. The linearization of the Schrödinger equation can also be obtained from the Hamilton Jacobi one. The same idea was extended for field theories singular or not. The usual Hamiltonian density and the momentum density are recovered by the envelope condition whenever it exists. In the singular case the result obtained is the same as in the Dirac theory and has the same advantage of no constraints. Therefore the usual

quantization can be performed. A generalization of the above procedure, named direct Hamiltonization, allows the determination of the Hamiltonian function for any mechanical system described or not by a Lagrangian. It was induced by the Hamiltonization of non holonomic systems where the Hamiltonian function is obtained from the system composed by the PDE that defines the Hamiltonian and the PDE given by the constraints in which is used the first set of the canonical equations of motion. As in this case the real Lagrangian is not known. In this approach we prove that any function of the generalized coordinates, generalized velocities and time can be added with no consequence on the description, generating an equivalent Hamiltonian. The difference is in the momentum defined by the condition of a canonical description of the system. As the direct Hamiltonization contains the alternative one, then the usual Hamiltonization and momenta is recovered while the envelope solution is selected after adding the Lagrangian function. Also this procedure assures the existence of a Hamiltonian function without any constraints whatsoever mechanical system is considered, therefore the usual quantization is always allowed. It can be expanded to field theory giving a direct Hamiltonization with the same consequences.

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About the concept of quantum information

Sebastian Fortin and Olimpia Lombardi
Universidad de Buenos Aires – CONICET

Although the word 'information' refers to a concept associated with very different phenomena, in the traditional communicational context, the classical locus is Claude Shannon's formalism. However, despite the existence of a precise formalism, the problems of the interpretation of the concept of information do not disappear: different, even incompatible interpretations still coexist.

During the last decades, new interpretive problems have arisen with the advent of quantum information; those problems combine the difficulties in the understanding of the concept of information with the well-known foundational puzzles derived from quantum mechanics itself. Benjamin Schumacher's article "Quantum Coding", it is usually considered the first precise formalization of the quantum information theory. In this context, the question 'What is quantum information?' is still far from having an answer which the whole quantum information community agrees with.

The aim of this paper is to consider some arguments traditionally put forward to support the idea that quantum information is qualitatively different from classical information. On the basis of the analysis of those arguments, we will conclude that there are no reasons to admit the existence of quantum information as qualitatively different from classical information: there is only one kind of information, physically neutral, which can be encoded by means of classical or of quantum states.

Entanglement in fermion systems

Nicolás Gigena
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The notion of entanglement in systems of distinguishable constituents is built upon the tensor product structure of the joint Hilbert space. In fermionic systems this structure is no longer present, wich prevents the straightforward extension to such systems of entanglement measures already defined in the distinguishable case.

Mainly two different approaches have been taken in generalizing the concept of entanglement to fermion systems: Entanglement between modes, and entanglement between particles. In this work we introduce a new measure of entanglement between modes and show that its minimum over unitary transformations in single particle space is a measure of entanglement between particles, which reduces to another measure previously introduced for two-fermion systems.

Distinguishability notion based on Wootters statistical distance: an application to discrete maps

Ignacio S. Gomez[1], Mariela Portesi[1] and Pedro W. Lamberti[2]
[1]Instituto de Física La Plata, CONICET, UNLP, Argentina, [2] Facultad de Matemática, Astronomía, Física y Computación, UNC, CONICET

Wootters proposed a statistical distance in Hilbert space. Here we study a concept of distinguishability inspired by means of a notion of distance for unidimensional discrete maps and we redefine it as a metric. Moreover, from this metric we associate a metric space to each invariant density of a given map, which results to be the set of all distinguished points when the number of iterations of the map tends to infinity. We illustrate in the case of the logistic map and we find the metric numerically for several values of its characteristic parameter. Finally, we propose a generalization to maps of arbitrary dimensions, and illustrate this with a pair of uncoupled logistic maps.

Inference over classical dynamical systems by the use of wave functions

Diego González[1], Sergio Davis[2]
[1]Departamento de Física, Facultad de Ciencias, Universidad de Chile and [2]Comisión Chilena de Energía Nuclear

Through the principle of Maximum Caliber (MaxCal for short), it is possible to create probabilistic models for dynamical systems in path space $P[x()]$ from which time-dependent properties can be obtained.

In this work, we provide the necessary conditions to create a dynamical model from MaxCal such that it is compatible with a continuity equation for the time-dependent probability $p(x,t)$ and a Hamilton-Jacobi equation for the current velocity appearing in the continuity equation. It is possible to combine both equations into a complex differential equation by using the Madelung representation, resulting in a formalism analogous to the Schrödinger equation. Through this procedure, our work introduces a parallel between the analysis of dynamical systems and quantum mechanics.

Two hidden hypothesis in the Bell's inequalities

Alejandro Hnilo
Centro de Investigaciones en Láseres y Aplicaciones (CEILAP, CONICET-CITEDEF)

Recently, the famous original paper by J.S.Bell's reached the 50 anniversary of its publication. In that paper, the contradiction of the predictions of Quantum Mechanics (QM) with the intuitive ideas of Locality and Realism (LR) was demonstrated, for the correlation between the measurements performed on a pair of remote entangled particles. The experiments performed until now show that that correlation is higher than allowed by LR. However, there are at least two non-evident hypotheses, additional to LR, in the derivation of the Bell's inequalities: the first one is that "proper" integrals (in the Riemann's or Lebesgue's sense) in the space of the hidden variables exist; the second one is similar to the ergodic hypothesis. Both hypotheses are not valid in some complex systems. Therefore, the experimental results can be interpreted as a refutation of the validity of LR in the Nature or, else, as the evidence of the existence of an underlying dynamics, which would be chaotic and non-ergodic. In this paper, the origin and meaning of the additional hypotheses is discussed.

Quantum Probabilities and Probabilistic Reasoning

Federico Holik
Instituto de Física La Plata, CONICET, UNLP, Argentina

Probabilistic reasoning will take place whenever probabilities are involved. In this talk we discuss what happens with inference rules when non-standard probabilities –such as those appearing in the quantum formalism- are present. In particular, we discuss how this non-Kolmgorovian structure alters the probabilistic knowledge of a rational agent with regard to the particular problems of decision making, machine learning and pattern recognition. We also discuss the implications of this structure in relationship with different philosophical frameworks.

The Big Bell Test

Laura Knoll
DEILAP (CITEDEF - CONICET)

The BIG Bell Test (BBT) is a worldwide project that brought human randomness to fundamental quantum physics experiments. During the 30th of November twelve laboratories around the world performed different experiments which involved Bell-like measurements. The random inputs needed to carry out these experiments were generated in real time by humans playing an online game. In this talk I will present the results obtained by the Buenos Aires Team (CITEDEF and Universidad de Buenos Aires). The experiment performed consisted in measuring a Clauser-Horne-Shimony-Holt (CHSH)-like inequality, using polarization entangled photons.

Un estudio histórico conceptual de la relación de incerteza tiempo-energía

Pedro W. Lamberti, Tristán Osán and Diego Bussandri
Facultad de Matemática, Astronomía, Física y Computación, UNC, CONICET

De todas las relaciones de incerteza, la relación tiempo-energía ha sido, desde los comienzos de la mecánica cuántica, la más controversial y difícil de demostrar. Parte de ello se debe a que el tiempo tiene un rol muy particular en mecánica cuántica. Esto ha hecho que dentro de las distintas interpretaciones de la mecánica cuántica, en las cuales el tiempo juega un rol diferente, la relación tiempo-energía, también haya tenido una interpretación distinta.

En este trabajo repasamos en un contexto histórico y conceptual, el camino recorrido por la relación de incertidumbre tiempo-energía desde los primeros años de la mecánica cuántica hasta el presente. Analizamos además algunos modelos que permiten avanzar en la interpretación de dicha relación de incertidumbre.

Temporal symmetry in quantum mechanics: is the micro-world blind to the passage of time?

Cristian López
Universidad de Buenos Aires – CONICET

The problem of the arrow of time owes its origin to the intuitive asymmetry between past and future we experience in daily life. From the philosophy of physics point of view, the goal is to ground this intuition on physics by finding a physical correlate to that time-asymmetry. Usually, the clue is to find laws that are non-invariant under time-reversal: those laws would embody time-asymmetry in the context of the physical theories they belong to. Within a (classical) physical theory, the common time-reversal operator T performs the transformation on the dynamical equations (laws), and also on all the dynamical variables defined in function of t (e.g., velocity or momentum). If a dynamical equation is invariant under time-reversal, then if is a solution, is a solution as well. Accordingly, if a dynamical equation is not time-reversal invariant, then either or is not a solution, and this would introduces a clear difference between past and future. In quantum mechanics, Schrödinger equation applies to closed systems: since energy is constant, the Hamiltonian is not a function of time. Then, the application of T to the equation gives This should lead to conclude that the Schrödinger equation is not time-reversal invariant and, consequently, quantum mechanics distinguishes between the two directions of time. In spite of that, it is usually claimed that quantum mechanics (and quantum field theory as well) is a time-reversal invariant theory (e.g. Earman 2002, Maudlin 2002, Castagnino, Gadella and Lombardi 2005; in specialized textbooks, Messiah 1966, Gasiorowicz 1966, Ballentine 1998, Sakurai and Napolitano 2011), since its main dynamical equation, Schrödinger equation, is time-symmetric under time-reversal operator. Why is this so? The strategy is to introduce a new operator T*, which not only reverses the sign of t, but it also transforms any complex elements into its complex conjugate. Now the Schrödinger equation turns out to be invariant under the application of $T*$: This shows that the talk about time-reversal invariance is not sufficiently precise in the quantum context: according to Costa de Beuregard's distinction (1980), Schrödinger equation turns out to be invariant under the application of the Wigner operator $T*$, but non- invariant under the application of the Racah operator T, which also reverses the Hamiltonian sign, . In other words, quantum mechanics is both $T*$-invariant and non T-invariant. This paradoxical and uncomfortable situation is traditionally overcome in quantum mechanical textbooks by pointing out the supposed formal inadequacy of the Racah operator (Messiah 1966, Gasiorowicz 1966, Ballentine 1998): since the Hamiltonian must have a positive spectrum, the Racah operator has to be dismissed to represent reversing time in quantum mechanics.

In this presentation, the problem of the arrow of time in quantum mechanics will be taken into account. Firstly, I will show there is truly a serious problem when time-reversal operator is carefully thought out in quantum mechanics: at least, two kinds of time-reversal operators can be suitably established in the theory, according to which quantum mechanics turns out to be time invariant and time non-invariant at the same time. Then, I will argue that the commonly accepted way to define a time reversal operator in quantum mechanics (time reversal plus complex conjugation) begs the question about the problem of the arrow of time – this kind of operator is built upon the assumption that temporal symmetry is a well-established symmetry of quantum mechanics, thus the problem of the arrow of time would be meaningless.

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Facing the difficulties of quantum histories

Marcelo Losada
Universidad de Buenos Aires – CONICET

The standard formulation of quantum mechanics has a remarkable predictive success. However, two aspects were considered as unsatisfactory by several authors. The first one is the distinction between ordinary physical processes and measurement processes. The second is the impossibility of defining logical operations between properties at different times.

The idea of *quantum history* was mainly motivated by these two unsatisfactory aspects of standard quantum mechanics. The Theories of *Quantum Histories* claim to have solved the two difficulties mentioned above. On the one hand, they provide a formulation of quantum mechanics in which measurements are treated in the same way as other physical processes. On the other hand, they extend the standard formalism of quantum mechanics in order to be able to define logical operations between properties at different times.

The TQH introduces original ideas directed to solve some of the traditional interpretive problems of standard quantum mechanics. However, some authors consider that this theoretical approach suffers from certain difficulties that cannot be overlooked. In this article we will consider the criticisms raised against the TQH, and we will classify them into two groups: theoretical and interpretive. Our main goal is to present a different perspective, called *Formalism of Generalized Contexts or of Contextual Histories*, in order to argue that this formalism is immune to the criticisms directed to the TQH, since it solves the conceptual objections and dissolves the interpretive criticisms.

Non-commutative generalization of geometric probability theory

César Massri
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The problem of determining measures which are invariant under the action of a group is an important one for physics. In many situations of interest, the task of the physicist is to find out what is the state of a system having certain constraints. One of the most important constrains are given by symmetries, and symmetries are usually represented mathematically by the action of a group.

In this talk, we study generalized measures in orthomodular lattices. First, we provide an extension to a non-Boolean setting of Groemer’s integral theorem. Then, we apply our extension to quantum theories to characterize (in a constructive way) all states which are invariant under the action of an arbitrary group. This is a join work with Dr. Holik and A. L. Plastino.

Coherence, Entanglement and Discord. Resource theories in the classical-quantum border

Juan Mauricio Matera
Instituto de Física La Plata, CONICET, UNLP, Argentina

One of the characteristics that distinguish quantum from classical systems is the phenomena of statistical interference, resulting from the coherent state superposition. Recently, a resource theory of coherence, analogue to the entanglement theory, was proposed to quantify this effects. In this talk, I will present a generalization of that theory for the case of bipartite systems, where one of the parties has access to general quantum operations, while the other one just has access to operations unable to produce coherence in its local state, neither quantum correlations on the global state. Afterwards, I will show how this formalism is related with the standard entanglement and discord theories. Finally, I will discus the application of this framework to the analysis of quantum algorithms in the family of DCQ1.

Fragile systems : A general hidden-variables theory

Yasmín Navarrete[1], Sergio Davis[2]
[1]Université Grenoble Alpes, and [2]Comisión Chilena de Energía Nuclear

One of the most well-known features of quantum systems is the fact that they are disturbed by the act of measurement, so that two consecutive measurements A and B do not necessarily commute. It is also widely believed that quantum phenomena cannot be reconciled with classical probabilities, or even with classical logic.

In this work, we show that the idea of fragility, i.e. the property of systems of being altered by observation, when combined with classical probabilities over a hidden-variables model, leads to the actual formalism of Quantum Mechanics complete with a complex Hilbert space, non-commuting operators and the trace rule for expectations. Our results widen the application of quantum mechanics as a tool for inference, available for use in different areas of Science such as biology, neuroscience and data analysis of complex systems. Indeed, every system that has non-commutative properties and whose expectation values are obtained by the trace rule over semi-positive matrix, can be treated as a fragile system, having an underlying hidden-variables structure.

Legendre Transform and Quantum Mechanics

Angel Plastino
Instituto de Física La Plata, CONICET, UNLP, Argentina

We describe the way in which the Legendre Transform description of Thermodynamicas can be transcribed into Quantum Mechanics.

Generalized Quantum Conditional Entropy

Raúl Rossignoli
IFLP/Depto. de Física, FCE UNLP - CIC

We will discuss the concept of generalized quantum conditional entropy in a bipartite quantum system, dependent on a local measurement on one of the subsystems. This quantity is a measure of the average mixedness of the unmeasured component after such measurement, and its minimum over all local measurements is related to both the quantum discord and the entanglement of formation between the unmeasured component and a purifying third system. We will examine its general properties and show that for certain classes of states the minimizing measurement can be determined analytically and is universal. We will also show that in the case of the linear entropy, such minimization can be done analytically for any qubit-qudit mixed state. A discussion of the usefulness of generalized entropies for studying correlations in quantum systems will be as well provided.

Is Dirac Hamiltonian related to a kinematical structure?

Mohammed Sanduk
Chemical and Process Engineering Department, University of Surrey, Guildford, GU2 7XH, UK

Quantum mechanics is based or formulated on postulates. One of these postulates states that the wave function is governed by time-dependent Schrödinger equation. Dirac equation is derived on the base of that postulate in addition to Dirac's proposed linearized Hamiltonian form. The Dirac equation does not derived completely but arranged according to quantum postulates.

Dirac equation in position space is:

$$i\frac{\partial\psi}{\partial t} = \left(-ic\vec{\alpha}\cdot\vec{\nabla} + \beta\omega\right)\psi. \tag{1}$$

For a mathematical form in one dimensional space, this equation becomes:

$$i\frac{\partial\psi}{\partial t} = \left(-i\frac{\partial x}{\partial t}\vec{\alpha}\frac{\partial}{\partial\vec{x}} + \beta\frac{\partial\phi}{\partial t}\right)\psi. \tag{2}$$

A similar form to that form of (2) can be attributed to the product rule differentiation for a function $\mathcal{Z}$ of the two multiplied factors. In 2016, Sanduk showed that the Dirac equation form could be derived as a complex time evolution equation of a function ($\mathcal{Z}$):

$$i\frac{\partial\mathcal{Z}}{\partial t} = \widehat{\mathcal{H}}\mathcal{Z}, \tag{3}$$

where $\widehat{\mathcal{H}}$ is a Dirac Hamiltonian form, and the function is a complex vector:

$$\vec{\mathcal{Z}} = \vec{b}exp\left(i(\vec{k}\cdot\vec{r} - \omega t)\right) = b\widehat{e}_r exp\left(i(\vec{k}\cdot\vec{r} - \omega t)\right), \tag{4}$$

where $\vec{b}$ is a real radial vector. The time derivation of (4) yields:

$$\vec{A} = \mp i\widehat{e}_\theta \quad \text{and} \quad B = \pm 1. \tag{5}$$

Equation (5) has Dirac equation form. Then, the quantity inside brackets of equation (5) has the form of Dirac Hamiltonian.

The structure of the complex vector can be considered in a trigonometrical form:

$$\vec{\mathscr{Z}} = \vec{b} \left(\cos(\vec{k} \cdot \vec{x} - \omega t) + \sqrt{- \sin^2(\vec{k} \cdot \vec{x} - \omega t)} \right) . \tag{6}$$

That leads to assume a general real algebraic form for the function:

$$\vec{r} = \vec{\mathfrak{b}} \left(\cos(\vec{k_2} \cdot \vec{s} - \omega t) \pm \sqrt{- \sin^2(\vec{k_2} \cdot \vec{x} - \omega t) + X} \right) , \tag{7}$$

where X is a real dimensionless quantity. This form is for position vector of a point in system of two rolling circles of radii a_1 and a_2. In addition to that $a_1 \ll a_2$, $a_2 = 1/k_2$, $\mathfrak{b} = a_1 + a_2$ and $X = a_1/\mathfrak{b}$.

In 2012, Sanduk introduced the concept of partial observation, and accordingly the quantities $X = 0$ ($a_1 = 0$). That means the small circle can not be recognised. Then equation (8) transforms to equation (4). Time differentiation is:

$$\frac{\partial r(r, \vec{t}, X)}{\partial t} = \frac{\partial(\vec{a}_2 + \vec{\mathfrak{b}} + \sqrt{X})}{\partial t} \left(\cos(\vec{k_2} \cdot \vec{s} - \omega t) \pm \sqrt{- \sin^2(\vec{k_2} \cdot \vec{x} - \omega t) + X} \right) +$$

$$(\vec{a}_2 + \vec{\mathfrak{b}} + \sqrt{X}) \left(\omega \sin(\vec{k_2} \cdot \vec{s} - \omega t) \pm \frac{\omega \sin(\vec{k_2} \cdot \vec{s} - \omega t) \cos(\vec{k_2} \cdot \vec{s} - \omega t) + \frac{\partial X}{\partial t}}{\sqrt{- \sin^2(\vec{k_2} \cdot \vec{x} - \omega t) + X}} \right) . \tag{8}$$

This form does not show any relationship with Dirac equation form, but Dirac equation and Hamiltonian forms can be restored when $X = 0$. Here one can say that:

1. This work is for a motion in plane, and can be generalised for three dimensional space.
2. The space and time combination terms in (5) are owing to the structure of two rolling circles.
3. The system shows spinning and circulation of small circle.
4. Both of the spacetime continuum and the complex function concept may raise due to the partial observation.
5. This approach for quantum form shows that there is no need for minimal physical length to be imposed as that of Snyder's approach.
6. This approach may agree with Heisenberg words "We have to remember that what we observe is not nature herself, but nature exposed to our method of questioning".

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Testing Quantum Determinism

Larry S. Schulman
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As experiments probe quantum phenomena ever more deeply, it becomes difficult to believe that there is anything other than pure, unitary, quantum time evolution. Without wave-function collapse, the physicist is left with the many-worlds interpretation as the source of quantum indeterminism. (I say "physicist" because I can't defend against all philosophical contortions.)

However, if one is willing to take a radical view of statistical mechanics, it is possible to have only unitary time evolution, and still have a single "world". In this view, all microscopic states (consistent with macroscopic observation) are NOT equally likely and only those called (in this theory) "special" appear. I will explain just how the "special" states achieve quantum determinism. Possible justification of this idea compromises the usual arrow of time.

Finally, with only unitary time evolution and a single world there are forces necessary to achieve the definite outcomes of quantum experiments. These forces are small, but should be observable, thereby testing the special state theory.

Quantum computational logic with qutrit

Giuseppe Sergioli
Università degli Studi di Cagliari

The standard theory of quantum computation relies on the idea that the basic information quantity is represented by a superposition of elements of the canonical basis (qubits) and the notion of probability naturally follows from the Born rule: basically, the truth and the falsity properties are represented by the operators that project over closed subsets of all "true" of "false" states of $\bigotimes^n \mathbb{C}^2$ respectively, where a state is said to be true or false if its last component is 1 or 0 , respectively.

In this talk we consider three valued quantum computational logics by introducing a third truth value. Hence, we could say that a state can be true and false but we can also introduce an "intermediate" fuzzy value $\left|\frac{1}{2}\right\rangle$. In order to introduce it in the quantum framework, we need to involve the Hilbert space $\mathbb{C}^3$ (qutrit space). We discuss extensions of several unary gates into this space and, using the notion of effect probability (that is not, in general, a projective probability), and we provide a characterization of an arbitrary qutrit. Finally, we propose an extensive method that allows to reasonably extend binary gates to the framework of qutrits.

Generalized quantum entropies : a definition and some properties

Steeve Zozor

Department of Signal and Image, GIPSA-Lab, University of Grenoble, France

In this presentation, a family of quantum entropies inspired by the clasical (h, ϕ)-entropies proposed by Salicrú *et al.* (more precisely, inspired by the Csiszár's divergencies) will be introduced. The proposed family includes several well-known entropies such that the von Neumann entropy or quantum versions of the Rényi's and Havrda-Charvát-Daróczy-Tsallis's entropies, among many others. The main properties of the proposed quantum (h, ϕ)-entropies lie on the the fundamental concept of majorization. The behavior of these entropies when a quantum state is subject to some quantum operations (unitary, measurement) will be characterized, and its behavior when dealing with composite systems as well. Some potential applications in detection of entanglement will be exposed. Finally, we will present possible definitions of associate measures such that conditional generalized quantum entropies.

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[1] G. M. Bosyk, S. Zozor, F. Holik, M. Portesi and P. W. Lamberti, *A family of generalized quantum entropies: definition and properties*, Quantum Information Processing, **15**(8): 3393–3420 (2016)
[2] M. Salicrú, M. L. Menéndez, D. Morales and L. Pardo, *Asymptotic distribution of (h, ϕ)-entropies.*, Communications in Statistics, **22**(7):2015–2031 (1993)
[3] I. Csiszàr, *Information-type measures of difference of probability distributions and indirect observations.*, Studia Scientiarum Mathematicarum Hungarica, **2**: 299–318 (1967)

Lectures

Lecture 1: Problemas ontológicos de la mecánica cuántica.

Olimpia Lombardi and Sebastian Fortin
Universidad de Buenos Aires – CONICET

1. Problemas ontológicos
    (a) Teorema de Kochen y Specker y contextualidad: desafío al principio de determinación omnímoda.
    (b) - No-separabilidad: desafío al principio de localidad.
    (c) Indistinguibilidad: desafío al principio de identidad de los indiscernibles (Principio de Leibniz).
    (d) Medición: el problema del límite clásico de la mecánica cuántica.
2. Algunas interpretaciones
    (a) Interpretación de Copenhague: la hipótesis del colapso.
    (b) Interpretación de Muchos Mundos.
    (c) Interpretaciones modales.
    (d) Mecánica cuántica Bohmiana.

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[1] Jeffrey Bub, *Interpreting the Quantum World.* Cambridge: Cambridge University Press, 1997.
[2] R. I. G. Hughes, *The Structure and Interpretation of Quantum Mechanics.* Cambridge Mass.: Harvard University Press, 1989.
[3] Michael Dickson, *Non-Relativistic Quantum Mechanics*, pp. 275-416, en Jeremy
[4] Butterfield y John Earman, *Philosophy of Physics.* Amsterdam: Elsevier, 2007.
[5] Artículos específicos de la Stanford Encyclopedia of Philosophy, http://plato.stanford.edu/.

Lecture 2: Desigualdades de Bell

Alejandro Hnilo
Centro de Investigaciones en Láseres y Aplicaciones (CEILAP, CONICET-CITEDEF)

(a) La paradoja de Einstein, Podolsky y Rosen.

(b) El *gedankenexperiment* de Bell.

(c) Otras desigualdades tipo-Bell. Los "logical loopholes".

(d) Revista de experimentos recientes.

Bibliografía

[1] J.Clauser y A.Shimony, *Bell's theorem: experimental tests and implications*, Rep. Prog. Phys. 41, 1881 (1978).
[2] J.Larsson, *Loopholes in Bell inequality tests of Local Realism*, arXiv: 1407.0363 (2014).
[3] A.Hnilo, *Eberhardt's inequality and recent loophole-free experiments*; arXiv: 1607.04177 (2016).

Lecture 3: Teoría de la información cuántica.

Steeve Zozor[1] and Mariela Portesi[2]
[1]GIPSA-Lab, CNRS and [2]Insituto de Física La Plata, CONICET, UNLP, Argentina

(a) Entropía – medida de incerteza: Axiomas, entropía de Shannon, propiedades. Entropía diferencial – caso vectorial. Entropía de von Neumann. Otras medidas de información clásicas y cuánticas.

(b) Información mutua – divergencias: Entropía condicional, información mutua. Divergencias.

(c) Desigualdades – relaciones entre entropías: Desigualdades usuales. Cadenas de Markov. Desigualdad de la potencia entrópica. Estimación, relaciones entre medidas de información.

(d) Relaciones de incerteza: Heisenberg y versiones entrópicas. Desde versiones entrópicas hasta versiones con momentos estadísticos.

Lecture 4: Lógica Cuántica y Probabilidades Cuánticas

Federico Holik
Insituto de Física La Plata, CONICET, UNLP, Argentina

(a) Definiciones y propiedades. Axiomas de Kolmogorov. Aspectos geométricos del espacio de estados cuánticos.

(b) Lógica Cuántica y Teorema de Gleason.

(c) Aspectos filosóficos de la Lógica Cuántica y las Probabilidades Cuánticas.

(d) Generalizaciones: Mecánica Cuántica Relativista y Mecánica Cuántica Estadística.

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I. Bengtsson and K. Zyczkowski, Geometry of Quantum States: An Introduction to Quantum Entanglement (Cambridge University Press, Cambridge, 2006).
G. Birkhoff and J. von Neumann, The Logic of Quantum Mechanics, Annals of Mathematics 37 (1936) 823-843. H. Putnam, Is logic empirical?, in R. Cohen and M. P. Wartofski (eds.), Boston Studies in the Philosophy of Science Vol. 5 (Dordrecht, D. Reidel, 1968).
M. Rédei and S. Summers, Quantum Probability Theory, Studies in History and Philosophy of Science Part B: Studies in History and Philosophy of Modern Physics Vol. 38, Issue 2, (2007) 390-417.
F. Holik, M. Sáenz, and A. Plastino, A discussion on the origin of quantum probabilities, Annals of Physics 340(1) (2014) 293 – 310.

Lecture 5: Mayorización y su aplicación al estudio de transformaciones de entrelazamiento

Gustavo M. Bosyk
Insituto de Física La Plata, CONICET, UNLP, Argentina

1. Mayorización
   (a) Definiciones y propiedades. Matrices doblemente estocásticas. Schur-concavidad y conexión con entropías generalizadas. Teorema de Schur-Horn.
   (b) Retículo de mayorización. Métrica asociada al retículo.
2. Transformaciones de entrelazamiento
   (a) Operaciones locales y comunicación clásica. Teoremas de Lo-Popescu y Nielsen.
   (b) Operaciones locales y comunicación clásica asistida por entrelazamiento. Mayorización trumping (catálisis).

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[1] A.W. Marshall, I. Olkin, and B.C. Arnold, *Inequalities: Theory of Majorization and Its Applications*, Springer Verlag, 2011.

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[5] M.A. Nielsen, *Conditions for a Class of Entanglement Transformations*, Phys. Rev. Lett. **83** (1999), pp.436-39.

[6] D. Jonathan and M.B. Plenio, *Entanglement-Assisted Local Manipulation of Pure Quantum States*, Phys. Rev. Lett. 83 (1999), pp.3566-3569.

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