

Third International Symposium QI 2009

# Quantum Interaction

March 25 - 27, 2009, Saarbrücken, Germany  
German Research Center for Artificial Intelligence

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## Program Brochure

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# CONTENT

WELCOME	3
LOCAL ORGANISATION	4
SCIENTIFIC PROGRAM	7
SOCIAL PROGRAM	11
INVITED TALKS & SPEAKERS	12
STUDENT TRAVEL GRANTS	14
ORGANISATION	15

# WELCOME

Welcome to the Third International Quantum Interaction Symposium (QI-2009)!

Quantum theory is being applied to domains such as artificial intelligence, cognition, information retrieval, biology, political science, economics, and social interaction. The international quantum interaction (QI) symposium series provides a unique cross-disciplinary forum for researchers interested in advancing and applying methods and structures of quantum theory to these and other domains outside of quantum physics on the physical, epistemological, mathematical, or philosophical levels. It is particularly concerned with the use of quantum algorithms to address, or to more efficiently solve problems in non-quantum domains - including contrasts between classical vs. quantum methods - and practical applications from nonquantum domains to quantum theory.

After highly successful meetings at Stanford (QI-2007) and Oxford (QI-2008), the series continues with its third edition in Saarbrücken. We are very pleased to offer you a carefully selected set of regular and invited talks of excellence that are given by renowned experts in the field. The scientific program of QI-2009 highlights the cross-disciplinary nature of quantum interaction covering topics such as theory and application of quantum mechanics to computation, cognition, decision theory, information systems, economics and social interaction. In particular, we are honored to receive an introductory tutorial on quantum probability theory by Professor Jerome Busemeyer from Indiana University (USA), and a keynote presentation on quantum entanglement detection by Professor Dagmar Bruss from the University of Duesseldorf (Germany).

Finally, we gratefully acknowledge the support of our sponsors Earl Research (USA) and DFKI (Germany), as well as Springer for publishing the proceedings in their Lecture Notes in Artificial Intelligence series, and the local organisation team.

We are looking forward to an inspiring event, and hope that you will enjoy both its scientific and social program!

*Peter Bruza, Matthias Klusch, William Lawless, Keith van Rijsbergen and Donald Sofge*  
Saarbrücken, March 2009.

# LOCAL ORGANISATION

## Symposium Venue:

The QI 2009 symposium takes place at the following address:

German Research Center for Artificial Intelligence (DFKI GmbH)  
Department for Agents and Simulated Reality  
Stuhlsatzenhausweg 3, 66123 Saarbruecken, Germany  
On Campus of the University of the Saarland, Building D3.2.

For local organisational help (available for attendees of the symposium only):

*Lea Yvonne Schäfer*  
Phone: +49-681-302-5276  
E-mail: [fbasr-sek@dfki.de](mailto:fbasr-sek@dfki.de)

## How to reach Saarbrücken:

1. **VIA plane to Frankfurt am Main Airport (FRA)**
  - o Take a flight to Frankfurt Airport (FRA)
  - o Take a train from FRA to Saarbrücken Hbf (Hauptbahnhof, main station); Travel time is approximately 2.5 hours. Information on train connections are available online from the Deutsche Bahn:  
<http://reiseauskunft.bahn.de/bin/query.exe/en?ld=212.199&rt=1&newrequest=yes&>
2. **VIA plane to Saarbrücken Airport (SCN)**
  - o Take a flight to Saarbrücken Airport, for example from Hamburg, Berlin, Munich
  - o Take a taxi to the Universität des Saarlandes in Saarbruecken. Travel time is about 20 minutes, Price: ca 25 euros
  - o Take a bus (RSW R10) from the airport to city centre (stop "Landwehrplatz", one-way fare is 2,30 euros). Travel time is about 30 minutes.
3. **VIA plane to Luxembourg Airport**
  - o Take a flight to Luxembourg airport
  - o Rent a car and drive directly to Saarbrücken on a motorway in about one hour.

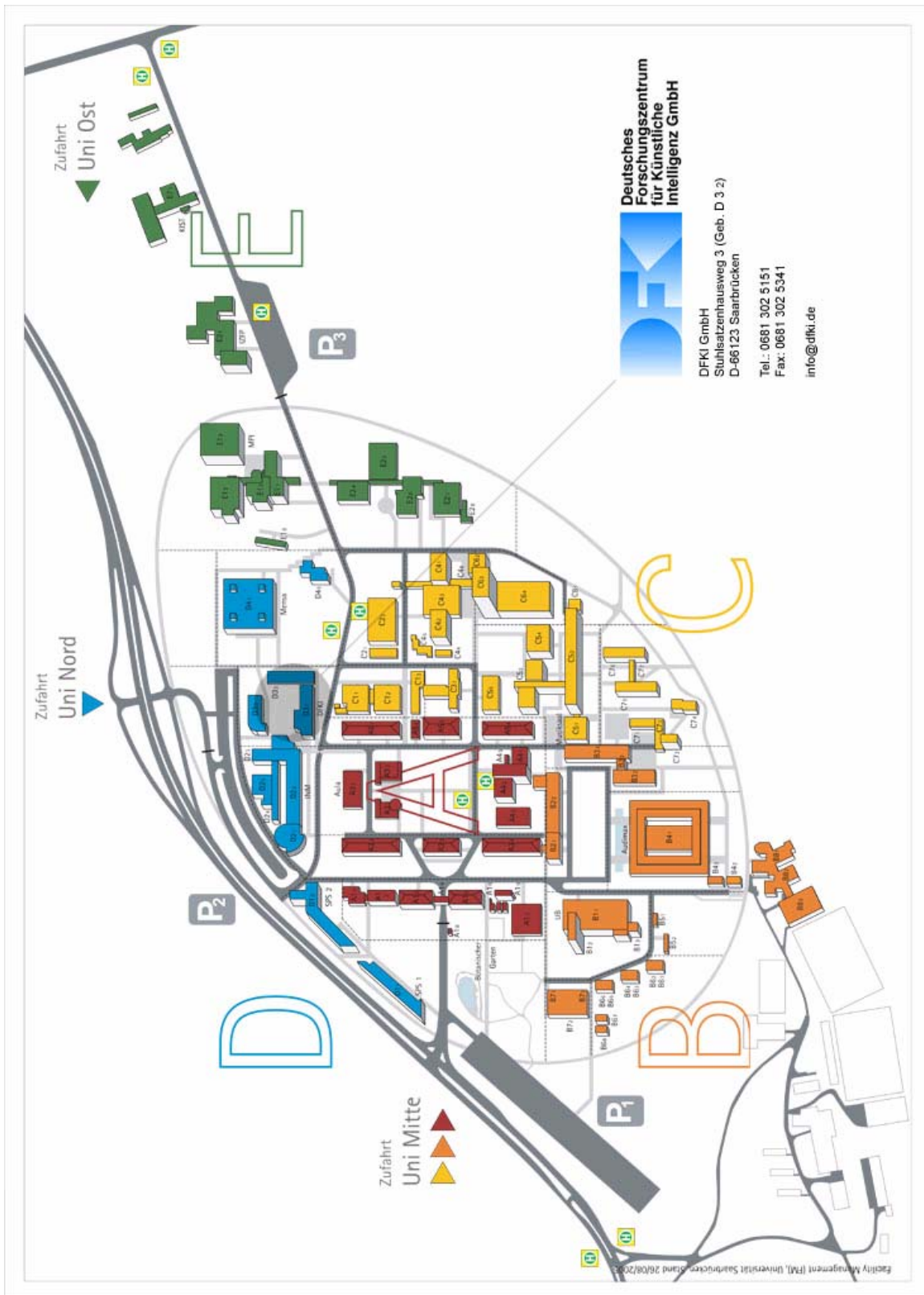
## How to reach the venue:

DFKI is located on the campus of the University of the Saarland outside downtown. The easiest way to reach DFKI from downtown is to take a cab to the main entrance of the University. Alternatively, you can take any bus line to the University (direction/stop "Universität" or "Uni"). If you come by car (with standard navigation system) just get your parking ticket at the campus gate, drive thru and get a free-of-charge guest ticket from us in return for this ticket at the DFKI reception desk (otherwise you would have to pay the parking fee when you are leaving the campus).

The gate keeper of the University has been instructed to allow visitors of the DFKI to pass through without any difficulties. After another 50 m you will see a large steel sculpture in the middle of a small round-about. Stay in the right-hand lane passing the bus stops just behind this round-about. After 80 meters you reach a X-crossing where you turn left, and keep going straight on for another 200 meters until you reach a T-crossing where you turn right - you will see already the DFKI building (no D3.2) on your left hand, it is white with blue window frames and a parking lot below the building. You get to the main entrance of DFKI in another 100 meters on your left.

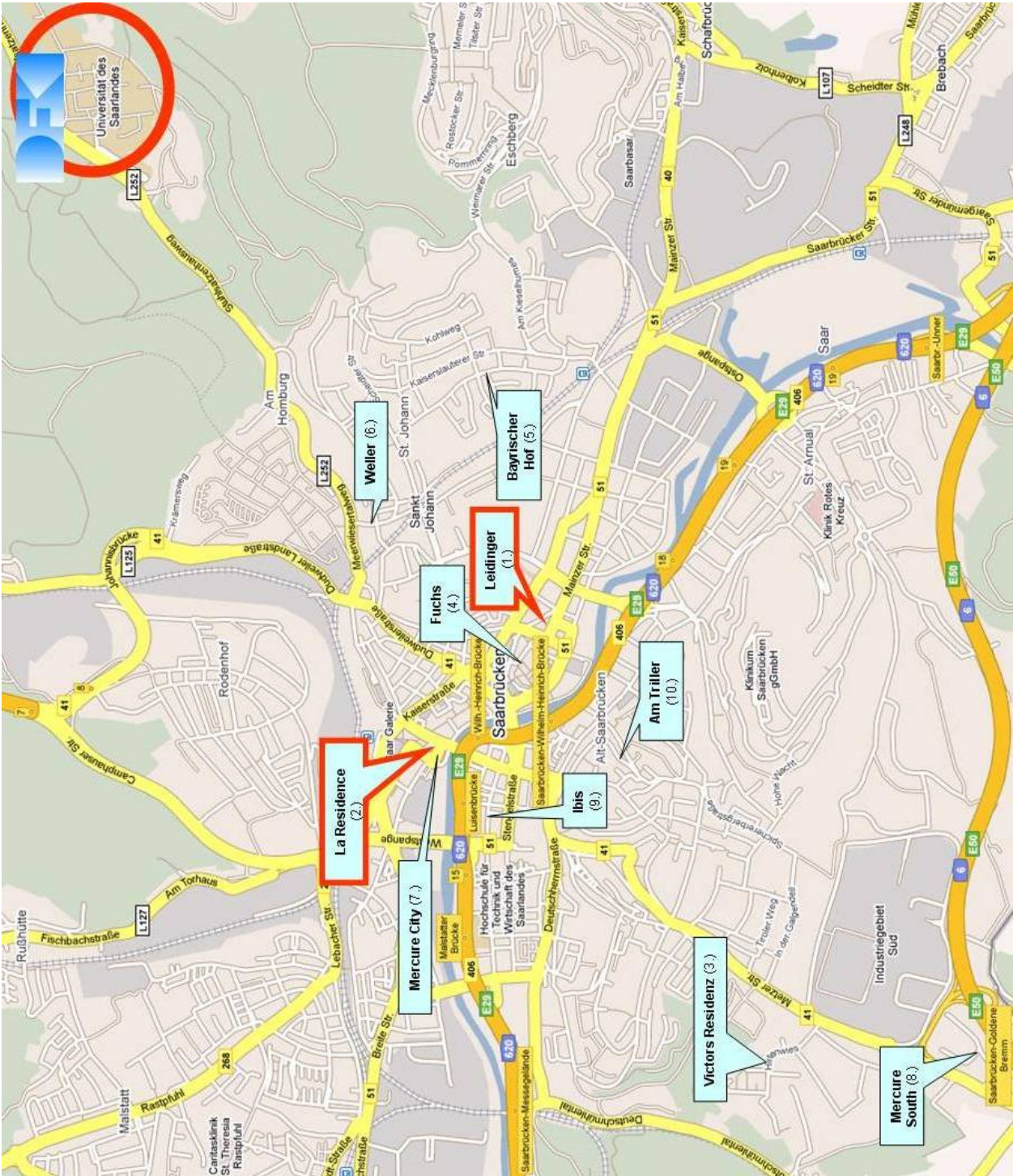
# Map of the University Campus with DFKI

Main entry to the University of the Saarland is marked "Uni Mitte".





Location of hotels and venue in Saarbruecken:



Lunch:

On all three days of the symposium lunch will be served to the participants in the restaurant "Stuhlsatzenhaus" on campus. Walking distance is approximately 10 minutes. We will guide you to this place.

# SCIENTIFIC PROGRAM

Wednesday, March 25, 2009

8:30 **Registration**

9:00 **Welcome and Opening**

[Bruza/Klusch]

**9:15 - 12:30 Invited Tutorial**

[see page 12]

**An Introduction to Quantum Probability Theory**

Jerome Busemeyer (Indiana University, USA)

10:30 - 11:00 **Coffee Break**

12:30 - 14:00 **Lunch (served in the “Stuhlsatzenhaus” on campus)**

**14:00 - 14:45 Invited Keynote Talk**

[see page 12]

[Chair: Klusch]

**Revealing Quantum Entanglement via Locally Noneffective Operations**

Dagmar Bruss (University of Düsseldorf, Germany)

14:45 - 15:15 **Coffee Break**

**Session I: Foundations**

[Chair: Sofge]

15:15 - 15:45

**Fractals and the Fock-Bergman Representation of Coherent States.**

Giuseppe Vitiello

15:45 - 16:15

**Generalising Unitary Time Evolution.**

Kirsty Kitto, Peter Bruza and Laurianne Sitbon

16:15 – 16:45

**Comparison of Quantum and Bayesian Inference Models.**

Jerome Busemeyer and Jennifer Trueblood

16:45 - 17:15

**Quantum-like Representation of Macroscopic Configurations.**

Andrei Khrennikov

**17:30 - 19:00 >>> Welcome Reception <<<**

[see page 11]

Afterwards people can break up to go to dinner at their own expense.

Thursday, March 26, 2009

### Session II: Quantum Cognition

[Chair: Busemeyer]

9:00 - 9:30

**Experimental Evidence for Quantum Structure in Cognition.**

Diederik Aerts, Sven Aerts and Liane Gabora Gabora

9:30 - 10:00

**Extracting Spooky-Activation-at-a-Distance From Considerations of Entanglement.**

Peter Bruza, Kirsty Kitto, Douglas Nelson and Cathy McEvoy

10:00 - 10:30

**Quantum Amplitude Amplification Algorithm: An Explanation of Availability Bias.**

Riccardo Franco

10:30 - 11:00

**Quantum Coherence without Quantum Mechanics in Modeling the Unity of Consciousness.**

Marcin Schroeder

11:00 – 11:30 **Coffee Break**

### Session III: Quantum Mechanics and Decision Theory

[Chair: Lawless]

11:30 - 12:00

**TI-Games: An Exploration Type Indeterminacy in Strategic Decision-Making.**

Ariane Lambert Mogiliansky and Jerome Busemeyer

12:00 - 12:30

**Classical Logical versus Quantum Conceptual Thought:  
Examples in Economy, Decision Theory and Concept Theory.**

Diederik Aerts and Bart D'Hooghe

12:30 - 14:00 **Lunch (served in the “Stuhlsatzenhaus” on campus)**

### Session IV: Quantum Mechanics and Computation

[Chair: Klusch]

14:00 - 14:30

**Quantum and Classical Structures in Nondeterministic Computation.**

Dusko Pavlovic

14:30 - 15:00

**A Symbolic Classical Computer Language for Simulation of Quantum Algorithms.**

Peter Nyman

15:00 - 15:15

**Quantum Theory, the Chinese Room Argument and the Symbol Grounding Problem.**

Ravi Gomadam

15:15 – 15:30 **Coffee Break/Board Bus**

15:30 - 22:00 >>> **Social Program** <<<

[see page 11]



**Friday, March 27, 2009**

**Session V: Quantum Mechanics and Social Interaction**

[Chair: van Rijsbergen]

9:00 - 9:30

**Conservation of Information: A New Approach To Organizing Human-Machine-Robotic Agents Under Uncertainty.**

William Lawless and Donald Sofge

9:30 - 10:00

**On Voting Process and Quantum Mechanics.**

Francois Dubois

10:00 - 10:30

**Nonseparability of Shared Intentionality.**

Christian Flender, Kirsty Kitto and Peter Bruza

10:30 – 11:00 **Coffee Break**

**Session VI: Quantum Mechanics and Semantic Space**

[Chair: Bruza]

11:00 - 11:30

**Semantic Spaces: Measuring the Distance between Different Subspaces.**

Guido Zuccon, Leif Azzopardi and Keith van Rijsbergen

11:30 - 12:00

**Characterizing High-Order Entanglements in Lexical Semantic Spaces Through Information Geometry.**

Hou Yuexian and Dawei Song

12:00 - 12:30

**Semantic Vector Combinations and the Synoptic Gospels.**

Dominic Widdows and Trevor Cohen

12:30 - 14:00 **Lunch (served in the “Stuhlsatzenhaus” on campus)**

**Session VII: Quantum Mechanics and Information Retrieval**

[Chair: Lawless]

14:00 - 14:30

**Eraser Lattices and Semantic Contents.**

Alvaro Huertas-Rosero, Leif Azzopardi and Keith van Rijsbergen

14:30 - 15:00

**Beyond Ontology in Information Systems.**

Christian Flender, Kirsty Kitto and Peter Bruza

15:00 - 15:15

**Structured Information Retrieval and Quantum Theory.**

Benjamin Piwowarski and Mounia Lalmas

15:15– 15:45 **Coffee Break**

## **Session VIII: Quantum Mechanics and Economics**

[Chair: Sofge]

15:45 - 16:15

**Hilbert Space Models Commodity Exchanges.**

Paul Cockshott

16:15 - 16:30

**Quantum Calculus (q-calculus) and Option Pricing: A Brief Introduction.**

Emmanuel Haven

## **Session IX: Closing**

**16:30 - 17:00 Closing Discussion**

# SOCIAL PROGRAM

**Wednesday, March 25, 2009**

17:30 - 19:00

The Welcome Reception takes place in the Foyer of DFKI with some fingerfood and beverages.

**Thursday, March 26, 2009**

15:30 - 22:00

*A shuttle will bring us from DFKI to the Steel Mill "Völklinger Hütte" in the town Völklingen [15:30 - 16:00].*

## **(1) Guided Visit to the Steel Mill "Völklinger Hütte" (World Cultural Heritage)**

[16:10 - 18:30]

For this visit, we will split up into two groups of visitors after our arrival at the steel mill entrance.



Our guided visit to the World Cultural Heritage Site at the Völklingen Ironworks will be a kind of an adventure: We go down deep into the dark corridors of the burden shed and climb up to the lofty heights of the blast furnace viewing-platform. The multi-media introduction to the sintering-plant takes us on a journey through time, from the beginnings of the Völklingen Ironworks right up to the present day. From the roof of the ore shed, a view opens up over the town of Völklingen and the active works of the steel company Saarstahl AG: An impressive panorama at any time of year, both by night and by day. At the granulating-plant, the laid out picnic area, located between colourful aquatic plants and uncompromising steel offers visitors a chance to relax. Then there is the ascent to the top platform 27 metres above ground: where the raw materials were once tipped into the blast furnaces. If anyone feels like going up a little further, they can climb up to the viewing-platform of the blast furnace group from which an incomparable panorama can be seen. The top platform, spanning a length of 200 metres is now open to visitors: altogether an impressive experience. The tour continues by walking via the coal track, with its new 20 metre long spiral chute, over the blower shed footbridge into the blower shed. Here the blowers can be seen: giants of iron and steel which generated the blast that was then channelled into the blast furnaces.

*Afterwards a shuttle takes us back to Saarbrücken downtown. Quick refreshments are available at the shuttle. [18:30 - 19:00]*

## **(2) Social Dinner at the Restaurant "Kulturcafé" in Saarbruecken**

[19:00 - 22:00]

We will have a nice buffet dinner served in this small, cosy restaurant right in the centre of Saarbrücken at the marketplace St-Johanner Markt.

Address: St. Johanner Markt 24, 66111 Saarbrücken

# Invited Talks & Speakers

Wednesday, March 25, 2009, 9:15 - 12:30 - Tutorial

## An Introduction to Quantum Probability Theory

Jerome Busemeyer (Indiana University, USA)

The cognitive revolution that occurred in the 1960's was based on classical computational logic, and the connectionist/neural network movements of the 1970's were based on classical dynamical systems. These classical assumptions remain at the heart of both cognitive architecture and neural network theories, and they are so commonly and widely applied that we take them for granted and presume them to be obviously true. What are these critical but hidden assumptions upon which all traditional theories rely?

Quantum information processing theory provides a fundamentally different approach to logic, reasoning, probabilistic inference, and dynamical systems. For example, quantum logic does not follow the distributive axiom of Boolean logic; quantum probabilities do not obey the disjunctive axiom of Kolmogorov probability; quantum reasoning does not obey the principle of monotonic reasoning. Nevertheless Mother Nature seems to rely quite heavily on quantum computing principles in many domains of science.

This tutorial will provide an exposition of the basic assumptions of classic versus quantum information processing theories. These basic assumptions will be examined, side by side, in a parallel and elementary manner. For example, classical systems assume that measurement merely observes a pre existing property of a system; in contrast, quantum systems assume that measurement actively creates the existence of a property in a system. The logic and mathematical foundation of classic and quantum theory will be laid out in a simple and elementary manner that uncovers the mysteries of both theories. Classic theory will emerge to be seen as a possibly overly restrictive case of the more general quantum theory. The fundamental implications of these contrasting assumptions will be examined closely with concrete examples and applications to cognition. New research programs in cognition based on quantum information processing theory will be reviewed.

Participant Background: This tutorial will introduce participants to an entirely new area and no previous experience or background with quantum theory will be assumed. No background in Physics is required. What is required is an elementary background in classic logic, classic probability, and linear algebra (e.g. matrix multiplication).



**Jerome Busemeyer** is Full Professor of Psychological and Brain Sciences, and Cognitive Science (since 1996) at Indiana University in Bloomington, USA. Formerly, he has been Manager of the Cognition and Decision Program of the Air Force Office of Scientific Research (2005-2007). Professor Busemeyer received both his Ph.D. (1979) and M.A (1976) from the University of South Carolina (USA), and spent his Post Doctoral Fellowship on Quantitative Methods (1980) at the University of Illinois (USA). Amongst others, he serves on the editorial board of the international journal for Mathematical Psychology and Experimental Psychology, and is member of Grant Review Panels of the NSF and NIMH for these areas. His special research interests are Quantitative Methods and Mathematical Modeling Judgment and Decision Making Concept Learning.

Homepage: <http://php.indiana.edu/~jbusemey/home.html>

Wednesday, March 25, 2009 14:00 - 14:45 - Keynote

## Revealing Quantum Entanglement via Locally Non-Effective Operations

Dagmar Bruss (University of Düsseldorf, Germany)

Quantum entanglement is at the heart of quantum information processing. Various methods for the detection of entanglement have been developed. Here, we will explain an approach that uses locally non-effective unitary operations which, however, do cause a change of the global density matrix - an indication for the existence of correlations. We investigate whether this method can distinguish between classical and quantum correlations.



Dagmar Bruss is Full Professor at the Institute for Theoretical Physics at the Heinrich-Heine-University of Düsseldorf, Germany (since 2004). She completed her doctorate in theoretical particle physics in 1994 at the University of Heidelberg, Germany. She joined the University of Oxford, England, as a European Research Fellow from 1996-97, where she started to work in the newly emerging field of quantum information theory. She spent another European Fellowship in 1998 at ISI Torino, Italy, and completed her Habilitation at the University of Hannover, Germany, in 2002. Her main research interest is in quantum information theory, in particular foundations, entanglement theory, quantum cloning and state estimation, quantum cryptography, and quantum optical implementations. Dagmar Bruss has written a book entitled "Quanteninformation" (in German), S.Fischer-Verlag (2003). Together with G. Leuchs she is Editor of the book "Lectures on Quantum Information", Wiley (2007).

Homepage: <http://www.thphy.uni-duesseldorf.de/~ls3/people/bruss.html>

# Student Travel Grants

There has been limited financial support provided to the following PhD students as (co-)authors of accepted papers to present their work at the QI 2009 symposium:

1. **Guido Zuccon (University of Glasgow, UK)**
2. **Alvaro Huertas-Rosero (University of Glasgow, UK)**
3. **Riccardo Franco (Politecnico di Torino, Italy)**

We are thankfully acknowledging the sponsoring of these grants by Earl Research (USA).





# Organisation

## Co-Chairs

Peter Bruza (Queensland University of Technology, Australia)  
Matthias Klusch (DFKI Saarbruecken, Germany)  
William Lawless (Paine College, USA)  
Keith van Rijsbergen (University of Glasgow, UK)  
Donald Sofge (Naval Research Laboratory, USA)

## Local Organising Team @DFKI

Léa Yvonne Schaefer  
Jasmin Lehmann  
Catrin Ehrhardt  
Maria Iskudi  
Patrick Kapahnke  
Steffen Metzger  
Matthias Klusch

## Program Committee

Diederik Aerts (Free University Brussels, Belgium)  
Sven Aerts (Free University Brussels, Belgium)  
Salvador Venegas-Andraca (Tecnologico de Monterrey, Mexico)  
Belal E Baaquie (National University of Singapore, Singapore)  
Dagmar Bruss (University of Düsseldorf, Germany)  
Peter Bruza (Queensland University of Technology, Australia)  
Jerome Busemeyer (Indiana University, USA)  
Stephen Clark (Oxford University, UK)  
Bob Coecke (Oxford University, UK)  
Charles Fox (Oxford University, UK)  
Riccardo Franco (Institute for Scientific Interchange, Italy)  
Liane Gabora (University of British Columbia, Canada)  
Emmanuel Haven (University of Leicester, UK)  
Andre Khrennikov (Växjö University, Sweden)  
Kirsty Kitto (Queensland University of Technology, Australia)  
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Massimo Melucci (University of Padua, Italy)  
Dusko Pavlovic (Kestrel Institute, USA and Oxford University, UK)  
Paavo Pyllkänen (University of Helsinki, Finland)  
Keith van Rijsbergen (University of Glasgow, UK)  
Donald Sofge (Naval Research Laboratory, USA)  
Giusseppe Vitiello (University of Salerno, Italy)  
Dominic Widdows (Google, USA)  
John Woods (University of British Columbia, Canada)