

**RESEARCH TEAM GRANTS IN SCIENCE AND TECHNOLOGY
2006
FINAL REPORT**

I. PROJECT PRESENTATION

PROJECT TITLE		CODE
STOCHASTIC ANALYSIS RESEARCH LABORATORY STOCHASTIC ANALYSIS RESEARCH LABORATORY		ADI-13
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PERIOD INFORMED		
Abril-07 - Abril-09		

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II. EXECUTIVE SUMMARY

This section should have a maximum of **5** pages long. Summarize the most relevant achievements of the entire project period indicating:

- 1) those explicitly related to the research progress and outcomes,
- 2) the activities and possible projections of international collaboration,
- 3) the results of the training of postgraduate students and young researchers,
- 4) the possible links to other national researchers either as groups and centers or, as individual researchers and
- 5) outputs of dissemination activities to the scientific community and outreach to non-specialized public. This summary will be sent to reviewers to inform them of the progress of the project from its beginning to the reported date.

Please consider that the contents of this section **may be published in CONICYT web site and/or reports that may be eventually printed and distributed.**

The Research Program “Stochastic Analysis Laboratory (PBCT-ADI13)” unified a number of researches which had started before the Bicentennial Program funds were granted. More precisely, theoretical contributions of certain significance which emerged in our first report, have clearly enhanced and currently appear as well established research directions. These directions are listed briefly here below:

T1) Analysis of Classical and Quantum Dynamics off the equilibrium. This subject includes contributions to the study of resonances in closed systems, as well as the so called Non-Equilibrium Dynamics in open quantum systems. Namely, recent progress has been obtained in the analysis of the entropy production in open quantum systems.

T2) Classical Statistical Inference and numerical treatment of open quantum systems. The theoretical proposal contained in the doctoral dissertation of a Laboratory student, suggests the possibility of using the classical reductions of quantum systems to carry out statistics of classical processes in them. Also, the researchers who develop methods of stochastic simulation of quantum systems have been obtaining results for a large class of concrete models. Moreover, we have continued implementing statistical analysis of stochastic processes in Engineering (communications) as well as in Neurosciences.

T3) Contributions to the Theory of Dilations. In this area, we have first tackled the classical Markovian dilations of open quantum systems. Also, we have started the study of Markovian dilations by using quantum noises with methods different to those previously used. Finally, we have obtained several results on dilations of non Markovian models for the dynamics associated to open quantum systems.

T4) Fractional Calculus and more general Evolution Equations. Some progress has been made in the use of Fractional Calculus to represent certain dynamics in which the evolution is described by fractional integrals or by Fractional Brownian Motion. On the other hand, we have continued working in backward stochastic differential equations.

A characteristic of the above mentioned research is the incorporation of several young collaborators and researchers of the international net associated to the Laboratory. We remark the particular relevance of the connection between these problems and the applications which, as it was originally formulated in our proposal, were oriented along

three main lines: applications to Physics, to Neurosciences and to Engineering. We now briefly report the achievements in each of these lines.

A1) Applications to Physics. These can be found in the development of T2 and especially T3. The line of research T2 strongly depends on the access to experimental data. To this end, we plan to establish alliances with experimental physicists in Chile and abroad. Namely, a close collaboration with the group of Quantum Optics directed by Professor Miguel Orszag in the Catholic University is currently being launched through our Center for Stochastic Analysis and Applications.

A2) Applications to Neurosciences. Substantial advances in the statistical treatment of experimental data were obtained. A very active work on the modeling of ion dynamics at mesoscopic scales started too. This research has been done by a Mathematical Engineering student of the Laboratory. As a result, a very important collaboration with the Centre of Neurosciences of Valparaíso has been launched through a joint program in Biostochastics (BIOS). In addition, we started a joint work in Ecology with a team of the corresponding Department of the Catholic University. Moreover, investigations in Molecular Dynamics and Stochastic simulation is currently starting in collaboration with engineers of the above mentioned university.

A3) Applications to Engineering. Telecommunications is one of the applications considered in this research line. There is a number of joint articles recently concluded, between researchers of this Laboratory and colleagues from Uruguay and France about the subject. Though, the areas that have originated a more extensive participation of members of the Laboratory and other research centers, were those of Renewable Energies and Mining. Concerning Renewable Energies, the Laboratory organized three international workshop about stochastic modeling of the energetic generation, fundamentally concentrated in oceanic and wind sources during the period 2007-2009. These meetings have opened the possibility of generating an inter university research Program in Renewable Energies (PER), joining other national research teams in the area. These applications provided thesis subjects to a number of Mathematical Engineers. They serve also to increase our collaboration with the INRIA team TOSCA, associated with our Laboratory.

In brief, concerning the development of applications, we have two main programs currently running in coordination with other ring and excellence centers (PBE and PER), which are of evident interest for our country, particularly the one on renewable energies.

Our Laboratory hosted two international scientific meetings: the 6th Workshop on Stochastic Analysis and Mathematical Physics (January 2008) and the 30th Conference on Quantum Probability and Related Topics (November 2009). In addition, annual Winter Schools on Stochastic Analysis and Applications have been organized in Valparaíso as well as our traditional weekly seminar “Stochastic Analysis and Mathematical Physics” at the PUC in Santiago.

With respect to young scientist training, the Laboratory has become an attraction pole. Especially for students of Mathematics and Mathematical Engineering in Universidad Católica and Concepción; a similar situation occurs in USACH; as well as in Valparaíso, where a number of Statistic students have been participating in research in Neurosciences and Communications. During this period, 7 undergraduate students have been graduated (Mathematical Engineers) as well as 9 students of Master in Mathematics from Universidad Católica. We have offered four postdoctoral positions and two grants to support doctoral theses, we have advised 4 Doctoral students. Currently, other 6 students are starting their doctoral theses under the advise of members of the Center.

Our Laboratory became a University Research Centre according to the rules of the Universidad Católica. That means an institutional recognition of its existence as well as a promotion of its activities at a much more autonomous level within the university. As such, this Centre received the support of the Faculties of Mathematics, Engineering and Physics in the P.U.C.

Finally, our Center coordinates a Research Network on Stochastic Analysis within the framework of the MathAmSud French Cooperation Program. This network includes researchers from the universities of Paris-South, Paris-VI, Institut Fourier de Grenoble, Centre de Physique Théorique de Marseille, INRIA team TOSCA, the universities of La República (Uruguay), San Andrés (Buenos Aires, Argentina), Centro de Física Nuclear (Bariloche, Argentina), University of Pernambuco (Brasil).

III. RESUMEN EJECUTIVO

Dado que el Resumen Ejecutivo podría ser publicado y/o distribuido, esta sección debe ser idéntica a la anterior en términos de contenido, pero en castellano.

El Programa de Investigación "Laboratorio de Análisis Estocástico (PBCT-ADI13)" unifica a un número de investigaciones que comenzaron su actividad conjunta antes que los fondos del Programa Bicentenario fueran concedidos. De manera más precisa, contribuciones teóricas de gran significado que surgieron desde nuestro primer informe han aumentado y constituyen hoy líneas de investigación bien establecidas. Estas líneas de investigación se mencionan brevemente a continuación:

T1) Análisis de la Dinámica Clásica y Cuántica fuera del equilibrio. Este tema incluye las contribuciones al estudio de las resonancias en sistemas cuánticos cerrados, como también la dinámica fuera del equilibrio de sistemas cuánticos abiertos. En particular, se han obtenido recientes avances en el análisis de la producción de entropía en los sistemas cuánticos abiertos.

T2) Inferencia Estadística Clásica y el tratamiento numérico de los sistemas cuánticos abiertos. La propuesta teórica que contiene la disertación de un trabajo doctoral de un estudiante de Laboratorio, sugiere la posibilidad de utilizar las reducciones clásicas de los sistemas cuánticos para llevar a cabo inferencia estadística clásica en ellos. Además, los investigadores que desarrollan los métodos de simulación estocástica de los sistemas cuánticos han obtenido resultados para una gran clase de modelos concretos. Por otra parte, hemos continuado con la aplicación de técnicas estadísticas de procesos estocásticos en Ingeniería (comunicaciones) y en Neurociencias.

T3) Contribuciones a la Teoría de Dilataciones. En esta área, en primera instancia hemos abordado la dilatación clásica Markoviana de los sistemas cuánticos abiertos. Además, hemos iniciado el estudio de las dilataciones de Markov mediante ruidos cuánticos con métodos diferentes a los utilizados anteriormente. Por último, hemos obtenido varios resultados en dilataciones de sistemas cuánticos abiertos no Markovianos.

T4) Cálculo fraccional y Ecuaciones de Evolución más generales. Se ha progresado en el uso de Cálculo Fraccional para representar ciertas dinámicas en donde la evolución es descrita por fracciones integrales o por el Movimiento Browniano Fraccionario. Por otra parte, hemos continuado trabajando en las ecuaciones diferenciales estocásticas retrógradas.

Una característica de la investigación mencionada anteriormente es la incorporación de varios colaboradores jóvenes e investigadores asociados a la red internacional al Laboratorio. Remarcamos la relevancia particular de la conexión entre los problemas y las aplicaciones, tal como fue formulada por primera vez en nuestra propuesta, se orientaron en torno a tres ejes principales: aplicaciones a la Física, a las Neurociencias y a la Ingeniería. A continuación, un breve informe de los logros en cada una de estas líneas.

A1) Aplicaciones a la Física. Las aplicaciones en esta línea se pueden encontrar particularmente en el desarrollo de T2 y T3. La línea de investigación T2 depende en gran medida del acceso a datos experimentales. Con este fin, se proyecta establecer alianzas con los físicos experimentales en Chile y el extranjero. Un avance en esta dirección, es la colaboración con el grupo de Óptica Cuántica dirigida por el profesor

Miguel Orszag en la Universidad Católica que se está poniendo en marcha a través de nuestro Centro de Análisis Estocástico y Aplicaciones.

A2) Aplicaciones hacia las Neurociencias. Avances sustanciales en el tratamiento estadístico de los datos experimentales fueron obtenidos. Un trabajo muy activo en la modelización de la dinámica de iones en escalas mesoscópica también se ha abierto. Esto ha sido tratado por un estudiante de Ingeniería Matemática que pertenece al Laboratorio. Como resultado, una colaboración muy importante con el Centro de Neurociencias de Valparaíso ha dado a luz un programa en Bioestocástica (BIOS) que se ha puesto en marcha. Además, hemos iniciado un trabajo conjunto en Ecología con un equipo del correspondiente Departamento de la Universidad Católica. Por otra parte, investigaciones en Dinámica Molecular y simulación Estocástica se ha puesto en marcha con la colaboración de ingenieros de la PUC.

A3) Aplicaciones a la Ingeniería. Estas aplicaciones han continuado con el estudio de las Telecomunicaciones. Esto se ha reflejado en varios artículos que se han concluido entre los investigadores de este laboratorio y colegas de Uruguay y Francia. No obstante, sin duda, las áreas que han originado una participación más amplia de los miembros del Laboratorio y otros centros de investigación fueron las de Energías Renovables y de Minería. En cuanto a las Energías Renovables, el Laboratorio organizó tres talleres internacionales durante el período 2007-2009 sobre la modelación estocástica de la generación energética, fundamentalmente concentrada en las fuentes oceánicas y del viento. Estas reuniones han abierto la posibilidad de generar un programa de investigación inter universitario en temas de Energías Renovables (PER), uniéndose a otros equipos de investigación del área en el país. Esto ha servido para dar temas de tesis a Ingenieros Matemáticos y también ha alimentado nuestra colaboración con colegas del equipo TOSCA del INRIA, asociado a nuestro laboratorio.

En resumen, en relación con el desarrollo de las aplicaciones, tenemos dos programas principales que actualmente se ejecutan con la coordinación con otros anillos y centros de excelencia (PBE y PER), que son de evidente interés para nuestro país, en particular el de las energías renovables.

Nuestro laboratorio ha organizado dos importantes eventos científicos internacionales: el 6º Taller de Análisis Estocástico y Física Matemática (Enero 2008) y la 30ª Conferencia sobre Probabilidades Cuánticas y Tems Relacionados. Además, hemos seguido con nuestras anuales Escuelas de Invierno de Análisis Estocástico y Aplicaciones en Valparaíso, como también con nuestro tradicional seminario semanal “Análisis Estocástico y Física Matemática” en la PUC en Santiago.

Con respecto a la formación de jóvenes científicos, el Laboratorio se ha convertido en un polo de atracción. Especialmente para los estudiantes de Matemáticas e Ingeniería Matemática en la Universidad Católica y Concepción, una situación similar ocurre en la USACH, así como en Valparaíso, varios estudiantes de Estadística han participado en la investigación en Neurociencias y Comunicaciones. Durante este período, 7 estudiantes universitarios se han graduado (Matemáticas Ingenieros), así como 9 estudiantes de Magíster en Matemáticas de la Universidad Católica. Hemos ofrecido cuatro posiciones postdoctorales y dos becas para apoyar estas tesis doctorales, hemos asesorado a 4 estudiantes de Doctorado. Actualmente, otros 6 alumnos están iniciando su tesis doctoral bajo la asesoría de los miembros del Centro.

Nuestro laboratorio se convirtió en un Centro de Investigación de la Universidad de acuerdo con las normas de la Universidad Católica. Eso significa reconocimiento institucional de su existencia, así como una promoción de sus actividades a un nivel más autónomo dentro de la universidad. Como tal, este Centro ha recibido apoyo de las Facultades de Matemáticas, Ingeniería y Física en la P.U.C

Finalmente, nuestro Centro coordina una Red de Investigación en Análisis Estocástico en el marco del Programa de Cooperación Francesa MathAmSud. Esta red incluye a investigadores de las universidades de París-Sur, París-VI, Instituto de Fourier de Grenoble, Centre de Physique théorique de Marsella, INRIA equipo TOSCA, las universidades de La República (Uruguay), San Andrés (Buenos Aires, Argentina), Centro de Física Nuclear (Bariloche, Argentina), Universidad de Pernambuco (Brasil).

Iç. RESULTS IN RESEARCH

Use a maximum of 15 pages in this section in order to inform the results of the research activities during the Project.

The information of this section is strictly confidential and the reviewers are bound by a non-disclosure agreement.

In order to fill up this section please follow the instructions:

- a) Organize this section according to the specific objectives of the Project, mentioning all changes, modifications or replacements.
- b) If the research team considers necessary to mention negative results and requires space to discuss them it should use this section for that purpose.
- c) Include all appendices that you consider necessary. Please do consider that reviewers have a limited time span to do their job. Limit the figure number to those that explain better what you try to convey in the text.
- d) If there are papers in progress related to the research results it is a good idea to include them in this section and make reference to them in the text rather than repeating the information in the report. **Those papers in press, published and/or accepted, should be listed in section VII.**

We start our report by quoting a part of our original proposal.

“Our project is aimed at creating a Research Laboratory in the field of Stochastic Analysis catching the contribution of specialists from various different fields: Probability, Differential Equations, Functional Analysis, and Statistics. This is possible due to previous joint work among different sub-teams of researchers. For instance, Claudio Fernández -whose mathematical origin is in Analysis- has been investigating resonances for closed quantum systems for years and has written a couple of papers with Rolando Rebolledo -a probabilist at the origin. Carlos Mora, who was a Ph.D. student of Rebolledo, is an expert in stochastic differential equations in infinite dimensional spaces, and has contributed important results on the numerical treatment of those equations. His research is naturally connected with that of Carlos Lizama (a specialist in Evolution Equations in infinite dimensional spaces) and with Rebolledo’s approach to open quantum systems. Many other examples of possible interactions between participants of the project can be shown. We will explain that in detail later, but we want to stress here that these interactions would not be possible without a funding scheme like that of “Scientific Rings” offered by the Bicentennial Foundation.

The interaction between us will be determined by two main facts: firstly, the mathematical work on its own, motivated by a number of fundamental ideas to connect classical Analysis with the probabilistic approach in its commutative and non commutative versions; and secondly, by the applications which are classified around three research axes:

- I. Applications to Physics;
- II. Applications to Biology;
- III. Applications to Engineering.

Referring to fundamental ideas connecting classical Analysis with the probabilistic and statistical approach, we consider the following keywords: evolution equations, open system dynamics, multiparticle systems, simulation, statistical inference.

In mathematical terms we deal, in a wide sense, with **dynamical systems** (DS) which could be **classical** (CDS) or **quantum** (QDS). The Classical Dynamical Systems considered here are indeed stochastic, as they appear in the mesoscopic limit of the interaction of a single particle with a large number of microscopic objects. The term “classic” refers to the use of Kolmogorov’s Probability model. So, given a natural phenomenon in Physics or in Biology we address the following general questions:

- (Q1) Which class of dynamical systems **S** are admissible to mathematically describe the phenomenon?
- (Q2) What are the structural properties of **S**, in particular its long-run behavior?
- (Q3) How can we identify **S** from experimental data?
- (Q4) Is it possible to numerically simulate **S** on a computer?
- (Q5) How can we test whether **S** is in accordance with experience?”

These questions have been a constant motivation for our work along the three years of our project execution. Today, we are in the position to state that we have developed a compendium of theoretical results (the “T” items below), most of which appeared as an attempt to answering the above questions, having always in mind the three main lines of applications (the “A” items). In addition, applications

Main research subjects. Starting from our main recent achievements, we classify our scientific contributions in two main families: Theoretical Results (T) and Applications (A).

(T1) Analysis of Classical and Quantum Dynamics off the equilibrium. This subject includes contributions to the study of resonances (Fernández), as well as recent progress in the analysis on the production of entropy in open quantum systems (Fagnola, Rebolledo). Fernández, Bourget, Cortés and Astaburuaga have done a systematic study of Mourre’s theory, writing some applications to the Spectral Theory of closed quantum systems (see e.g.[5]). Also, Fernández and Astaburuaga analyzed the behavior of radiating solutions of Schrödinger equations with complex-valued potentials.

Along the same research direction (T1), new results on non conventional and conventional condensation in Bose systems had been communicated by Corgini [22, 19, 20, 21]. Going beyond closed systems in (T1), to consider open quantum dynamics, Fagnola and Rebolledo touched up old results of their own about the convergence of Quantum Markov Semigroups towards a steady state (see [36]). This research has been extended in a joint paper with Dhahri [33], which has been submitted for publication, where the decoherence-free subalgebra has been characterized. Also, their investigations on the Entropy Production for Quantum Markov Semigroups has been published in [35]. In that paper, Fagnola and Rebolledo propose a characterization of the entropy production for an open system. A common idea in a number of papers, based on axiomatic or phenomenological approaches, is that non-equilibrium states are characterized by non-zero entropy production. Moreover, when the evolution is given by a Markov semigroup, equilibrium states are characterized by the detailed balance condition (Kossakowski). Fagnola and Rebolledo in their paper

start discussing the entropy production for a classical Markov process, extract the main concepts of detailed balance condition, and go through the extension of entropy production to the quantum framework, where the dynamics is given by a Quantum Markov Semigroup (QMS). So that, this is a new genuinely non-commutative notion of entropy production.

Quantum Decoherence has been inspiring several researches in our group, in particular, studies of Rebolledo on Decoherence of Quantum Markov Semigroups and Rebolledo and Spehner on Decoherence induced by Adiabatic Limits [84], both previously reported, have been followed by the M.Sc. thesis of one of our graduate students, J. Agredo, where a Decoherence rate functional is proposed.

(T2) Classical Statistical Inference and numerics. This includes statistical inference in stochastic processes applied to Engineering ([4],[11], [12],[10]) and to quantum systems through their classical reductions (see [3]). Our research line (T2) evolved towards a deeper insight in Statistical Inference, and an extremely diversified connection with discrete time dynamics, numerical resolution of stochastic differential equations as well as Measurement Theory in Quantum Mechanics. One should rename this research direction as Statistical Inference, Stochastic Numeric and Measurement Theory. Combining classical stochastic processes and non commutative probabilistic models, all of them inspired by open system dynamics, this research direction is becoming a relevant bridge between most theoretical studies of the team and their applications to Physics, Engineering and Biology. Thus, in the classical Bayesian statistical flavor we have had several contributions by Quintana and coauthors (see [32, 31, 30][34][47]), while Bertin and Torres were intrigued by long memory effects (cf. [10]). However, Quintana inquired about other methodological questions as well (cf. [45], [48][75, 74, 76]). Elliptical functional measurements and distributions strongly influenced Galea's research, who applied his results in estimation and testing to Finance (cf. [44, 42, 43]). Arenas and Rebolledo went on working in statistical inference of stochastic processes in classical and quantum models. The applications to open quantum dynamics have been justified by the theoretical results contained in [82]. Moreover, Arenas did an important job supporting engineers working in Electric Power Systems as well as researchers in Biophysics. As a result, she obtained a very reliable model of consumer's demand of electricity. Research direction (T2) received also a contribution of Lizama and coauthors, who analyzed difference equations in [1, 15, 23, 25]. Fierro and Torres from their side, contributed to probabilistic methods for resolving differential equations in [41]. Undoubtedly, one major contribution in (T2) has been the contribution of Mora [71], who analyzed the evolution of a quantum observable represented by an unbounded operator. His method of investigation deeply used previous results of his own on stochastic differential equations in infinite dimensional spaces driven by classical Brownian motions. This research worth being classified as belonging to (T2) because ingenious stochastic numerical schemes are used to prove the existence and uniqueness of solutions to the above equations. Finally, Ricardo Castro, who obtained a postdoctoral position in our Laboratory, has been working with his former advisor A. Barchielli on Measurement Theory, their results have recently been submitted for publication (cf. [8]). Stochastic simulation of quantum systems has been implemented through the work of Mora and students.

(T3) Contributions to the Theory of Dilations. A dilation could be confusedly understood in several different ways, here we refer to the construction of either a commutative or non commutative flow on a big space such that its projection over a smaller space -usually named as the "main system"- coincides with a semigroup given

at the outset. Turning first to classical dilations, one should cite again the work done by Mora alone [71, 70] and Mora and Rebolledo together [72, 73]. In parallel, Rebolledo wrote the survey paper [82], where classical dilations and restrictions of quantum Markov semigroups are studied. Among other consequences, that paper justifies the use of classical statistics in the analysis of dissipation inherent to open quantum systems. Finally, in a recent paper, Le Jan and Rebolledo are proposing a completely new way of dealing with classical dilations of consistent families of completely positive maps (see the list of preprints below). Going beyond the Markovian case, Kossakowski and Rebolledo started a systematic study of different classes of non Markovian open quantum dynamics (cf. [56, 58, 57, 59]). The structure of quantum Master equations for those classes has been studied and in a forthcoming paper, a concept of semi-Markov quantum dynamics is being studied.

(T4) Fractional Calculus and Evolution Equations. Within this subjects we have followed three research directions. Firstly, fractional differential equations and fractional Brownian motion. Secondly, Backward Stochastic Differential Equations, and, finally, non Markov approach to Open System Dynamics. In the first subject, under the leadership of Lizama, numerous investigations were carried (see for instance [2, 24, 49, 64, 69]). The second subject, as well as that of the Fractional Brownian Motion, has been Torres privileged terrain, while Rebolledo concentrated on the third one, that is, non Markov approach to open system dynamics, a job undertaken jointly with Kossakowski (op.cit.) in the quantum case, and with Lizama in the classical one (cf. [65]). An interesting fact worth of being explained in further detail about the three aforementioned subjects. A close collaboration between researchers started due to the discovery of various common features in their investigations. Thus, Torres and Lizama have both a joint research in progress which touch fractional Brownian Motion; on the other hand, Lizama and Rebolledo entertained a joint investigation on cosinus transforms and non Markov reservoirs in open system dynamics theory. Certainly, the group owes much to the enthusiastic intervention of Lizama in customary Laboratory's workshops and seminars. Some progress has been made also in the use of Fractional Calculus to represent certain dynamics in which the evolution is described by fractional integrals or by Fractional Brownian Motion [37]. These dynamics have been studied through the Theory of Integral Equations of Convolution type, and they appear in a number of phenomena in Physics, Engineering and Biology.

There is an increasing interest of researchers to open the Laboratory to a fruitful dialog with engineers, physicists and biophysicists mainly. During the execution of our project, an important progress was made in that direction. Namely, a number of papers were produced jointly with specialists of other branches of science or engineers (see [7, 14, 18, 17]) and, more significantly, several students of Mathematical Engineering have been advised in their theses by members of the Laboratory (see the tables in Section V as well as the files of the corresponding memoirs). These memoirs cover different aspects of our main fields of application: Ocean Energy, Copper Mines, Neurosciences. It is worth mentioning for instance three important memoirs developed by Mathematical Engineers: J. T. Neumann (stochastic models of copper mills); R. Cofré (stochastic model of the Calcium ion channel); G. Delgado (stochastic resolution of sea waves equations and applications to the Oscilating Water Column device); H. Mardones and S. Niklitschek (numerical solution of stochastic differential equations). Moreover, alliances with engineers as well as with neuroscientists and biophysicists, started due to the rich interaction promoted by our workshops and thesis advising. These alliances yield to the dawn of our Stochastic Analysis Centre. This emergence involves the promotion of two main research programs to be carried with our allies in

Engineering and Biophysics. They are the Non Conventional Renewable Energies Program (NCREP) and the Biostochastic Program (BIOSP). These programs will enhance our three lines of applications which we precise below.

(A1) Applications to Physics. Founded in the development of (T2) and especially (T3). Moreover, Physicist Miguel Orszag and his collaborators, currently joining our Center, have been studying different subjects on this line of research for three decades. Namely, the complete study of the Dicke model was followed by joint work with Scully on noise reduction in atomic systems. But the subject which attracted his recent research most is Quantum Information. In particular, teleportation of continuous variables, logical gates, discrimination of non orthogonal states and applications to cryptography. The incorporation of Orszag to our team is very promising about the physical issues of our research on open quantum systems.

(A2) Applications to Neurosciences. Substantial advances in the statistical treatment of experimental data have been obtained. A modeling of ion dynamics in mesoscopic scales started too, using stochastic differential equations (Cofré, Rebolledo). As a result, a very important collaboration has been launched with the Center of Neurosciences of Valparaíso, and the Ecology Department of the Catholic University in Santiago, giving birth to a Biostochastics program. The most important investigation currently in progress is the connection between stochastic simulation and molecular dynamics, motivated by biological models. New students starting their graduate diplomas (Magister and Doctoral thesis) arrived this year to our Center, looking for getting co-advised thesis, involving specialists of different areas.

(A3) Applications to Engineering. The areas that have originated a more extensive participation of members of the Laboratory and other research centers were those of Renewable Energies and Mining (Kliemann, Rebolledo). Recently, Engineer Professors Sebastián Ríos, Rodrigo Cienfuegos, and Cristián Escauriaza joined our Center. The Center organized three international workshops on stochastic modeling of the electrical generation, fundamentally concentrated in oceanic and wind sources. These meetings have opened the possibility of generating an inter university research Program in Renewable Energies. The above mentioned investigators, together with Soledad Torres, Karine Bertin, Angela Ganz, and Rolando Rebolledo, are involved in a new project on renewables which will be developed with INRIA research group TOSCA.

To summarize, our Laboratory has reached a threshold in its development from both, the theoretical point of view, entertaining original investigation in four significant research directions, and starting an important alliance yielding to a vast domain of applications. It is widely accepted that our species is living in the era of online decision making. Internet and all new communication devices breaking the borders, reducing distances, are providing new ways of interaction between human beings. These increased human interactions are becoming a sort of paradigm resolved in the concept of open system dynamics. Thus, to assist decision making one needs to seek for online mathematical resources and modeling based on dynamics of the like. That is our challenge.

Preprints. Here below, we refer finished papers, which are under revision, previous to be submitted for publication.

[1] V. Cortés: FRIEDRICH TIME DEPENDENT MODEL AND MOURRE THEORY, preprint.

- [2] C. Fernández, C. Lizama, V. Poblete: WELL POSEDNESS AND COMPACTNESS OF TRAJECTORIES FOR FLEXIBLE STRUCTURAL SYSTEMS, preprint.
- [3] M. A. Astaburuaga, C. Fernández, R. Coimbra Charao: STABILIZATION OF WAVE EQUATION WITH NEUMANN BOUNDARY CONDITION AND LOCALIZED NONLINEAR DAMPING, preprint.
- [4] M. Galea, P. Giménez: ESTIMATION AND TESTING IN THE FUNCTIONAL ELLIPTICAL MODELS, preprint.
- [5] L. L. R. Rifo, S. Torres: FULL BAYESIAN ANALYSIS FOR A CLASS OF JUMP-DIFFUSION MODELS, preprint.
- [6] C. Tudor(CES, SAMOS), S. Torres: DONSKER THEOREM FOR THE ROSENBLATT PROCESS AND A BINARY MARKET MODEL, preprint.
- [7] M. Levine, S. Torres, F. Viens: CONSISTENT ESTIMATORS FOR THE LONG-MEMORY PARAMETER IN LARCH AND FRACTIONAL BROWNIAN MODELS, preprint.
- [8] J. San Martín, M. Martínez, S. Torres: NUMERICAL METHODS FOR RBSDE, preprint.
- [9] C. Gonzalez, M. Galea, S. Torres: PRICE CALCULATION FOR A POWER EXPONENTIAL JUMP DIFFUSION MODEL, preprint.
- [10] F. Quintana, P. Müller, G. L. Rosner, M. A. Rellig: SEMIPARAMETRIC BAYESIAN MODEL FOR REPEATED BINARY MEASUREMENTS, preprint.
- [11] F. Quintana, P. Müller, G. L. Rosner, M. Munsell: SEMI-PARAMETRIC BAYESIAN INFERENCE FOR MULTI-SEASON BASEBALL DATA, preprint.
- [12] M. Corgini: EXACTLY SOLUBLE BOSE SYSTEMS: NON-CONVENTIONAL AND GENERALIZED BOSE-EINSTEIN CONDENSATION. Preprint.
- [13] M. Corgini: STUDY OF TWO COUPLED BOSE-EINSTEIN CONDENSATES. Preprint.
- [14] A. Lejay, E. Mordecki, S. Torres: NUMERICAL APPROXIMATION OF BACKWARD STOCHASTIC DIFFERENTIAL EQUATIONS WITH JUMPS, Preprint.
- [15] P. Iglesias, J. San Martín, S. Torres, F. Viens: OPTION PRICING UNDER A GAMMA-MODULATED DIFFUSION PROCESS, Preprint.
- [16] Y. Le Jan and R. Rebolledo. Measurements and consistent families of Quantum Operations.
- [17] M. Corgini, D.P Sankovich. Approximating Hamiltonian Method for Bosons: The Mean Field Bose Gas Model.
- [18] Peter Muller, Fernando Quintana. Garu Rosner. Bayesian Clustering with Regression.
- [19] Federica Giardina, Alessandra Guglielmi, Fernando Quintana, Fabrizio Ruggeri. Bayesian first order auto regressive latent variable models for multiple binary sequences.
- [20] A. Jara, E. Lessaffre, M. de Iorio and F. A. Quintana. Bayesian Semiparametric Inference for Multivariate Doubly-Interval-Censored Data.
- [21] Rolando De la Cruz, Guillermo Marshall, and Fernando A. Quintana. Joint modeling a primary endpoint and longitudinal data.
- [22] Asch J., Bourget O., Joye A., Localization properties of the Chalker-Coddington model.

5. NATIONAL AND INTERNATIONAL COLLABORATION

Please include in this section a brief explanation of the activities performed by the participants of this project in conferences, workshops, symposia and other exchange activities. Include summaries and programs of presentations.

Indicate in this section those visits and stays in private labs, academic units, research centers, enterprises, public agencies and so on, that allowed the development of research or other objectives. Include the objectives of the activity and its relevance to the Project. The place visited and the persons contacted should be identified.

Also, include here the short and long visits of researchers from abroad. Please identify the visiting person, his/her specialty, their institution of origin, the objective of the visit, the results (if any).

Mention the long-term links established between the research team and international institutions. What are the projections in time and scope of these collaborations?

Participation in Scientific Events

Name	Scientific Event	Date	Venue	Participation status	Title of the conference or contributed talk
Rolando Rebolledo	"Encuentro Matemático de la Zona Sur".	April 2009	Punta Arenas, Chile	meeting	A class of open system dynamics and their evolution equations
Rolando Rebolledo	XIII Simposio Boliviano de Matemática	July 2009	Santa Cruz de la Sierra, Bolivia,	Invited Conference	"Ecuaciones diferenciales y probabilidades: dos aplicaciones".
Rolando Rebolledo	CLAPEM	November 2009	Naiguatá, Venezuela	Invited Conference	"Contiguity of quantum and classical Markov semigroups"
Rolando Rebolledo	30th Conference on Quantum Probability and Related Topics	November 2009	Santiago, Chile	Conference Speaker	"A view on Quantum Semimarkov Processes".
Rodrigo Cofre	WONAPDE 2010 Third Chilean Workshop on Numerical Analysis of Partial Differential Equations	January 11-15, 2010	Universidad de Concepcion, Chile	Conference	"A stochastic model of gating process on calcium ion channel"
Ricardo Castro	http://mox.polimi.it/it/iniziative/view.php?en=en&id=791	December 2009	Politecnico di Milano, Milan	Seminar	*Quantum Stochastic Calculus and Continual Measurement with Unbounded Coefficients

Verónica Poblete	XXIII Jornadas de Matemática de la Zona Sur	28/04/2009 al 30/04/2009	Universidad de Magallanes	Congress	Decay Estimates and Compactness of trajectories for Flexible structural Systems
Angela Ganz	30th Conference on Quantum Probability and Related Topics	November 2009	Santiago, Chile	Conference Speaker	Numerical approximation of distribution of the equilibrium measure of McKean Vlasov equation
Angela Ganz	WONAPDE 2010 Third Chilean Workshop on Numerical Analysis of Partial Differential Equations	January 11-15, 2010	Universidad de Concepción, Chile	Conference	Convergence analysis of particle methods to approximate equilibrium solution of some McKean Vlasov equations
Angela Ganz	XXIII Jornadas de Matemática de la Zona Sur	28/04/2009 al 30/04/2009	Punta Arenas, Chile	Conference	Approximation of equilibrium measure of some stochastic systems with McKean-Vlasov interactions
Ricardo Castro	XXIII Jornadas de Matemática de la Zona Sur	28/04/2009 al 30/04/2009	Punta Arenas, Chile	Conference	Medición en óptica cuántica
Angela Ganz	VII Escuela de invierno	20-24 julio 2009	Valparaíso Chile	Conference	Weak approximation of equilibrium distributions of some stochastic systems with McKean-Vlasov interactions
Angela Ganz	30th Conference on Quantum Probability and Related Topics	November 2009	Santiago, Chile	Conference Speaker	Numerical approximation of distribution of the equilibrium measure of McKean Vlasov equation
Angela Ganz	WONAPDE 2010 Third Chilean Workshop on Numerical Analysis of Partial Differential Equations	January 11-15, 2010	Universidad de Concepción, Chile	Conference	Convergence analysis of particle methods to approximate equilibrium solution of some McKean Vlasov equations
Carlos Mora	30th Conference on Quantum Probability and Related Topics	November 23-28, 2009	Santiago, Chile	Speaker	Relations between stochastic Schrödinger equations and quantum master equations
Carlos Mora	33rd Conference on Stochastic Processes and	July, 27-31, 2009	Berlin, Germany	Speaker	Description of quantum dynamics of open systems by

	Their Applications				means of stochastic Schrödinger equations.
Carlos Mora	XXIII Jornada de Matemática de la Zona Sur	April, 28-30, 2009	Punta Arenas, Chile	Speaker	Ecuaciones estocásticas de Schrödinger de tipo lineal.
Raúl Fierro	XIX Congreso de Matemáticas Capricornio COMCA 2009	05/08/2009 al 07/08/2009	Universidad Católica del Norte	Congress	Martingale Estimators for a Class of Epidemic Models.
Raúl Fierro	XXXVI Jornadas Nacionales de Estadística	06/10/2009 al 09/10/2009	Universidad de la Frontera	Congress	A Chain-Binomial Model for Multitype Epidemics.
María Soledad Torres Díaz	VII Escuela de Invierno de Análisis Estocástico y Aplicaciones	Jul 20-24 2009	ISCV, Valparaíso	Organizer	
María Soledad Torres Díaz	Coloquio del Departamento de Ingeniería Matemática Universidad de Concepción	Jun 10, 2009	Universidad de Concepción	Conference	"Métodos de aproximación para soluciones de Ecuaciones Diferenciales Estocásticas Backward con Saltos" http://www.ing-mat.udec.cl/
María Soledad Torres Díaz	Jornadas de Matemática de la Zona Sur	Ap. 27-30 2009	Universidad de Magallanes	Conference , Organizar Sesion	
Claudio Fernández	Coloquio Facultad de Ciencias	18/3/2009	Universidad de Chile	Conference	Sojourn time and exponential decay
Claudio Fernández	XXIII Jornadas de Matemática de la Zona Sur	28/04/2009 al 30/04/2009	Universidad de Magallanes	Conference	Mourre theory for magnetic Schrodinger operators
Claudio Fernández	workshop "Spectral Problems for Quantum Hamiltonians"	22/2/2010 al 26/2/2010	EPFL, LAusanne	Conference	Commutator methods for unitary operators
Claudio Fernández	Seminario de Análisis	5/3/2010	Politecnico de Milán	Seminar	Mourre Thory and unitary operators
Claudio Fernández	Seminario de Física matemática	21/4/2010	Centro de Física Teórica, Marsella	Seminar	Commutator methods for magnetic Schrodinger operators
Claudio Fernández	Seminario de Análisis	29/4/2010	Universidad de Lisboa	Seminar	Mourre theory and unitary operators, application to beams and plates
Carlos Lizama	III UMALCA	31/08/2009 al 4/09/2009	Universidad de Santiago de Chile	Invited Conference	Caracterizaciones de Regularidad Maximal para algunas clases de ecuaciones diferenciales abstractas
Carlos Lizama	III UMALCA	31/08/2009 al 4/09/2009	Universidad de Santiago de Chile	Poster	Movimiento Browniano fraccionario generalizado y su conexión con la derivada fraccionaria de Riemann-Liouville
Carlos Lizama	VII Escuela de Invierno de Análisis Estocástico y Aplicaciones.	20/07/2009 al 24/07/2009	Instituto de Sistemas Complejos,	Conference	Propiedades de regularidad para ecuaciones diferenciales

			Valparaíso		en espacios de funciones
Carlos Lizama	XXIII Jornadas de Matemática de la Zona Sur	28/04/2009 al 30/04/2009	Universidad de Magallanes	Conference	On the stochastic versión of the generalized Basset equation.
Carlos Lizama	XXIII Jornadas de Matemática de la Zona Sur	28/04/2009 al 30/04/2009	Universidad de Magallanes	Conference	Soluciones débiles acotadas de ecuaciones diferenciales en espacios abstractos

Name	Scientific Event	Date	Venue	Participation status	Title of the conference or contributed talk
Rolando Rebolledo	Inaugural Lecture at INACAP	March 27, 2008	INACAP, Osorno	Plenary Conference	Some technological challenges of the production of Non Conventional Renewable Energies
Rolando Rebolledo	Jornadas Matemáticas Zona Sur	April, 23-25, 2008	Universidad Austral, Valdivia	Invited Plenary Conference	Classical dilations and reductions of open quantum dynamics
Rolando Rebolledo	40th ROMP Symposium	June, 25-27, 2008	University of Torun, Torun, Poland	Invited Plenary Conference	A probabilistic approach to non Markovian Quantum Dynamics
Rolando Rebolledo	Probability Seminar	July, 1 st , 2008	University of Torun, Torun, Poland	Conference	Classical stochastic processes connected with decoherent quantum dynamics
Rolando Rebolledo	VI Escuela de Invierno de Análisis Estocástico y Aplicaciones	July, 21-25, 2008	Universidad de Valparaíso	3 Lectures	Complete positivity and non commutative Markov semigroups
Rolando Rebolledo	COMCA 2008, Iquique	July 30, August 2, 2008	Universidad Arturo Prat, Iquique	Invited Conference	On a class of semi-Markov quantum dynamics
Rolando Rebolledo	X Jornadas de Matemática y Filosofía "Rolando Chuaqui"	August, 20-22, 2008	Universidad Católica de Chile	3 Lectures	Kolmogorov y von Neumann unidos por el Azar
Rolando Rebolledo	29 th Conference on Q. Probability and Related Topics	October 13-18, 2008	Hammamet, Tunisia	Invited Conference	A discussion of a concept of Quantum Entropy Production
Rolando Rebolledo	Encuentro SOMACHI 2008	November 6-8, 2008	Universidad de Valparaíso	Conference in an Invited Session, "Stochastic Analysis and Mathematical Physics"	On Quantum Entropy Production
Rolando Rebolledo	V ERPEM	November 13-14, 2008	Solís, Uruguay	Conference in an Invited Session, "Stochastic Analysis and Mathematical Physics"	Linear Stochastic Schrödinger Equation and the Quantum Exclusion Semigroup
Carlos Lizama		May 27 th , 2008	University of Puerto Rico	Lecture	Almost automorphic mild solutions to fractional differential equations
Carlos Lizama		July 11th, 2009	Universidad Técnica Federico Santa María,	Lecture	Es posible extraer la raíz cuadrada de una EDP
Carlos Lizama		March 10th, 2009	Pontificia Universidad Católica de Chile	Lecture in the Faculty of Mathematics	Solutions of Evolution Equations
Carlos Lizama		November 26th, 2008	Pontificia Universidad Católica de Chile	Lecture in the Electrical Engineering Department	La transformada de Fourier Fraccionari
Carlos Lizama	XXII Jornada de Matemática de la Zona Sur,	April 23-25, 2008	Universidad Austral de Chile, Campus Isla Teja	Invited Conference	Discrete time evolution equations of second order
Carlos Lizama	XVIII Congreso de Matemática Capricornio (COMCA	July 30th-August 1st 2009	Universidad Arturo Prat, Iquique	Invited Conference	Fractional Cauchy Problems and powers of operators

	2008),				
Carlos Lizama	Seminario Gafevol	July 17th, 2008	Universidad de Santiago de Chile		Fractional equations of evolution and the Cauchy problem
Carlos Lizama	LXXVIII Encuentro de la Sociedad de Matemática de Chile	November 6-8, 2008	Valparaíso		On a generalized Langevin equation
Carlos Lizama	V Encuentro Regional de Probabilidades y Estadística Matemática (ERPEM)	November 13-15, 2008	Solis, Uruguay		A generalized Lanevin equation
Carlos Lizama		September 24th, 2008	Facultad de Ciencias, Universidad de Chile		Is it possible to extract the square root of an EDP?
Carlos Lizama	VI Escuela de Invierno de Análisis Estocástico y Aplicaciones	July 21-25, 2008	Instituto de Sistemas Complejos, Valparaíso		Fractional equations of evolution and the Cauchy problem

Name	Scientific Event	Date	Venue	Participation status	Title of the conference or contributed talk
Manuel Galea	LXXVIII Encuentro Anual Somachi,	November 6-8 2008,	Universidad de Valparaíso y Laboratorio ANESTOC	Invited Conference	The Sharpe Model Under t -Distributions
M. Corgini	Winter School of Stochastic Analysis and its Applications	August 2008	Universidad de Valparaíso, Valparaíso	expositor	"Critical Behavior of Some Closed Many Particle Systems
M.Corgini	Congreso de Matemáticas COMCA08	August 2008	Universidad Arturo Prat, Iquique, Chile	Organizer of the invited session	"Critical Behavior of a Bose Mean Field Model
Soledad Torres	LXXVIII Encuentro Anual Somachi	November 6-8 2008,	Universidad de Valparaíso y Laboratorio ANESTOC	Invited Conference	The Sharpe Model Under t -Distributions
María Soledad Torres Díaz	VI Escuela de Invierno de Análisis Estocástico y Aplicaciones	July 21-25th, 2008	Valparaíso	Organizer	
María Soledad Torres Díaz	XXII Jornadas de Matemática de la Zona Sur	April 24-25th	Valdivia	Participant	
María Soledad Torres Díaz	COMCA	July 30th-August 3rd, 2008	Iquique	Invited Conference	Some processes with long memory
Wolfgang Kliemann	International Conference on Stochastic Analysis and Mathematical Physics VI,	January 2008	Santiago, Chile	Invited Conference	Stability Radii'
Wolfgang Kliemann	XXII Jornada de Matemática de la Zona Sur	April 23 – 25, 2008.	Universidad de Valdivia, Valdivia, Chile		Mathematics Education: Discovering, Sharing and Applying Mathematics'
Angela Ganz	XXIII Jornada de Matemática de la Zona Sur 2009. Punta Arenas	April 28-30th 2009	Punta Arenas Chile	expositor	Approximation of equilibrium measure of some stochastic systems with McKean-Vlasov interactions
Manuel Galea	VIII Congreso	October 7-	Universidad	Presenter	Hypothesis testing in an

	Latinoamericano de Sociedades de Estadística (CLATSE)	10th, 2008.	de la República, Montevideo, Uruguay		errors-in-variables model with heteroscedastic measurement errors
Manuel Galea	Encuentro anual Somachi	November 6-8th 2008	Universidad de Valparaíso, Valparaíso, Chile.	Presenter	The Sharpe Model Under t-Distributions
Fernando Quintana	Conference in U. California Santa Cruz	February 2, 2009	Santa Cruz, California, USA	Invited Seminar	On clusterwise Bayesian Regression
Fernando Quintana	Joint Statistical Meetings 2008	August 3-7, 2008	Denver, Colorado, USA	Contributed Speaker	Bayesian Clustering with Regression
Fernando Quintana	Meeting of the North American Classification Society	June 5-7	Saint Louis, Missouri	Contributed Speaker	Similarity Analysis and its Applications to Bayesian Clustering
Verónica Poblete (Trabajo en conjunto con C. Fernández y C. Lizama)	Stochastic Analysis and Mathematical Physics VI.	January 3-9 2008	Facultad de Matemáticas, Pontificia Universidad Católica.		Well posedness and compactness of trajectories for flexible structural systems
Verónica Poblete	Coloquio	April 23rd 2008.	Facultad de Ciencias. Universidad de Chile.		Multipliers and Maximal Regularity
Verónica Poblete	Congreso de Matemática Capricornio (COMCA)	29/07 /08 to 02/08/08	Universidad Arturo Prat		Maximal Regularity of Second Order Equations Equations with Delay
Verónica Poblete (Trabajo en conjunto con C. Fernández y C. Lizama)	Encuentro SOMACHI	November 6-8 2008	Valparaíso		Well posedness and compactness of trajectories for flexible structural systems
Karine Bertin	Encuentro SOMACHI	November 2008		Coordinator session y orator	Selection of variables in high-non-parametric regression
Karine Bertin	Groupe de travail Orsay	July 2008		orator	Asymptotic normality of the Nadaraya Watson estimator and application to telecommunications
Mallén Arenas	Stochastics Análisis and Mathematical Physics VI (SAMP)	Enero	PUC, Santiago.		Statistical Inference of Classical Stochastics Processes Derived from Open Quantum Systems.
Mallén Arenas	XXII Jornada de Matemáticas de la Zona Sur	Abril	Universidad Austral, Valdivia		Test of Hypothesis in Continuous Process
Mallén Arenas	LXXVIII Encuentro Anual de la Somachi.	Noviembre	Valparaiso		Test of Hypothesis in Continuous Process
Mallén Arenas	V Encuentro Regional de Probabilidades y Estadística (Erpem).	Noviembre	Solís, Uruguay		Classical Statistical Inference Reductions of Quantum Markovian Semigroups
Claudio Fernández	IV Workshop in Applied Mathematics 2008	27-28 Nov., 2008.	Antofagasta, Chile	Conference	Non existence of eigenvalue solutions for beams and plates

Claudio Fernández	COMCA	August 2008.	Iquique, Chile	Conference	Absence of singular continuous spectrum for some time periodic magnetic Schrödinger operators
Claudio Fernández	Gafevol	Jan. 2008.	Usach, Santiago, Chile	Conference	Dissipative Scattering
Claudio Fernández	Spectral and Scattering Theory for Quantum Magnetic Systems	July 7-11, 2008.	CIRM, Luminy, Marsella, France	Conference	Absence of singular continuous spectrum for some time periodic magnetic Schrödinger operators
Claudio Fernández	Encuentro Zona Sur	April, 2008.	Valdivia, Chile		Non existence of eigenvalue solutions for beams and plates
Claudio Fernández	Congreso Nacional de la Sociedad Matemática Mexicana	Oct.20-24, 2008.	Valle de Bravo, México	Conference	Absence of singular continuous spectrum for some time periodic magnetic Schrödinger operators
Claudio Fernández	Analysis Seminar	March, 2008.	U.Federal de Rio de Janeiro, Brasil	Conference	Eigenvalue solutions for evolution equations
Claudio Fernández	Coloquio	Oct. 2008.	U. de Chile	Conference	On eigenvalues of beams and plates
Carlos M. Mora	LXXVIII Encuentro de la SOMACHI	November, 6-8	Valparaíso	Talk	Evolución de observables cuánticos no acotados.
Carlos M. Mora	XXII Jornada de Matemática de La Zona Sur	April, 23-25	Valdivia	Talk	Evolution towards equilibrium in open quantum systems

Visits and stays (in research centers, academic units, private labs, enterprises, public agencies and so on)

Name	Visit/ Stay	Date	Venue	Participation Status	Contact Person	Development of research or other objective
Ricardo Castro	Stay	December 2009	Politecnico di Milano,		Alberto Bachielli	
Ricardo Castro	Stay	December 2009	Università degli Studi di Palermo		Fabio Bagarello	
Rolando Rebolledo	Stay	March 4-15, 2010	Université de Paris-Sud" (Orsay)		Yves Le Jan	
María Soledad Torres Díaz	Stay	April 25-29, 2009	Universidad de Campinas, Brasil		Laura Ramos Rifo- Jesus Garcia	Bayesian Analysis of Skew Brownian motion
María Soledad Torres Díaz	Stay	Sep. 7 – 22, 2009	INRIA, Francia		Antoin Lejay	Paper submitted on Numerical Analysis for BSDE with Jumps.
María Soledad Torres Díaz	Stay	March 15-24, 2010	Universidad de Campinas, Brasil		Laura Ramos Rifo – Jesus Garcia	LS estimators for linear models with long memory noise.
Manuel Galea	Stay	August 12-22	Universidad de São Paulo, Brasil		Gilberto Paula	Influence Diagnostics in Statistical Models

Claudio Fernández	Stay	28/9/2010 al 11/10/2010	CPT-Marsella		Joachim Asch	
Carlos Lizama	Stay	14 December, 2009 – 31 January 2010	Universidad de Zaragoza		Pedro J. Miana	Development of Research

Name	Visit/ Stay	Date	Venue	Participation Status	Contact Person	Development of research or other objective
Fernando Quintana	M.D Anderson Cancer Center	November 2008-February 2009	University of Texas, Houston	Visiting Associate Professor	Peter Muller	
Rolando Rebolledo	Stay	June 25-July 3, 2008	University of Torun, Poland	Visiting Professor	Prof. Andrzej Kossakowski	Research on non Markovian Q. Dynamics
Rolando Rebolledo	Stay	July 14-15	Universidad de San Andrés, Buenos Aires	Visiting Professor	Prof. Ricardo Fraiman	Workshop on Stochastic Analysis
Rolando Rebolledo	Stay	Sept. 29-Oct. 18	Université de Paris-Sud (Orsay)	Visiting Professor	Prof. Yves Le Jan	Research on Dilations
Verónica Poblete	Universidad de Puerto Rico	June 29 th -July 20 th 2008	Departamento de C.s Naturales	Visiting Professor	Valentin Keyantuo	Fractional Equations
Karine Bertin	Stay	July 01-31 2008		Invited Professor	Vincent Rivoirard	Research on problems of non-parametric estimation
Maria Soledad Torres	Universidad de Paris I, INRIA, Instituto Elie Cartan, UMR, CNRS	December 27-2007 to March 2008	France	Visiting researcher	Antoine Lejay, Frederi Viens, Samy Tindel	Fractional Brownian Motion
Maria Soledad Torres	Universidad de Campinas	April 10 th -18 th , 2008	Brasil	Visiting researcher	Laura Ramos	Bayesian models in neuroscience
Maria Soledad Torres	Le Mans	June 16th -29th, 2008	France	Visiting researcher	Jean Pierre Lepeltier	Differential stochastic equations Backwards
Maria Soledad Torres	Universidad de San Andrés	July 13 th -16 th , 2008	Argentina	Visiting researcher	Daniel Fraiman	Statistics applied in neuroscience
Maria Soledad Torres	Universidad de La República	November 17 th – November 21 st , 2008	Montevideo	Visiting researcher	Ernesto Mordecki	Differential stochastic equations
Mallén Arenas	Stay	Octubre	ICIMAF La Habana, Cuba	Visiting Professor	Rolando Biscay	
Claudio Fernandez		March 22-April 01	LNCC Rio, Brasil	Visiting Professor	Prof. Gustavo Perla	Research on Beam Eq.
Claudio Fernandez		June 30- July 15, 2008	CPT Marsella Francia	Visiting Professor	Prof. Pierre Duclos And Joachim Asch	Research on Spectral Theory
Claudio Fernández		Oct. 17-25, 2008	UNAM Mexico	Congreso Sociedad Matemática	Prof Rafael Del Río	Conference

Researchers from abroad

Visiting person	Dates	specialty	Institution of origin	Objectives of the visit	Results
Yves LeJan	Jan 5- Jan 20		UNIVERSITE DE PARIS-SUD	MathAmSud	
Mateo Gregoratti	Nov 23-28		Politecnico di Milano	30th QPRT Congress	
Alberto	Nov 23-28		Politecnico di	30th QPRT	

Barchielli			Milano	Congress	
Jean Claude Zambrini	Nov 23-28		COMPLEXO INTERDISCIPLINAR DA UNIVERSIDAD DE LISBOA	30th QPRT Congress	
Jean Belissard	Nov 23-28		GEORGIA INSTITUTE OF TECHNOLOGY	30th QPRT Congress	
Phillipe Briet	Nov 16-Dec 13		Marsella, France	Work with Claudio Fernández	
Denes Petz	Nov 23-28		TECHNICAL UNIVERSITY OF BUDAPEST	30th QPRT Congress	
Franco Fagnola	Nov 21-28		Politecnico di Milano	30th QPRT Congress	
Takeyuki Hida	Nov20-28		MEIJO UNIVERSITY, Japan	30th QPRT Congress	
Luigi Accardi	Nov 23-Dec6		UNIVERSITA DI ROMA TOR VERGATA, Italy		
Adrian Budini	Nov 16-Nov30		Centro Atomico Bariloche		
Mireille Bossy	Nov8-29 Nov		Inria,	Tosca Project Team	
Denis Talay	Nov 8-Nov15		INRIA SOPHIA ANTIPOLIS - MEDITERRANEE	Tosca Project Team	
Ricardo Fraiman	12 Oct-17 Oct		U. SAN ANDRES		
Etienne Tanre	3 Oct- 17 de Oct		INRIA,SOPHIA-ANTIPOLIS	Tosca Project Team	
Franco Fagnola	July 25-Aug 30		Politecnico di Milano		
Nelson Barrera	Dec. 13 2008 – 05 Jan 2009		University of Cambridge	Research	Starting collaboration in Membrane protein structure
Verónica González	Jan 10-18 2009		Universidad de Campinas, Brasil	Research	Starting collaboration in Linear Models with long memory noise
Jesús García	Jan 10 – 18 2009		Universidad de Campinas, Brasil	Research	Starting collaboration in Linear Models with long memory noise
Ciprian Tudor	Jan 09-25 2009		Université Paris 1		
Ciprian Tudor	Jan 08-21 2010		Université Paris 1	WONAPDE 2010, Concepción Chile	ECOS Project submitted in 2010
Filidor Vilca	July 17 – August 07		Universidad Estadual de Campinas, Sao Paulo, Brasil.	Work with Manuel Galea	
Patricia Giménez	Nov 22 – Dec 02		Universidad Nacional de Mar del Plata, Argentina	Work with Manuel Galea	
Pedro J. Miana	Nov 17- Nov 28	Functional Analysis	Universidad de Zaragoza	30th QPRT Congress	Talk in Congress and research with C. Lizama
Anna Karczewska	Nov 16 Nov 29	Stochastic Analysis	University of Zielona Gorá	30th QPRT Congress	Talk in Congress and research with C. Lizama

Visiting person	Dates	specialty	Institution of origin	Objectives of the visit	Results
Patricia	November 9-	Statistics	Universidad de	Addressing the	We have obtained the following

Giménez	19th, 2008		Mar del Plata, Argentina.	topic of Local Influence using the method of corrected score in the MEM functional.	results: (1) An algorithm to obtain the estimators of model parameters and their asymptotic properties. (2) Using the corrected score, we calculated the Delta matrix for different patterns of disturbance and the observed information matrix.
Rolando Biscay	March 28- April 28, 2008	Stochastic Analysis	Cuban Academy of Sciences	Research on applications of Stochastic Analysis to Neuroscience	Joint work in progress with Mallén Arenas and Rolando Rebolledo on Statistical Inference on infinite dimensional spaces
Yan Pautrat	April 16-May 2, 2008	Stochastic Analysis	Université de Paris-Sud	Research on Dilations	Joint work in progress on quantum dilations
Andrzej Kossakowski	Nov. 17-30, 2008, 2008	Physics	University of Torun	Non Markovian Dynamics	Joint paper (in press) on the structure of generators of non Markovian Master Equations
Peter Imkeller	July 19-Aug. 1, 2008	Stochastic Analysis	Humboldt University, Berlin	Lectures in the Winter School	Three lectures on "Stochastic Resonance" in the VI Winter School of Stochastic Analysis, Valparaíso
Antoine Lejay	August 4-18, 2008	Stochastic Analysis	Université de Nancy	Research on various topics	Joint work (in progress) on estimation with Mallén Arenas and Rolando Rebolledo
Étienne Tanré	Sept.6-18, 2008	Stochastic Analysis	INRIA, Sophia-Antipolis	Research on applications of Stochastic Analysis to Engineering	Joint paper authored by Neumann, Otero, Rebolledo and Tanré on a Stochastic Model for Copper Mills
Dominique Spehner	Dec.15-21, 2008	Physics	Université de Grenoble	Research on Decoherence	Research in progress on non Markovian dynamics
Yves Le Jan	Jan. 6-19, 2009	Stochastic Analysis	Université de Paris-Sud	Research on Dilations	Joint paper (in progress) with Rolando Rebolledo on classical dilations of consistent QMS
Nicolas Kluchnitkoff	February, March 2009	Statistics	Université de Strasbourg	Research on problems of non-parametric estimation	Obtention of minimax results for beta-kernels estimators
Nelson Barrera	December 13 th -January 5 th , 2009	Biologist	Department of Chemistry University of Cambridge	Prediction of synergism on frequency of responses in the attojoule range Skew-distributions: theory and applications in biology	
Laura Ramos	July 18 th -25 th , 2008	Statistics	Universidad Estadual de Campinas	Participant in the VI Escuela de Invierno providing a conference	Conference "Análisis bayesiano en test de Diagnóstico secuencial"
Daniel Fraiman	July 20th-25th, 2008		Universidad de San Andrés	Participant in the VI Escuela de Invierno providing a conference	Conference "Brain dynamics: What can we learn from the Ising Model?"
Ernesto Mordecki	March 6th-20th, 2008		Universidad de La República	Modelos de difusión con Saltos y Estimación de parámetros de variables aleatorias dependientes con discontinuidades en los parámetros.	
George	March 18-22	Partial	Universidad de	Participation in	Participation in seminar

Anastassiou		Differential Equations	Memphis	seminar	
Pierre Duclos	April 02-20	Mathematical physics	CPT Marsella	Research	Progress in the study of Sojourn time
Gustavo Perla Menzala	January 02-15		National laboratory of scientific computation, Brazil	Participation in seminar Stochastic Analysis and Mathematical Physics VI Jan 3-9 2008, Facultad de Matemáticas, PUC, Chile.	Titulo de la charla: Simultaneous Exact Control For The Maxwell Equations And A Vector Wave Equation

çI. TRAINING OF STUDENTS, POST-GRADUATES AND YOUNG RESEARCHERS

This section consists mainly in the following table. Nevertheless, if there are special highlights that you consider should be mentioned in addition to the information required, please refer to Section III (RESEARCH RESULTS) making specific reference to the student or young researcher work.

No.	Name of student	Gender (M/F)	Thesis Title	Type of degree ¹	Degree denomination	Status ²	Tutor's name	Category in the Project	University that gives the degree
1	Julián Agredo Echeverry	M	UN ESTUDIO DE DECOHERENCIA EN SEMIGRUPOS MARKOVIANOS CU´ ANTICOS	Graduate Degree	Magister en Ciencias Exactas mención Matemáticas.		Rolando Rebolledo		Pontificia Universidad Católica de Chile
2	Katherine Machuca Pérez	F	GRANDES DESVÍOS PARA PROCESOS NO NECESARIAMENTE CONTINUOS	Graduate Degree	Magíster en Matemáticas	finished	Raúl Fierro Pradenas		Pontificia Universidad Católica de Valparaíso
3	Elena Orellana Villaz´on	F	PUNTO FIJO ALEATORIO PARA OPERADORES UNIVALUADOS Y MULTIVALUADOS	Graduate Degree	Magíster en Matemáticas	finished	Raúl Fierro Pradenas		Pontificia Universidad Católica de Valparaíso
4	Gabriel Delgado Kieffe	M	Modelación Matemática de un Dispositivo de Potencia OWC		Titulo de Ingeniero Civil especialidad Ingeniería Matemática		Rodrigo Cienfuegos, Rolando Rebolledo		Pontificia Universidad Católica de Chile
5	Felipe Poblete	M	"Ausencia de valores propios de dos familias de operadores"	Graduate Degree	Magister en Ciencias Exactas		Olivier Bourget		Pontificia Universidad Católica de

¹ Undergraduate degree or professional title (1); Master or equivalent (2); Ph.D. or equivalent (3).

² Finished (F-year) or In Progress (IP)

					mención Matemáticas.				Chile
6	Angelica Vega	F	Sobre la regularidad de los vectores propios de un operador unitario.	Graduate Degree	Magister en Ciencias Exactas mención Matemáticas.	To be defended in June 2010	Olivier Bourget		Pontificia Universidad Católica de Chile
7	Hernán Alfredo Mardones González	M	Solución numérica de ecuaciones diferenciales estocásticas con ruido multiplicativo		título profesional de Ingeniero Matemático		Carlos M. Mora González		Universidad de Concepción
8	Sebastián Niklitschek Soto	M	Solución numérica de ecuaciones estocásticas de Langevin-Poisson		título profesional de Ingeniero Matemático		Carlos M. Mora González		Universidad de Concepción
9	Rodrigo Alejandro Cofré Torres	M	Estocástico de la dinámica de apertura del canal iónico de calcio		título de Ingeniero Civil de Industrias, con Diploma en Ingeniería Matemática		Rolando Rebolledo		Pontificia Universidad Católica de Chile
10	Alejandro Aguilera	M	Integración Estocástica Cuántica	Graduate Degree	Magister en Matemáticas		Raúl Fierro Pradenas		Pontificia Universidad Católica de Valparaíso
11	Efraín Cruz	M	Bilinear control systems with unbounded control.	Doctorate Degree	Ph.D.	finished	Wolfgang Kliemann		Pontificia Universidad Católica de Chile del Norte
12	Wen Li		Memory structures in financial time series	Doctorate Degree	Ph.D.	finished	Wolfgang Kliemann and Alicia Carriquiry		Iowa State University
1	Fernando Vera	M	Affine control systems	Doctor	Ph.D.	finish	Wolfgang		

3				ate Degree		ed	Kliemann		
	Julián Agredo	M	Quantum Decoherence	Doctorate Degree	Ph.D.		Rolando Rebolledo		
	Rodrigo Cofré	M	Graph dynamics in Neuroscience	Doctorate Degree	Ph.D.		Rolando Rebolledo		
	Mauricio Tejo	M	Stochastic approach to Brain Dynamics	Doctorate Degree	Ph.D.		Rolando Rebolledo		
14	Nelson Cifuentes	M	Ionization for some non autonomous Hamiltonians	Doctorate Degree	Ph.D.		Claudio Fernandez		Pontificia Universidad Catolica de Chile
15	Wolfgang Rivera	M	Resonances in closed and open quantum systems	Doctorate Degree	Ph.D.		Claudio Fernandez		Pontificia Universidad Catolica de Chile
16	Alejandro Muñoz	M	Contiguity and Asymptotic Statistical Analysis in Open Quantum Systems	Doctorate Degree	Ph.D.		Rolando Rebolledo		Pontificia Universidad Catolica de Chile
17	Morgan Caitlin Baldwin	F	Stochastic analysis of the Marotzke and Stone climate model.		Master of Science		Wolfgang Kliemann		
18	José Tomás Neumann	M	A stochastic model of the process of milling of copper minerals, based on Smoluchowski equation		Ingeniero Matemático P.U.C		Rolando Rebolledo		Pontificia Universidad Catolica de Chile
19	José Tomás Neumann	M	Smoluchowski equation in open quantum systems		Magister en Ciencias, mención		Rolando Rebolledo		Pontificia Universidad Catolica de

					Matemáticas				Chile
20	Mallén Arenas	F	Statistical inference of stochastic processes derived from classical quantum open systems.		Doctor		Rolando Rebolledo		Pontificia Universidad Católica de Chile
21	Claudio Rivera	M	Scattering clásico en potenciales discontinuos y campos magnéticos		Magister en Ciencias, mención Matemáticas		Claudio Fernandez		Pontificia Universidad Católica de Chile
22	Jorge Andrés Clarke De la Cerda	M	DISPERSIÓN LINEAL DE CUADRATURAS EN MEDICIONES CONTINUAS Y SIMULTÁNEAS DE POSICIÓN Y MOMENTO		Ingeniero Matemático		Carlos Mora		Universidad de Concepcion

Note: Please consider all the students registered in previous progress reports.

ϷII. PUBLICATIONS

List the publications **resulting from the entire project period**. Include only submitted, accepted and in press manuscripts or published publications stating their status. Indicate title, authors, year of publication and press company in case of book information.

Include letters or email messages confirming reception or acceptance of manuscripts. Include abstracts only of those papers published. In the digital version, include a copy of papers published.

Do not include manuscripts in preparation or submitted in this section (you can include them in section IV).

Indicate those international collaborators in the author's list of each paper or manuscript by underlining their names.

When filling up the table of indicators, consider only the citations for those papers resulting from this project.

The Program has to confirm that the publications acknowledge the funding from CONICYT. To do so, please indicate in your list the website where publications may be downloaded or send a digital copy or include a printed issue of the paper. (Also indicate these other alternatives in the same list)

To access the published material, evaluators are kindly requested to follow the links through our web site www.anestoc.cl (under the section "Publications).

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ϡIII. DISSEMINATION AND KNOWLEDGE TRANSFER ACTIVITIES (OUTREACH)

This section includes all dissemination activities that are not a classic mean to deliver scientific knowledge (papers, reviews, congress presentations –oral and posters-, book chapters), which are listed in the previous sections.

Also include here knowledge transfer activities delivered to: non-research professionals, researchers from other disciplines than those involved in the project, enterprises, students and institutions of basic and secondary education or general public.

Please summarize the activity and its objectives, enclosing all additional material considered necessary as an appendix.

Name	Scientific Event	Date	Venue	Participation status	Title of the conference or contributed talk
Marisa Radrigán y Andrea Moreira	Philosophical Discussion	May 7, 2009	Facultad de Matemáticas, sala 2	USACH	Las bases cognitivas y naturalistas de la matemática: la explicación genealógica de Piaget y Dehaene (Parte I)
Marisa Radrigán y Andrea Moreira	Philosophical Discussion	May 14, 2009	Facultad de Matemáticas, sala 2	USACH	Las bases cognitivas y naturalistas de la matemática: la explicación genealógica de Piaget y Dehaene (Parte II)
Rolando Núñez	Philosophical Discussion	May 28, 2009	Facultad de Matemáticas, sala 2		Matemática corporeizada y sus fundamentos metafóricos: una introducción a la teoría de Lakoff y Núñez (Parte I)
Rolando Núñez	Philosophical Discussion	June 4, 2009	Facultad de Matemáticas, sala 2		Matemática corporeizada y sus fundamentos metafóricos: una introducción a la teoría de Lakoff y Núñez (Parte II)
Rolando Núñez	Philosophical Discussion	July 2, 2009	USACH		COGNICIÓN Y MATEMÁTICA CORPOREIZADA 2a parte.
Rolando Biscay. Instituto de Cibernética, Matemática y Física de la Habana, Cuba	Philosophical Discussion	July 30, 2009			¿Existe la inferencia inductiva?
Cristobal Holzapfel. Universidad de Chile	Philosophical Discussion	September 24, 2010	Facultad de Matemáticas, sala 2		Juego y aventura: La aventura de jugar"
Denise Depoortere. Jefa Biblioteca Gauss - PUC	Philosophical Discussion	October 15, 2009	Facultad de Matemáticas, sala 2		"Los tesoros de la Biblioteca Augusta de Wolfenbuttel y la historia de su famoso bibliotecario Gottfried Leibniz".

Type of activity	Name of Activity	date	venue	presenter	Participants (non-research professionals, researchers from other disciplines, students,	objective
Philosophical discussion	Causalidad y contrafactualidad	March 13th, 2008	Facultad de Matemáticas, sala 2	Michel Mouchart		
Philosophical discussion	Causalidad, manipulación y posibilidad: críticas a la teoría de Woodward	April 10th, 2008	Facultad de Matemáticas, sala 2	Wilfredo Quezada		
Philosophical discussion	<u>Procesos y pseudoprocesos en teorías fisicalistas de causalidad</u>	May 9th, 2008	Facultad de Matemáticas, sala 2	Luis Pavez Flores		
Philosophical discussion	"Tiempo y causalidad"	June 26th, 2008	Facultad de Matemáticas, sala 2	Wolfgang Kliemann		
Philosophical discussion	"Causalidad y termodinámica: Los aportes de Boltzmann y Gibbs"	June 12th, 2008	Facultad de Matemáticas, sala 2	Guillermo Calderón		
Philosophical discussion	Lógica, tiempo y relatividad especial	June 5th, 2008	Facultad de Matemáticas, sala 2	Wilfredo Quezada		
Philosophical discussion	"Inferencia estadística y causalidad: alcance y limitaciones de la teoría de Pearl"	July 3rd, 2008	Facultad de Matemáticas, sala 2	Ernesto San Martín		
Philosophical discussion	"Diálogo sobre causalidad en las ciencias"	July 23rd, 2008	Instituto de Sistemas Complejos de Valparaíso, ISCV. Artillería n° 470, C° Artillería, Valparaíso	Tomás Pérez-Acle, PUC; Wilfredo Quezada, USACH		
Philosophical discussion	Causalidad en cosmología física contemporánea"	August 8th, 2008	Facultad de Matemáticas, sala 2	Norman Cruz		
Philosophical discussion	"¿Hay un marco matemático-físico para la causalidad en Ciencias Biológicas?"	September 25th, 2008	Auditorio Ninoslav Bralic, Facultad de Matemáticas, P.U.C.	Tomás Pérez Acle		
Philosophical discussion	Probabilidad cuántica y una teoría realista de la medida	October 9th, 2008	Auditorio Ninoslav Bralic, Facultad de Matemáticas, P.U.C.	Ricardo Castro Santis		
Philosophical discussion	Complementariedad y límite cuántico"	October 23rd, 2008	Auditorio Ninoslav Bralic, Facultad de Matemáticas, P.U.C.	Carlos Saavedra		
Philosophical discussion	Complejidad, causalidad y azar	December 4th, 2008	Auditorio Ninoslav Bralic, Facultad de Matemáticas, P.U.C.	Rolando Rebolledo		

workshops	<u>Third Workshop on Renewable Energy, Energy Efficiency, Stochastic Modelling and Environment.</u>	July 10th and 11th, 2008	Universidad de La Serena, Chile	Laboratorio de análisis estocásticos y aplicaciones (Marco Corgini Videla)		
workshops	"Modelos cinéticos y metodos probabilista para EDP "	Every Wednesday starting March 25th, 2008	Facultad de Matemáticas	Angela Ganz	Directed to professors and graduate and post graduate students of mathematical engineering	It aims to motivate and explain the techniques that deal with probabilistic resolution models that come from EDP kinetic interaction.
Seminar	VI Escuela de Invierno de Análisis Estocástico y Aplicaciones	July 21-25 th 2008	Valparaíso - Chile	Organized by Soledad Torres D. (UV-Anestoc) Rolando Rebolledo (PUC – Anestoc and Adrian Palacios (Instituto de Sistemas Complejos de Valparaíso – UV)	Alicia Carriquiry Ramon Latorre Laura Ramos Soledad Torres Daniel Aguayo Daniel Fraiman Peter Imkeller Rolando Rebolledo Eleonora Catsigeras Pierre Guiraud Natalia Bahamonde Marco Corgini Humberto Prado participants: 31 students and about 20 professors	To establish scientific partnerships and collaboration with Europe, the United States and Latin America and to encourage college students to do scientific research and post graduate studies in Probability and Statistics

IE. LESSONS LEARNED

The following section can be used in case of available information related to the possible difficulties, inconveniences or similar issues in the management of the project within the host institution, between CONICYT and the host institution, institution and researchers or any other combination of participants and activities involved. The idea is to resolve these issues on behalf of better practices in the current and future handling of these initiatives.

Information provided in this section must be concise, stating all variables involved and outcomes. Do not extend further than 2 pages. Indicate the need of confidentiality when required.

Our report of activities shows that our team has attained a threshold in our development. Our Laboratory became a Centre, with numerous flourishing projects and ideas, facing the challenge of surviving as a research institution beyond the financial support of PBCT through its "Ring" funding program. The Catholic University will provide some administrative support for the novel Centre, but it is understood that the research network we settled up has to be able to obtain new income from external sources. Unfortunately, the schedule of project's contest this year does not allow us to apply for a renewal of our Research Ring. Thus, we have to be prepared for a substantial lack of funds this year and until a new application could be successful for the whole team.

As mentioned in our past report last year, it has been necessary to assume the risk of the wide range of specialties among our team investigators. Indeed, for already trained researchers it becomes difficult to start doing research in the specialty of another at the peril of losing precious time to advance its own theme. However, the possibility of expanding horizons maintains the vitality of research, incorporating new questions in domains believed to be depleted or, which turns out to be more manageable from a different perspective. The interactions between various specialists cannot be imposed in an administrative manner and is rather a cultural task of more general a nature. We must admit the great merit of competitions in the modality "Ring", which allows the construction of huge networks of cooperative research. As far as we experience this development, we have worked in three directions-up to enhance multidisciplinary research, with varying success: on the one hand, we have encouraged the more mature researchers to attend and participate in various seminars we managed, although in subjects that do not fall within its own specialty. Secondly, we have helped trained students in topics that can build bridges between different specialties. This has been much more successful because we have particularly talented students and curious to taste with different colleagues to visit and participate in all possible seminars. Finally, we have developed instances of encounter in which mathematics is thought beyond mathematics, namely through the philosophical discussion. We believe that this is the deepest form of establishing bridges of multidisciplinary research. The success of this way of addressing the problem today is evident in a sector of our young students and researchers.

E. INDICATORS

The following table corresponds to a selection of general and specific indicators that may or may not apply to the scope of your project. If you require or would like to define indicators particular to your activities and results, please include them at the end of this table. This program is aware that quantitative indicators do not cover most of the actual impact of your activities.

Please add up here all outputs resulting **from the three-year period**.

General	N° of Main Researchers	4
	N° of Associated Researchers	9
	Gender (%) of the main researchers	F =25%
		M =75%
	Gender (%) of the associated researchers	F =45%
M =55%		
Scientific production	N° of ISI publications	68
	N° of non- ISI publications	19
	Percentage of publications Co-authored with researchers of the Project	16,00%
	Average impact index of ISI publications	1.1
	Average number of citations per article up to this date	1.35
	N° of international presentations/conferences	91
	N° of national presentations/conferences	44
Commercial or other production (only if applies)	N° of patent applications	0
	N° of patents granted	0
	N° of licenses and/or material transfer agreements	0
	N° of Spin-offs	0
	Percentage of the annual funding of the project received from companies	0
	Annual sales volume of the companies involved	0
	N° of employees of the companies involved	0
	Industrial sector of the companies involved	0

Human resources training	Number of undergraduate students	14
	Female (%) of undergraduate students	0
	Number of Master's students	27
	Female (%) of Master's students	33%
	Number of Ph.D. students	13
	Female (%) of Ph.D. students	6%
	Number of postdocs participating in the project	8
	Female (%) of postdocs	66%
	Number of undergraduate theses finished	9
	Number of graduate theses finished (Master)	7
	Number of graduate theses finished (Ph.D)	4
	Percentage of co-tutored theses with external researchers	0
	Percentage of co-tutored theses with researchers of the Project	1
	National and International collaboration	N° of national collaboration projects
N° of international collaboration projects		2
Number of stays/visits to other institutions by students or researchers of the project		93
Number of stays/visits in the project from students or researchers of other centers or projects		42
N° of public or private(not enterprises) involved in the project		5
Percentage of publications Co-authored with external researchers		15,00%
Dissemination and extramural activities	N° of dissemination/extramural events	29
	N° of times the project appears in mass media	6
	Total N° of attendants to dissemination events	240
	N° of national academic attendants	158
	N° of international academic attendants	72
	N° of attendants from non-academic sectors	10
	N° of documents, reports, proceedings resulting from dissemination/extramural events or activities	10