

## **DOCTORAT *HONORIS CAUSA***

Acord núm. 253/2005 del Consell de Govern, pel qual s'aprova la concessió del doctorat *Honoris Causa* al Dr. Juan Ignacio Cirac.

- Document aprovat per la Comissió Permanent del dia 14/11/2005.
- Document aprovat pel Consell de Govern del dia 29/11/2005.

**DOCUMENT CG 15/11 2005**

Secretaria General  
Novembre de 2005

EXCEL·LENTÍSSIM SR. JOSEP FERRER LLOP

Benvolgut Rector,

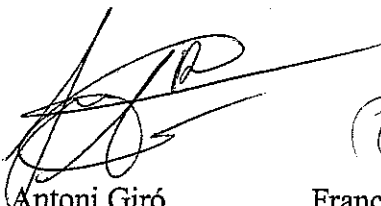
Amb motiu de l'any mundial de la Física, les unitats bàsiques signants, totes elles lligades directa o indirectament a aquesta disciplina, pensem que fora bo aprofitar aquest any 2005 per reforçar la importància i el lligam d'aquesta àrea del saber amb la tecnologia i l'arquitectura. És per això que hem pensat que una manera de fer-ho seria donar per primera vegada a la UPC, la més alta distinció acadèmica, el "Doctorat Honoris Causa per la UPC" a un Físic.

Entre els possibles candidats hem seleccionat un físic català, natural de Manresa, que malgrat ser molt jove, ja s'ha distingit per la seva vàlua científica i reconeixement a nivell internacional. Ens estem referint al Dr. Ignacio Cirac, director del Max-Planck Insitut für Quantenoptik, i que des de fa uns anys està col·laborant estretament en el desplegament i la consolidació de l'Institut de Fotònica.

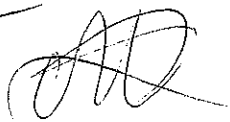
Hom podria pensar que és prematur concedir aquest tipus de guardó a una persona que encara està als inicis de la seva carrera científica, però no hem d'oblidar que per altre costat, en aquestes circumstàncies és bo anticipar-se i ser dels primers en fer públic reconeixement de la seva trajectòria i recolzament a la nostra institució.

Després d'aprovar per consens la proposta, per part dels òrgans col·legiats de les unitats bàsiques signants, et fem a mans el seu curriculum per tal que aquesta pugui ser analitzada i tramitada per a la seva consideració als òrgans de Govern de la UPC.

Quedant com sempre a la teva disposició per ampliar la informació et saludem ben cordialment.



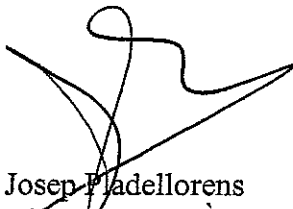
Antoni Giró  
Director Dept. FEN



Francisco Marqués  
Director Dept. FA



Antoni Broquetes  
Director Dept. TSC



Josép Pladellorens  
Director Dept. Òptica



Núria Lupon  
Directora EOO



Lluís Torner  
Director. ICFO

Barcelona, 13 de juliol de 2005.

## RESUME

**J. Ignacio Cirac**

### Personal Data

NAME: Cirac, Juan Ignacio  
PLACE AND DATE OF BIRTH: Manresa (Spain), 11 October 1965  
NATIONALITY: Spanish  
ADDRESS: Max-Planck Insitut für Quantenoptik,  
Hans-Kopfermannstr. 1, D-85748 Germany  
E-MAIL: [Ignacio.Cirac@mpq.mpg.de](mailto:Ignacio.Cirac@mpq.mpg.de)  
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FAX: +49 89 32905 336

### Education

Licenciado (graduate) in Theoretical Physics, Univ. Complutense de Madrid, June 1988.  
Ph. D. in Physics, Univ. Complutense de Madrid, July 1991.

### Field of Specialization

Theoretical Quantum Optics, Quantum Information, Degenerate Quantum Gases.

### Professional Experience

Since 2002 "Honorarprofessor", Technical University of Munich (Physics Departement),  
Since 2001 Director of the Theory Division, Max-Planck Institut für Quantenoptik,, and member of the Max-Planck Society.  
1996 – 2001 Professor, Institut für Theoretische Physik, Universität Innsbruck.  
1993 – 1994 Research Associate, Joint Institute for Laboratory Astrophysics, University of Colorado.  
1991 – 1996 "Profesor Titular de Universidad", Departamento de Física Aplicada, Univ. de Castilla-La Mancha.  
1989 – 1991 Fellow "Formacion del Personal Investigador" (Prog. General), Departamento de Optica, Univ. Complutense of Madrid,

### Other activities

Managing Director of the Max-Planck Institut für Quantenoptik, Garching, Germany, since June 2004.  
Associate Editor, Physical Review A, 2000-2003.  
Associate Editor, Revista Espanola de Física, 2002-2005.  
Founding Managing Editor, Quantum Information and Computation, since 2001.  
Associate Editor, Review of Modern Physics, since 2005.

## **Awards and Honors**

Premio Nacional Investigadores Noveles, Royal Physical Society of Spain, 1993.

Felix Kuschnitz Preis, Austrian Academy of Sciences, 2001

Medal of the Royal Physical Society of Spain, 2003.

Fellow of the American Physical Society.

Corresponding member of the Spanish Academy of Sciences.

Corresponding member of the Austrian Academy of Sciences.

## Research Visits

1. Institute for Theoretical Physics, University of Innsbruck, 2 September to 23 November 1990.
2. Joint Institute for Laboratory Astrophysics, University of Colorado, 18 July to 30 September 1991.
3. Joint Institute for Laboratory Astrophysics, University of Colorado, 1 July to 18 September 1992.
4. Institute for Laser Physics, University of Hamburg, 30 November to 10 December 1992.
5. Joint Institute for Laboratory Astrophysics, University of Colorado, 15 June 1993 to 1 February 1994.
6. Joint Institute for Laboratory Astrophysics, University of Colorado, 25 June to 15 August 1994.
7. Institute for Theoretical Atomic and Molecular Physics, Harvard Univ., 15 August to 15 September 1994.
8. Institute for Theoretical Physics, University of Innsbruck, 10 October 1994 to 5 February 1995.
9. Centre d' Études Nucléaires de Saclay, 7 July 1995 to 7 August 1995.
10. Institut für Theoretische Physik, University of Innsbruck, 1 October to 23 December 1995.
11. Victoria University, Wellington, 27 January 1996 to 17 February 1996.
12. Institute for Theoretical Physics, University of Innsbruck, 20 March to 25 March 1996.
13. Centre d' Études Nucléaires de Saclay, 7 April to 14 April 1996.
14. Institute for Theoretical Physics, University of California in Santa Barbara, 1 October to 31 October 1996.
15. Clarendon Laboratory, Oxford University, 9 September to 15 September 1997.
16. Institute for Theoretical Physics, University of California in Santa Barbara, 2 February to 26 February 1998.
17. Benasque Center for Physics, 5 July to 24 July 1998.
18. Clarendon Laboratory, Oxford University, 10 November to 15 November 1998.
19. Benasque Center for Physics, 9 July to 23 July 1999.
20. University Autonoma of Madrid, 26 August to 9 September 1999.
21. University of Hannover, 11 February to 27 February 2000.
22. University of Bristol, 20 May to 26 May 2000.
23. National Institute Standards and Technology (Gaithersburg), 3 March to 10 March 2001.
24. Institute for Theoretical Atomic and Molecular Physics, Harvard Univ., 10 March to 17 March 2001.
25. Joint Institute for Laboratory Astrophysics, University of Colorado, 6 February to 10 February 2002.
26. California Institute of Technology, 24 May to 28 May 2002.
27. University of Paris, Orsay, 15 December to 20 December 2003.
28. Harvard University and MIT, 3 April to 7 April 2004.
29. Institute for Theoretical Physics, University of Santa Barbara, 5 May to 28 May 2004.
30. Harvard University, 7 February to 10 February 2005.

## Invited Presentations at Conferences and Workshops

1. *Non-classical states of motion in an ion trap*, Workshop on Fundamentals of Quantum Optics III, Innsbruck (Austria), March 1993.
2. *Squeezed states of motion in an ion trap*, Optical Society of America Annual Meeting 93, Toronto (Canada), October 1993.
3. *Quantum statistical properties of a laser cooled ideal gas*, Workshop on Quantum field theory of cold atoms, Boulder (Colorado), July 1994.
4. *Qubits and ions*, Workshop on Quantum Computation, Torino (Italy), October 1994.
5. *Quantum statistics of a laser cooled ideal gas*, Workshop on Theoretical Quantum Optics, Munich (Germany), November 1994.
6. *Quantum Computations with cold trapped ions*, Dynamics of simple quantum systems; atoms, molecules and heterostructures, Sandbjerg (Denamark), May 1995.
7. *Quantum Computations with cold trapped ions*, Workshop on Quantum Computation and Quantum Optics, Pisa (Italy), June 1995.
8. *Quantum Computations with cold trapped ions*, Workshop on Quantum Computation, Torino (Italy), June 1995.
9. *Quantum computations with cold trapped ions*, XXXI Rencontres Moriond, Les Arcs (France), January 1996.
10. *Quantum mechanics with trapped ions*, Quantum Optics satellite meeting, Queensland (Australia), July 1996.
11. *Quantum computing and error correction schemes*, International Conference on Quantum Electronics, Sydney (Australia), July 1996.
12. *Quantum mechanics with trapped ions*, Fundamental Problems in Quantum Mechanics, Oviedo (Spain), July 1996.
13. *Quantum computing with trapped ions*, European Physical Society meeting, Sevilla (Spain), September 1996.
14. *Quantum Computers and Quantum Networks*, V International Conference on Squeezed States and Uncertainty Relations (Plenary), Balatonfured (Hungary), May 1997.
15. *Communication in a quantum network: a quantum optical implementation*, Workshop on Quantum Optics and Quantum Computation, Pisa (Italy), June 1997.
16. *Quantum communication between distant nodes in a quantum network*, Gordon Conference on Atomic Physics, New Hampshire (USA), June 1997.
17. *Manipulation of condensates with lasers*, Bose Einstein Condensation, Castelvecchio (Italy), July 1997.
18. *Transmission of quantum information in a quantum network: a quantum optical implementation*, Fundamental Problems in Quantum Theory Workshop, Baltimore (USA), August 1997.
19. *Quantum Computations with "hot" trapped ions*, Experimental Realizations of Quantum Logic, Cambridge (USA), August 1997.
20. *Quantum Communication and Computation*, V Reunión Nacional de Optica, Valencia (Spain), September 1997.
21. *Quantum Communication and Computation*, Física Estadística 97, Madrid (Spain), September 1997.
22. *Quantum Computations with Trapped Ions I: Theory*, Tutorial Workshop on Quantum Information, Almagro (Spain), October 1997.

23. *Creation of Dark Solitons and Vortices in BECs*, Workshop on Quantum Gases, Konstanz (Germany), June 1998.
24. *Quantum Communication and Computation*, XVI International Conference on Atomic Physics, Windsor (Canada), August 1998.
25. *Error Correction and Fault Tolerant Quantum Computing*, Quantum Computing Pathfinder Conference, Helsinki (Finland), September 1998.
26. *Quantum Information and Communication*, Physikertagung der deutschen physikalischen Gesellschaft 1999, Heidelberg (Germany), March 1999.
27. *Quantum computing with trapped atoms*, American Physical Society Centennial Meeting, Atlanta (USA), March 1999.
28. *Quantum optical implementations for quantum information*, 14th International Conference on Laser Spectroscopy, Innsbruck (Austria), June 1999.
29. *Quantum computation and communication*, International Conference of the EGAS 31, Marseille (France), July 1999.
30. *Quantum Information Processing with Quantum Optical Systems*, 49. Jahrestagung der Österreichischen Physikalischen Gesellschaft, September 1999.
31. *Quantum information processing with quantum optical systems*, Quantum Optics X, Palma de Mallorca (Spain), October 1999.
32. *Entanglement of Gaussian optical beams*, Workshop on Quantum Control and Information, Nof Genossar (Israel), November 1999.
33. *Quantum Communication and Computation*, 100 years of Quantum Mechanics, Museo de la Ciencia de Barcelona (Spain), March 2000.
34. *Multi-atom entangled states*, TMR--Network "The physics of quantum information" meeting, Viena (Austria) September 2000.
35. *Quantum information processing with multi-level systems*, International workshop on mysteries, puzzles, and paradoxes in Quantum Mechanics, Gargano in Garda (Italy), September 2000.
36. *El futuro de la computación cuántica*, International conference "la ciencia y la tecnología ante el nuevo milenio", CSIC Madrid (Spain), November 2000.
37. *Multiparticle entanglement*, Workshop of the A2 Konsortium, Hannover (Germany), February 2001.
38. *Multiparticle entanglement with Bose-Einstein condensates*, Workshop on solid state quantum computing, Warsaw (Poland), April 2001.
39. *Recent developments in quantum information theory*, 4th Annual Workshop on Resonances and Time Asymmetric Quantum Theory, Jaca (Spain), May 2001.
40. *Quantum repeaters with atomic ensembles*, International conference on Quantum Information, Rochester (USA), June 2001.
41. *Quantum repeaters with atomic ensembles*, Quantum Optics V, Zakopane (Poland), June 2001.
42. *Quantum repeaters with atomic ensembles*, Workshop on Quantum Computers and Quantum Chaos, Como (Italy), June 2001.
43. *Separability and distillability properties of Gaussian states*, Second ESF QIT Conference Quantum Information: Theory, Experiment, and Perspectives, Gdansk (Poland), July 2001.

44. *Separability and distillability properties of Gaussian states*, ESF Workshop on Quantum Information and Spacetime Structure, Madrid (Spain), September 2001.
45. *Separability and distillability*, Workshop on Quantum Challenges 2001, Essen (Germany), September 2001.
46. *Quantum Entanglement: Theory and Applications*, XXVIII Reunion Bienal de la RSEF, Sevilla (Spain), September 2001.
47. *Multiparticle Entanglement*, Quantum Optics XII, San Feliu de Gixols (Spain), October 2001.
48. *Quantum repeaters based on atomic ensembles*, QIPC Workshop, Torino (Italy), October 2001.
49. *Towards quantum information processing with quantum optical systems I and II*, Workshop on Quantum Computation, Seoul (Korea), November 2001.
50. *Towards quantum information processing with quantum optical system*, Internation Workshop on Quantum Computation and Quantum Optics, Pohang (Korea), November 2001.
51. *Quantum repeaters with atomic ensembles*, XII Solvay Conference in Physics, Delphi (Greece), November 2001.
52. *Strongly correlated systems and BEC*, Ringberg Meeting, Ringberg Schloss (Germany), December 2001.
53. *Entanglement in quantum optical systems*, Workshop on the future of quantum information, Ecole Normal Superieur, Paris (France), December 2001.
54. *Entanglement with atomic systems*, Kolloquium DFG Schwerpunkt Quanteninformationverarbeitung, Bad Honnef (Germany), January 2002.
55. *General overview of entanglement with quantum optical systems*, 2002 Winter Conference on Condensed Matter Physics, Aspen (USA), February 2002.
56. *Entanglement and distillation in quantum optical systems*, IV Adriatico research conference on quantum interferometry, Trieste (Italy), March 2002.
57. *Recent results in quantum information theory*, European research conference on Quantum Information, San Feliu de Gixols (Spain), March 2002.
58. *Entanglement of states and operations*, Workshop on Decoherence, Durham (UK), April 2002.
59. *Entanglement in Quantum Optical Systems*, Quantum Electronics and Laser Conference, Long Beach (USA), May 2002.
60. *Advances in Quantum Information and Computation*, 2002 Meeting of the American Physical Society DAMOP, Williamsburg (USA), May 2002.
61. *Gaussian operations and states*, A2 Meeting, Braunschweig (Germany), June 2002.
62. *Entanglement of states and physical operations*, International conference on Quantum Communication, Measurement and Computing, Boston (USA), July 2002.
63. *Entangling atomic ensembles*, EPS 12 Trends in Physics, Budapest (Hungary), August 2002.
64. *Quantum Information Processing and Communication with Quantum Optical Systems*, Trends in Nanotechnology (TNT) 2002, Santiago de Compostela (Spain), September 2002.
65. *Quantum Information Processing and Communication*, COSMOCAIXA 2002, Madrid (Spain), September 2002.
66. *Entanglement in Multiparticle systems*, Symposium on Quantum Information, Uppsala (Sweden), October 2002.



67. *Entanglement properties of Gaussian states*, Workshop on Quantum Information, Cryptography, and Error Correction, MSRI, Berkley (USA), November 2002.
68. *Quantum Information Processing with Quantum Optical Systems*, Meeting of the Royal Society, London (UK), November 2002.
69. *Quantum information processing in optical lattices*, Symposium 'Cold atoms and quantum information', Collège de France, Paris (France), February 2003.
70. *Quantum Information processing with quantum optical systems*, SQUINT 5th Annual Meeting, Santa Fe (USA), February 2003.
71. *Entanglement creation in multiparticle systems*, Obergurgl Meeting 2003, Obergurgl (Austria), February 2003.
72. *Quantum information and quantum optical systems*, (Plenary), DPG Frühjahrstagung, Hannover (Germany), March 2003.
73. *Entanglement of Formation of Gaussian States*, Continuous Variable Quantum Information Processing Workshop, Aix en Provence (France), April 2003.
74. *Limits on Gates with trapped ions*, Simons Conference on Quantum and Reversible Computation, Stony Brook (USA), May 2003.
75. *Quantum Information with quantum optical systems*, Gordon Research Conference on Atomic Physics, Tilton School (USA), June 2003.
76. *Strong correlation effects in cold atomic gases*, ICOLS 03, Palm Cove (Australia), July 2003.
77. *Entanglement of Gaussian states and spin systems*, Workshop on Quantum Measurements and Quantum Stochastics, Aarhus (Denmark), August 2003.
78. *Entanglement in spin and harmonic oscillator lattices*, Quantum Challenges II, Warsaw (Poland), September 2003.
79. *Entanglement and strong correlation effects in optical lattices*, Euroscop conference BEC 2003, San Feliu de Gixols (Spain), September 2003.
80. *Entanglement in Atomic Systems*, 304. WE-Heraeus-Seminar, Bad Honnef (Germany), October 2003.
81. *Quantum cryptography*, Meeting of the Spanish Mathematical Society, Barcelona (Spain), November 2003.
82. *Entanglement and correlations in spin and quantum optical systems*, Lorentz Center Workshop Fundamentals of Solid State Quantum Information Processing, Leiden (Netherlands), December 2003.
83. *Entanglement in spin systems*, Gordon Conference on Quantum Information, Ventura (USA), February 2004.
84. *Quantum Information with Quantum Optical Systems*, LATSIS Symposium, Laussane (Switzerland), March 2004.
85. *Boson and Fermions in Optical Lattices*, Workshop on Cold Fermions, Levico (Italy), March 2004.
86. *Studying strong correlation effects in optical lattices*, KITP Conference on Frontiers in Quantum Gases, Santa Barbara (US), May 2004.
87. *Fast gates and quantum simulations with trapped ions*, Workshop on the development of the trapped ion quantum computer, University of Michigan, Ann Arbor (US), May 2004.
88. *Fast Quantum Gates and Coherent Control with Trapped Ions*, CLEO/IQEC 04, San Francisco (US), May 2004.
89. *Quantum spin systems: entanglement and implementations*, ICAP 2004, Rio de Janeiro (Brasil), July 2004.

90. *Multiparticle entangled states* , Workshop on Quantum Entanglement, Decoherence, Information, and Geometrical Phases in Complex Systems, Trieste (Italy), November 2004.
91. *Teoría cuántica de la información: conceptos básicos y aplicaciones*, Encuentro Física Fundamental "Alberto Galindo" November 2004.
92. *Projected-pair entangled states: properties and applications*, Workshop on Entanglement and Quantum Information, Pisa (Italy), December, 2004.
93. *PEPS: properties and applications*, Workshop on Entanglement and Quantum Information, Oberwolfach (Germany), January 2005.

## Lectures in Summer Schools and Special Courses

1. *Quantum Communication and Computing*, (4 lectures of 1 hour), European PhD Summer School in Physics, Trento (Italy), 8-20 June 1997.
2. *Quantum Information*, (5 lectures of 1.5 hours), Universitat de Barcelona (Spain), 26-30 January 1998.
3. *Quantum Information*, (4 lectures of 1 hour), International School of Physics Enrico Fermi, Varenna, 27 June-9 July 2000.
4. *Error correction and physical implementations*, DPG Schule für Physik Quanten--Computing und Information, Physikzentrum Bad Honnef (Germany), 9-13 October 2000.
5. *Quantum Information*, (6 lectures of 1 hour), Summer school on theoretical Physics, Stellenbosch (Sudafrica), 23 January- 2 February 2001.
6. *The physics of entanglement*, (3 lectures of 1 hour), Seminar of Rhodanien, Dolomieu (France), 26 February- 2 March 2001.
7. *Entanglement*, (3 lectures of 1.5 hours), Les Houches school on quantum entanglement, Les Houches (France), 26 - 28 March 2001.
8. *Quantum Information*, (3 lectures of 2 hours), University of Heidelberg, Heidelberg (Germany), 17-19 April 2001.
9. *Quantum Computation*, (2 lectures of 2 hours), Cursos de verano de la Universidad Menendez Pelayo, 2-7 July 2001.
10. *Entanglement in Atomic Systems*, (1 lecture of 1 hour), International School of Physics Enrico Fermi, Varenna, 17-27 July 2001.
11. *Entanglement and distillability*, (3 lectures of 1.5 hours), IX Escuela de Física Teórica, Santiago de Compostela, 3-14 September 2001.
12. *Quantum Information*, VII Granada Seminar (4 lectures of 1 hours), Granada (Spain), 1-4 September 2002.
13. *Quantum entanglement theory: measurements and manipulation* (2 lectures of 1.5 hours), International School on Quantum Computation and Information, Lisboa (Portugal), 4-7 September 2002.
14. *Entanglement in Atomic Systems I and II* (2 lectures of 1.5 hours), Workshop on Quantum Information and Quantum Computation, Trieste (Italy), 14-25 October 2002.
15. *Separability and entanglement in Quantum Information* (1 lecture of 1 hour), Workshop on Entanglement at the nanoscale, Trieste (Italy), 28 October- 8 November 2002.
16. *Strongly correlated systems with cold atomic gases* (3 lectures of 1.5 hours), School on quantum gases in low dimensions, Les Houches (France), 15-25 April 2003.

17. *Quantum Optics and Quantum Computation Theory* (3 lectures of 1.5 hours), WEH Summer School, Wittenberg (Germany), 28-30 July 2003.
18. *Quantum Information Theory* (20 hours), Curso de Doctorado, University Autonoma of Madrid (Spain), 2-6 February, 2004.
19. *Basics of Quantum Information Theory* (3 hours), Summer School on Quantum Optics and Quantum Information, Niels Bohr Institute, Copenhagen (Denmark), 11-13 August 2004.
20. *Entanglemen and purification* (4.5 hours), Summer School on the Basics of Quantum Information, Cargesse (France), 22-25 August, 2004.

### Seminars and Colloquia

1. *Cooling a trapped ion with a standing wave*, Joint Institute for Laboratory Astrophysics, Boulder (USA), 12 September 1991.
2. *Preparation of Fock states by observation of quantum jumps in ion traps*, National Institute for Standards and Technology, Gaithersburg (USA), 9 September 1992.
3. *Generation of nonclassical motional states in ion traps*, University of Hamburg (Germany), 8 December 1992.
4. *Non-classical states of motion in ion traps*, Joint Institute for Laboratory Astrophysics, Boulder (USA), 17 September 1993.
5. *Quantum statistical properties of a laser cooled ideal gas*, National Institute of Standards and Technology, Gaithersburg (USA), 19 November 1993.
6. *Schemes for atomic state teleportation*, National Institute of Standards and Technology, Gaithersburg (USA), 19 August 1994.
7. *The bose: a theoretical description for the atom laser*, Harvard University, Cambridge (USA), 17 August 1994.
8. *Cooling with external fields: the elevator cooling*, Massachussets Institute of Technology, Cambridge (USA), 10 September 1994.
9. *Teleportation*, University of Innsbruck (Austria), 17 November 1994.
10. *Quantum computations with trapped ions*, University Konstanz (Germany), 25 November 1994.
11. *Quantum computations with cold trapped ions*, École Normal Supérieure, Paris (France), 11 July 1995.
12. *Ion traps*, University of Ulm (Germany), 27 November 1995.
13. *Ion traps*, University of Innsbruck (Austria), 11 December 1995.
14. *Trapped ions in the strong excitation regime: ion interferometry and non-classical states*, Joint Institute for Laboratory Astrophysics, Boulder (USA), 17 October 1995.
15. *Trapped ions in the strong excitation regime: ion interferometry and non-classical states*, Los Alamos National Laboratory (USA), 20 October 1995.
16. *Error correction in Quantum Computing*, California Institute for Technology, Pasadena (USA), 30 January 1996.
17. *Quantum Reservoir Engineering*, University of Auckland (New Zealand), 2 February 1996.
18. *Computacion Cuantica*, University of Granada (Spain), 29 April 1996.

19. *Quantum mechanics with trapped ions*, Max Plank Institute for Quantum Optics, Garching (Germany), 11 June 1996.
20. *Quantum reservoir engineering*, Inst. for Theoretical Physics, Santa Barbara (USA), 18 October 1996.
21. *Schrödinger lions made out of bosons*, University of Trento (Italy), 13 February 1997.
22. *Quantum Communication and Computation*, University Autonoma of Madrid (Spain), 22 September 1997.
23. *Quantum Communication and Computation*, University Complutense of Madrid (Spain), 23 September 1997.
24. *Creation of Solitons and Vortices in Bose-Einstein-Condensates*, Institute for Theoretical Physics, Santa Barbara (USA), 11 February 1998.
25. *Comunicación cuántica en presencia de ruido*, University of Salamanca (Spain), 19 November 1998.
26. *Black holes with Bose-Einstein condensates*, Benasque Center for Science (Spain), 24 July 1999.
27. *Quantum Information Processing*, AMOLF, Amsterdam (The Netherlands), 6 December 1999.
28. *Quantum Communication and Computation*, University Autonoma of Madrid (Spain), 17 December 1999.
29. *Quantum Computing with arrays of microtraps*, Max-Planck Institute for Quantum Optics, Garching (Germany), 17 February 2000.
30. *Separability and distillability of mixed states*, University Autonoma of Madrid (Spain), 22 May 2000.
31. *Separability and distillability of mixed states*, Laboratory Kastler, École Normal Supérieure, Paris (France), 7 June 2000.
32. *Quantum optical approach to Bose-Einstein condensation and quantum information process*, Max-Planck Institute for Quantum Optics, Garching (Germany), 1 September 2000.
33. *Se puede construir un ordenador cuántico?*, Agora de la Ciencia, Residencia de Estudiantes del CSIC, Madrid (Spain), 19 October 2000.
34. *El futuro de la computación cuántica*, University of Zaragoza (Spain), 13 November 2000.
35. *Multiatom entanglement with Bose-Einstein condensates*, Erwin Schrödinger Institute, Vienna (Austria), 4 December 2000.
36. *Irreversibilidad en la manipulación asintótica de entanglement*, Universidad de Cantabria, Santander (Spain), 9 February 2001.
37. *Progress on Bose-Einstein condensation and quantum information*, University of Hannover (Germany), 14 February 2001.
38. *Anyons in Bose-Einstein condensates*, NIST, Gaithersburg (USA), 7 March 2001.
39. *Anyons in Bose-Einstein condensates*, ITAMP, Cambridge (USA), 12 March 2001.
40. *Entanglement in Bose-Einstein condensates*, University of Kaiserslautern (Germany), 7 May 2001.
41. *Separability and distillability in quantum information*, Technische Universität, Munich (Germany), 30 May 2001.
42. *Quantum Entanglement: Theory and Applications*, University of Castilla-La Mancha, Ciudad Real (Spain), 26 September 2001.
43. *Anyons in Bose-Einstein condensates*, Ludwig-Maximilian Universität, Munich (Germany), 9 January 2002.

44. *Anyons in Bose-Einstein condensates*, Joint Institute for Laboratory Astrophysics, Boulder (USA), 7 February 2002.
45. *Quantum information processing with quantum optical systems*, Max-Planck Institut für Quantenoptik, Garching (Germany), 26 February 2002.
46. *Some mathematical problems in Quantum Information Theory*, Ecole Normal Supérieur, Paris (France), 2 April 2002.
47. *Strongly correlated systems and BEC*, LENS, Florence (Italy), 10 May 2002.
48. *Physical operations with Gaussian states*, CALTECH, Pasadena (USA), 24 May 2002.
49. *Quantum information in quantum optical systems*, Univ. Regensburg (Germany), 17 November 2003.
50. *Quantum information in quantum optical systems*, ETH Zürich (Switzerland), 12 November 2003.
51. *Entanglement and correlations in spin systems*, University Augsburg (Germany), 2 December 2003.
52. *Quantum Information: basic concepts and applications*, Orsay (France), 16 December 2003.
53. *Quantum Information processing with quantum optical systems*, Orsay (France), 18 December 2003.
54. *Quantum Information and Quantum Optical Systems*, University of Geneva (Switzerland), 23 January 2004.
55. *Quantum Information and Quantum Optical Systems*, University of Freiburg (Germany), 9 February 2004.
56. Localizable entanglement and projected entangled pair states, MIT (USA), 5 April 2004.
57. *Quantum Behaviour in ion traps and optical lattices*, Harvard, 6 April 2004.
58. *Quantum Information and Quantum Optical systems*, University of Tübingen, 20 April 2004.
59. *Quantum information processing and quantum optical systems*, University of Karlsruhe, 11 June 2004.
60. *Projected entangled-pair states: properties and applications*, University Toronto (Canada), 19 November 2004.
61. *BEC and strong correlation behavior in trapped-ion systems*, University Toronto (Canada), 19 November 2004.
62. *BEC with ions and scalable quantum computation with neutral atoms*, Harvard University (US), 9 February 2005.

## List of Publications

J. Ignacio Cirac

### 1.- Published

1. *Analytic approximation to the interaction of a two-level atom with squeezed light*, J. I. Cirac and L. L. Sánchez-Soto, Phys. Rev. A **40**, 3743 (1989).
2. *Population trapping in the Jaynes-Cummings model via phase coupling*, J. I. Cirac and L. L. Sánchez-Soto, Phys. Rev. A **42**, 2851 (1990).
3. *Collective resonance fluorescence in a strongly squeezed vacuum*, J. I. Cirac and L. L. , Optics Comm. **77**, 26 (1990).
4. *Trapping in the multiphoton Jaynes-Cummings Model*, J.I. Cirac and L. L. Sánchez-Soto, Optics Comm. **80**, 67 (1990).
5. *Suppression of spontaneous emission by squeezed light in a cavity*, J. I. Cirac and L. L. Sánchez-Soto, Phys. Rev. A **44**,1948 (1991).
6. *Population trapping in two-level models: Spectral and statistical properties*, J. I. Cirac and L. L., Phys.Rev. A **44**, 3317 (1991).
7. *Two-level system interacting with a finite-bandwidth thermal cavity mode*, J. I. Cirac, H. Ritsch and P. Zoller, Phys. Rev. A **44**, 4541 (1991).
8. *Deflection of atoms by circularly polarized light beam in triple Laue configuration*, M. A. M. Marte, J. I. Cirac and P. Zoller, J. of Mod. Opt. **38**, 2265 (1991).
9. *Laser cooling of trapped ions in a standing wave*, J. I. Cirac, R. Blatt, P. Zoller and W. D. Phillips, Phys. Rev. A **46**, 2668 (1992).
10. *Interaction of a two-level atom with a cavity mode in the bad cavity limit*, J. I. Cirac, Phys. Rev. A **46**, 4354 (1992).
11. *Laser cooling of a trapped ion in a squeezed vacuum*, J. I. Cirac and P. Zoller, Phys. Rev. A **47**, 2191 (1993).
12. *Preparation of Fock states by observation of quantum jumps*, J. I. Cirac, R. Blatt, A. S. Parkins and P. Zoller, Phys. Rev. Lett. **70**, 762 (1993).
13. *Dark squeezed states of the motion of a trapped ion*, J. I. Cirac, A. S. Parkins, R. Blatt and P. Zoller, Phys. Rev. Lett. **70**, 556 (1993).
14. *Cooling of a trapped ion coupled strongly to a quantized cavity*, J. I. Cirac, A. S. Parkins, R. Blatt and P. Zoller, Optics Comm. **97**, 353 (1993).
15. *Laser cooling of a trapped ion with polarization gradients*, J. I. Cirac, R. Blatt, A. S. Parkins and P. Zoller, Phys.Rev. A **48**, 1434 (1993)
16. *Spectrum of resonance fluorescence from a trapped ion*, J. I. Cirac, R. Blatt, A. S. Parkins and P. Zoller, Phys. Rev. A **48**, 2169 (1993).
17. *Phase-shifts and intensity dependence in frequency modulation spectroscopy*, H.-R. Xia, J. I. Cirac, S. Swartz, B. Kohler, D. S. Elliot, J. L. Hall, and P. Zoller, J. of the Opt. Soc. of Am. B **11**, 721(1993).
18. *Laser cooling a trapped ion: effects of the micromotion*,

- J. I. Cirac, L. J. Garay, R. Blatt, A. S. Parkins and P. Zoller, Phys. Rev. A **49**, 421 (1994).
19. *Quantum collapse and revivals from a single trapped ion*,  
J. I. Cirac, R. Blatt, A. S. Parkins and P. Zoller, Phys. Rev. A **49**, 1202 (1994).
  20. *Laser cooling of trapped ions: designing two-level atoms for sideband cooling*,  
I. Marzoli, J. I. Cirac, R. Blatt and P. Zoller, Phys. Rev. A **49**, 2771 (1994).
  21. *Non-classical states of motion in a 3-dimensional trap by adiabatic passage*,  
J. I. Cirac, R. Blatt and P. Zoller, Phys. Rev. A (RC) **49**, R3174 (1994).
  22. *Cooling and localization of atoms in laser induced potentials*,  
R. Taieb, R. Dum, J. I. Cirac, P. Marteand P. Zoller, Phys. Rev. A **49**, 4876 (1994).
  23. *Quantum statistical properties of a laser cooled ideal gas*,  
J. I. Cirac, M. Lewenstein and P. Zoller, Phys. Rev. Lett. **72**, 2977 (1994).
  24. *Inhibition of quantum tunneling in by observing laser scattered light*,  
J. I. Cirac, A. Schenzle and P. Zoller, Europhys.Lett. **27**, 123 (1994).
  25. *Preparation of macroscopic superpositions in many atom systems*,  
J. I. Cirac and P. Zoller, Phys. Rev. A (RC) **50**, R2799 (1994).
  26. *Quantum dynamics of a laser cooled ideal gas*,  
J. I. Cirac, M. Lewenstein and P. Zoller, Phys. Rev. A **50**, 3409 (1994).
  27. *Schemes for atomic state teleportation*,  
J. I. Cirac and A. S. Parkins, Phys. Rev. A (RC) **50**, R4441 (1994).
  28. *Laser cooling of a trapped atom in a cavity: bad cavity limit*,  
J. I. Cirac, M. Lewenstein and P. Zoller, Phys. Rev. A **51**, 1650 (1995).
  29. *Quantum motion of trapped ions*,  
R. Blatt, J. I. Cirac, A. S. Parkins and P. Zoller, Physica Scripta T**59**, 294 (1995).
  30. *Generalized Bose-Einstein condensation and multistability of a laser cooled ideal gas*,  
J. I. Cirac, M. Lewenstein and P. Zoller, Phys. Rev. A **51**, 2899 (1994).
  31. *Quantum computations with cold trapped ions*,  
J. I. Cirac and P. Zoller, Phys. Rev. Lett. **74**, 4091 (1995).
  32. *Master equation for sympathetic cooling of trapped particles*,  
J. I. Cirac, M. Lewenstein and P. Zoller, Phys. Rev. A **51**, 4617 (1995).
  33. *Chaotic and regular behavior of a trapped ion interactiong with a laser field*,  
R. Chacón and J. I. Cirac, Phys. Rev. A **51**, 4900 (1995).
  34. *Trapping states with cold ions*,  
R. Blatt, J. I. Cirac and P. Zoller, Phys. Rev. A **52**, 518 (1995).
  35. *Cooling of atoms in external fields*,  
J. I. Cirac and M. Lewenstein, Phys. Rev. A **52**, 4737 (1995).
  36. *Decoherence in a continuously monitored quantum computer based on cavity QED*,  
T. Pellizari, S. Gardiner, J. I. Cirac and P. Zoller, Phys. Rev. Lett. **75**, 3788 (1995).
  37. *Populationg a Bose condensate in the boson-accumulation regime*,  
J. I. Cirac and M. Lewenstein, Phys. Rev. A **53**, 2466 (1995).
  38. *Collective laser cooling of two trapped ions*,  
A. Vogt, J. I. Cirac and P. Zoller, Phys. Rev. A **53**, 950 (1996).

39. *Trapped ions in the strong excitation regime: ion interferometry and non-classical states*,  
J. F. Poyatos, J. I. Cirac, R. Blatt and P. Zoller, Phys. Rev. A **54**, 1532 (1996).
40. *Motion tomography of a trapped ion*,  
J. F. Poyatos, R. Walser, J. I. Cirac, R. Blatt and P. Zoller, Phys. Rev. A (RC) **53**, R1966 (1995).
41. *Quantum motion of trapped ions*,  
J. I. Cirac, A. S. Parkins, R. Blatt and P. Zoller, Adv. At. and Mol. Phys. **37**, 237 (1996).
42. *Theory of an atom laser*,  
M. Holland, K. Barnett, C. Gardiner, J. I. Cirac and P. Zoller, Phys. Rev. A (RC) **54**, R1757 (1996).
43. *Interferences of Bose condensates*,  
M. Naraschewski, H. Wallis, A. Schenzle, J. I. Cirac and P. Zoller, Phys. Rev. A **54**, 2185 (1996).
44. *Quantum Reservoir Engineering with laser cooled trapped ions*,  
J. F. Poyatos, J. I. Cirac and P. Zoller, Phys. Rev. Lett. **77**, 4728((1996).
45. *Enforcing coherent evolution in dissipative systems*,  
J. I. Cirac, T. Pellizari and P. Zoller, Science **273**, 1207 (1996).
46. *Continuous observation of interference fringes from Bose condensates*,  
J. I. Cirac, C. Gardiner, M. Naraschewski and P. Zoller, Phys. Rev. A (RC) **54**, R3714 (1996).
47. *Collective laser cooling of trapped atoms*,  
J. I. Cirac, M. Lewenstein and P. Zoller, Europh. Lett. **35**, 647 (1996).
48. *Magnetic tomography of a cavity state*,  
R. Walser, J. I. Cirac and P. Zoller, Phys. Rev. Lett. **77**, 2658 (1996).
49. *Non-classical states and measurement of general observables of a trapped ion*,  
S. Gardiner, J. I. Cirac and P. Zoller, Phys. Rev. A **55**, 1683 (1997).
50. *Low energy excitations of a Bose-Einstein-Condensate: a variational approach*,  
V.M. Perez, H. Michinel, J. I. Cirac, M. Lewenstein and P. Zoller, Phys. Rev. Lett. **77**, 5320 (1996).
51. *Complete characterization of a quantum process: the two-bit quantum gate*,  
J. F. Poyatos, J. I. Cirac and P. Zoller, Phys. Rev. Lett. **78**, 390 (1997).
52. *Quantum state transfer and entanglement distribution among distant nodes in a quantum network*,  
J. I. Cirac, P. Zoller, H. J. Kimble and H. Mabuchi, Phys. Rev. Lett. **78**, 3221 (1997).
53. *Laser cooling beyond the Lamb-Dicke limit*,  
G. Moriggi, J. I. Cirac, M. Lewenstein and P. Zoller, Europhys. Lett. **39**, (1997).
54. *Ideal Quantum Communication over Noisy Channels: a Quantum Optical Implementation*,  
S. J. van Enk, J. I. Cirac and P. Zoller, Phys. Rev. Lett **78**, 4293 (1997).
55. *Coherent eavesdropping strategies for the 4 state quantum cryptography protocol*,  
J. I. Cirac and N. Gisin, Phys. Lett. A **229**, 1 (1997).
56. *Dynamics of Bose-Einstein-Condensates: variational solutions of the Gross-Pitaevskii equation*,  
V. Pérez-García, H. Michinel, J. I. Cirac, M. Lewenstein and P. Zoller, Phys. Rev. A **56**, 1424 (1997).
57. *Quantum state transfer in a quantum network: a quantum optical implementation*,  
S. van Enk, J. I. Cirac, P. Zoller, H. J. Kimble, and H. Mabuchi, J. Mod. Opt. **44** 1727 (1997).
58. *Stability and collective excitations of a two-component Bose-condensed gas: a moment approach*,  
Th. Busch, J. I. Cirac, V. M. Pérez-García, and P. Zoller, Phys. Rev. A **56** 2978 (1997).
59. *Mimicking a squeezed bath interaction: quantum reservoir engineering with atoms*,



- N. Lütkenhaus, J. I. Cirac, and P. Zoller, Phys. Rev. **57**, 548 (1998).
60. *On the Improvement of Frequency Standards with Quantum Entanglement*, S. F. Huelga, C. Macchiavello, T. Pellizzari, A. K. Ekert, M. B. Plenio, and J. I. Cirac, Phys. Rev. Lett. **79**, 3865 (1997).
  61. *Purifying two-bit quantum gates and joint measurements in cavity QED*, S. van Enk, J. I. Cirac, and P. Zoller, Phys. Rev. Lett. **79**, 5178 (1997).
  62. *Quantum Superposition States of Bose-Einstein-Condensates*, J. I. Cirac, M. Lewenstein, K. Mølmer and P. Zoller, Phys. Rev. A **57**, 1208 (1998).
  63. *Quantum chaos in an ion trap: the delta-kicked harmonic oscillator*, S. Gardiner, J. I. Cirac, and P. Zoller, Phys. Rev. Lett. **79**, 4790 (1997).
  64. *Photonic Channels for Quantum Communication*, S. van Enk, J. I. Cirac, and P. Zoller, Science **279**, 205 (1998).
  65. *Creation of Dark Solitons and Vortices in Bose-Einstein-Condensates*, R. Dum, J. I. Cirac, M. Lewenstein and P. Zoller, Phys. Rev. Lett. **80**, 2972 (1998).
  66. *Laser cooling of single trapped atoms to the ground state: a dark state in position space*, G. Morigi, J.I. Cirac, K. Ellinger and P. Zoller, Phys. Rev. A **52**, 2909 (1998).
  67. *Reabsorption of Light by Trapped Atoms*, Y. Castin, J. I. Cirac and M. Lewenstein, Phys. Rev. Lett. **80**, 5305 (1998).
  68. *Entanglement engineering of one-photon wavepackets using a single-atom source*, K.M. Gheri, C. Saavedra, P. Törm, J. I.. Cirac and P. Zoller, Phys. Rev. A **58**, R2627 (1998).
  69. *Quantum gates with "hot" trapped ions*, J. F. Poyatos, J.I. Cirac, and P. Zoller, Phys. Rev. Lett. **81**, 1322 (1998).
  70. *Cold bosonic atoms in optical lattices*, D. Jacksh, C. Bruder, J.I. Cirac, C. Gardiner and P. Zoller, Phys. Rev. Lett. **81**, 3108 (1998).
  71. *Quantum repeaters: the role of imperfect local operations in quantum communication*, H.- J. Briegel, W. Dür, J. I. Cirac, and P. Zoller, Phys. Rev. Lett. **81**, 5932 (1998).
  72. *Quantum repeaters based on entanglement purification*, W. Dür, H.- J. Briegel, J. I. Cirac, and P. Zoller, Phys. Rev. A **59**, 169 (1999).
  73. *Lower bounds for entanglement purification*, G. Giedke, H.- J. Briegel, J. I. Cirac, and P. Zoller, Phys. Rev. A **59**, 2651 (1999).
  74. *Quantum communication and the creation of maximally entangled pairs of atoms over a noisy channel*, H.- J. Briegel, W. Dür, S. J. Van Enk, J. I. Cirac, and P. Zoller Phil. Tran. Roy. Soc. Lond. A **356**, 1841 (1998).
  75. *Creation of entangled states of distant atoms by interference*, C. Cabrillo, J. I. Cirac, P. Garcia-Fernandez, and P. Zoller, Phys. Rev. A **59**, 1025 (1999), quant-ph/9810013.
  76. *Inhibition of spontaneous emission in Fermi gases*, T. Busch, J. R. Anglin, J. I. Cirac, and P. Zoller, Europhys. Lett. **44**, 1 (1998).
  77. *Transmission of quantum information in a quantum network: a quantum optical implementation*, S. van Enk, J. I. Cirac, P. Zoller, J. H. Kimble, and H. Mabuchi, Fortschritte der Physik-Progress of Physics. **46**, 689 (1998).
  78. *Characterization of decoherence processes in quantum computation*, J. F. Poyatos, J. I.. Cirac and P. Zoller. Optics Express **2**, 372 (1998).
  79. *Quantum communications in a quantum network*,

- J. I. Cirac, S. J. van Enk, P. Zoller, H. J. Kimble, and H. Mabuchi, *Physica Scripta* **T76**, 223 (1998).
80. *Entanglement of atoms via cold controlled collisions*,  
D. Jaksch, H.-J. Briegel, J.I. Cirac, C. W. Gardiner, and P. Zoller, *Phys. Rev. Lett.* **82**, 1975 (1999).
  81. *Distributed quantum computation over noisy channels*,  
J. I. Cirac, A. K. Ekert, S. F. Huelga, and C. Macchiavello, *Phys. Rev. A* **59**, 4249 (1999).
  82. *Laser Cooling of two trapped ions: Sideband cooling beyond the Lamb-Dicke limit*,  
G. Morigi, J. Eschner, J.I. Cirac and P. Zoller, *Phys. Rev. A* **59**, 3797 (1999).
  83. *Optimal purification of a single qubit*,  
J. I. Cirac, A. K. Ekert, and C. Macchiavello, *Phys. Rev. Lett.* **82**, 4344 (1999).
  84. *Quantum Communication with dark Photons*,  
S.J. van Enk, H.J. Kimble, J.I. Cirac, and P. Zoller, *Phys. Rev. A* **59**, 2659 (1999).
  85. *Separability and distillability of multiparticle quantum systems*,  
W. Dür, J. I. Cirac, and R. Tarrach, *Phys. Rev. Lett.* **83**, 3562 (1999).
  86. *Multiparticle teleportation*,  
W. Dür and J. I. Cirac *J. Mod. Optics* **27**, 247 (2000).
  87. *Quantum gates with neutral atoms: Controlling collisional interactions in time dependent traps*,  
T. Calarco, E.A. Hinds, D. Jaksch, J. Schmiedmayer, J.I. Cirac, P. Zoller, *Phys. Rev. A* **61**, (2000) quant-ph/9905013.
  88. *A scalable quantum computer with ions in an array of microtraps*,  
J. I. Cirac and P. Zoller, *Nature* **404**, 579 (2000).
  89. *Distillability and partial transposition in bipartite systems*,  
W. Dür, J. I. Cirac, M. Lewenstein, D. Bruss, *Phys. Rev. A* **61**, 062313 (2000) quant-ph/9910022.
  90. *Controlled source of entangled photonic qubits*,  
C. Saavedra, K. M. Gheri, P. Törma, J. I. Cirac, and P. Zoller, *Phys. Rev. A* **61**, 062311 (2000).
  91. *Spin monopoles with Bose-Einstein condensates*,  
J. J. Garcia-Ripoll, J. I. Cirac, J. Anglin, V. Perez-Garcia, and P. Zoller, *Phys. Rev. A* **61**, 053609 (2000) quant-ph/9811340.
  92. *Separability in  $2 \times N$  composite quantum systems*,  
B. Kraus, J. I. Cirac, S. Karnas, and M. Lewenstein, *Phys. Rev. A* **61**, 062302 (2000) quant-ph/9912010.
  93. *Classification of multi-qubit mixed states: separability and distillability properties*,  
W. Dür and J. I. Cirac, *Phys. Rev. A* **61**, 042314 (2000) quant-ph/9911044.
  94. *Inseparability criterion for continuous variable systems*,  
Lu-Ming Duan, G. Giedke, J. I. Cirac, P. Zoller, *Phys. Rev. Lett.* **84**, 2722 (2000) quant-ph/9908056.
  95. *Entanglement purification of Gaussian continuous variable quantum states*,  
Lu-Ming Duan, G. Giedke, J. I. Cirac, and P. Zoller, *Phys. Rev. Lett.* **84**, 4002 (2000) quant-ph/9912017.
  96. *Quantum computing with neutral atoms*,  
H.-J. Briegel, T. Calarco, D. Jaksch, J. I. Cirac, P. Zoller, *J. Mod. Optics* **47**, 415 (2000) quant-ph/9904010.
  97. *Activating bound entanglement in multi-particle systems*,  
W. Dür and J. I. Cirac, *Phys. Rev. A* **62**, 22302 (2000), quant-ph/0002028.
  98. *Nonlinear Matter Wave Dynamics with a "Chaotic" Potential*,  
S. A. Gardiner, D. Jaksch, R. Dum, J. I. Cirac, and P. Zoller, *Phys. Rev. A* **62**, 23612 (2000), quant-ph/9912092.
  99. *Operational criterion and constructive checks for the separability of low rank density matrices*,

- P. Horodecki, M. Lewenstein, G. Vidal, and I. Cirac, Phys. Rev. A **62**, 32310 (2000), quant-ph/0002089.
100. *Physical implementation for entanglement purification of Gaussian continuous variable quantum states*,  
Lu-Ming Duan, G. Giedke, J. I. Cirac, and P. Zoller, Phys. Rev. A **62**, 32304 (2000), quant-ph/0003116.
101. *From classical to quantum computers. Quantum computations with trapped ions*,  
J. F. Poyatos, J. I. Cirac, and P. Zoller, Physica Scripta T86, 72 (2000).
102. *Reversible combination of inequivalent kinds of multipartite entanglement*,  
G. Vidal, W. Dür, and J. I. Cirac, Phys. Rev. Lett. **85**, 658 (2000), quant-ph/0004009.
103. *Fast quantum gates for neutral atoms*,  
D. Jaksch, J. I. Cirac, P. Zoller, S. L. Rolston, R. Cote, and M. D. Lukin, Phys. Rev. Lett. **85**, 2208 (2000), quant-ph/0004038.
104. *Optimization of entanglement witnesses*,  
M. Lewenstein, B. Kraus, J. I. Cirac, and P. Horodecki, Phys. Rev. A **62**, 52310 (2000), quant-ph/0005014.
105. *Cooling of a small sample of Bose atoms with accidental degeneracy*,  
M. Lewenstein, J. I. Cirac, and L. Santos, J. Phys. B **33**, 4107 (2000), quant-ph/0005097
106. *Separability and distillability in composite quantum systems -a primer-*,  
M. Lewenstein, D. Bruss, J. I. Cirac, B. Kraus, M. Kus, J. Samsonowicz, A. Sanpera, and R. Tarrach, J. Mod. Opt. **77**, 2481 (2000), quant-ph/0006064.
107. *Laser Induced Condensation of Trapped Bosonic Gases*,  
L. Santos, Z. Idziaszek, J. I. Cirac, and M. Lewenstein, J. Phys. B **33**, 4143 (2000), quant-ph/0005107.
108. *Squeezing and entanglement of atomic beams*,  
L.-M. Duan, A. Sørensen, J. I. Cirac, and P. Zoller, Phys. Rev. Lett. **85**, 3991 (2000), quant-ph/0007048.
109. *Black holes in Bose-Einstein condensates*,  
L. J. Garay, J. R. Anglin, J. I. Cirac, and P. Zoller, Phys. Rev. Lett. **85**, 4643 (2000), gr-qc/0002015.
110. *Quantum communication between atomic ensembles using coherent light*,  
Lu-Ming Duan, J. I. Cirac, P. Zoller, and E. S. Polzik, Phys. Rev. Lett. **85**, 5643 (2000), quant-ph/0003111.
111. *Three qubits can be entangled in two inequivalent ways*,  
W. Dür, G. Vidal, and J. I. Cirac, Phys. Rev. A **62**, 62314 (2000), quant-ph/0005115.
112. *Many-particle entanglement with Bose-Einstein-Condensates*,  
A. Sørensen, L.-M. Duan, J. I. Cirac, and P. Zoller, Nature **409**, 63 (2001), quant-ph/0006111.
113. *Dynamic splitting of a Bose-Einstein-Condensate*,  
C. Menotti, J. R. Anglin, J. I. Cirac, and P. Zoller, Phys. Rev. A **63**, 023601 (2001), cond-mat/0005302.
114. *Sonic black holes in dilute Bose-Einstein-Condensates*,  
L. J. Garay, J. R. Anglin, J. I. Cirac, and P. Zoller, Phys. Rev. A **63**, 023611 (2001), gr-qc/0005131.
115. *Entangling operations and their implementation using a small amount of entanglement*,  
J. I. Cirac, W. Dür, B. Kraus, and M. Lewenstein, Phys. Rev. Lett. **86**, 544 (2001), quant-ph/0007057
116. *Characterization of separable states and entanglement witnesses*,  
M. Lewenstein, B. Kraus, P. Horodecki, and J. I. Cirac, Phys. Rev. A **63**, 044304 (2001), quant-ph/0005112.
117. *1/2-Anyons in small atomic Bose-Einstein condensates*,  
B. Paredes, P. Fedichev, J. I. Cirac, and P. Zoller, Phys. Rev. Lett. **87**, 010402 (2001), cond-mat/0103251.
118. *Irreversibility in asymptotic manipulations of entanglement*,  
G. Vidal and J. I. Cirac, Phys. Rev. Lett. **86**, 5803 (2001), quant-ph/0102036.
119. *Uniting Bose-Einstein condensates in optical resonators*,

- D. Jaksch, S.A. Gardiner, K. Schulze, J.I. Cirac, and P. Zoller, Phys. Rev. Lett. **86**, 4733 (2001), cond-mat/0101057.
120. *Geometric manipulation of trapped ions for quantum computation*,  
L.-M. Duan, J. I. Cirac, and P. Zoller, Science **292**, 1695 (2001), quant-ph/0111086.
121. *Non-local Operations: Purification, storage, compression, tomography, and probabilistic implementation*,  
W. Dür and J. I. Cirac, Phys. Rev. A **64**, 012317 (2001), quant-ph/0012148.
122. *Optimal Creation of Entanglement Using a Two—Qubit Gate*,  
B. Kraus and J.I. Cirac, Phys. Rev. A **63**, 062309 (2001), quant-ph/0011050.
123. *Entangling ions in arrays of microscopic traps*,  
T. Calarco, J.I. Cirac and P. Zoller, Phys. Rev. A **63**, 062304 (2001), quant-ph/0010105.
124. *Dipole Blockade and Quantum Information Processing in Mesoscopic Atomic Ensembles*,  
M. D. Lukin, M. Fleischhauer, R. Cote, L. M. Duan, D. Jaksch, J. I. Cirac, and P. Zoller, Phys. Rev. Lett. **87**, 037901 (2001), quant-ph/0011028.
125. *Quantum Correlations in Two-Fermion Systems*,  
J. Schliemann, J. I. Cirac, M. Ku's, M. Lewenstein, and D. Loss, Phys. Rev. A **64**, 022303 (2001), quant-ph/0012094.
126. *Visible compression of commuting mixed states*  
W. Dür, G. Vidal, and J. I. Cirac, Phys. Rev. A **64**, 022308 (2001), quant-ph/0101111.
127. *Separability Properties of Three-mode Gaussian States*  
G. Giedke, B. Kraus, J. I. Cirac, and M. Lewenstein, Phys. Rev. A **64**, 052303 (2001), quant-ph/0103137.
128. *Entanglement Criterion for all bipartite Gaussian States*,  
G. Giedke, B. Kraus, M. Lewenstein, and J. I. Cirac, Phys. Rev. Lett. **87**, 167904 (2001), quant-ph/0104050.
129. *Entanglement capabilities of non-local Hamiltonians*,  
W. Dür, G. Vidal, J. I. Cirac, N. Linden, and S. Popescu, Phys. Rev. Lett. **87**, 137901 (2001), quant-ph/0006034.
130. *Multiparticle entanglement and its experimental detection*,  
W. Dür and J. I. Cirac, J. Phys. A **34**, 6837 (2001), quant-ph/0011025.
131. *Distillability Criterion for all bipartite Gaussian States*,  
G. Giedke, L.-M. Duan, J. I. Cirac, and P. Zoller, Quant. Inf. Comp. **1**, 79 (2001); quant-ph/0104072.
132. *Separability and Distillability of Gaussian states -- the complete story*,  
G. Giedke, B. Kraus, L.-M. Duan, P. Zoller, M. Lewenstein, and J. I. Cirac, Fort. Phys. **49**, Issue 10-11, 973 (2001).
133. *Long-distance quantum communication with atomic ensembles and linear optics*,  
L.-M. Duan, M. Lukin, J. I. Cirac, and P. Zoller, Nature **414**, 413 (22 Nov. 2001), quant-ph/0105105.
134. *Storing quantum dynamics in quantum states: stochastic programmable gate for  $U(1)$  operations*,  
G. Vidal, L. Masanes, J.I. Cirac, Phys. Rev. Lett. **88**, 047905 (2002), quant-ph/0102037.
135. *Irreversibility in asymptotic manipulations of a distillable entangled state*,  
G. Vidal and J. I. Cirac, Phys. Rev. A **65**, 012323 (2002), quant-ph/0107051.
136. *Quantum entanglement in spinor Bose-Einstein condensates*  
L.-M. Duan, J. I. Cirac, P. Zoller, Phys. Rev. A **65**, 033619 (2002), quant-ph/0107055.
137. *Dynamically turning off interactions in a two component condensate*,  
D. Jaksch, J. I. Cirac, and P. Zoller, Phys. Rev. A **65**, 033625 (2002), cond-mat/0110494.
138. *Catalysis in non--local quantum operations*,  
G. Vidal and J. I. Cirac, Phys. Rev. Lett. **88**, 167903 (2002), quant-ph/0108077.

139. *Characterization of Distillable and Activable States using Entanglement Witnesses*,  
B. Kraus, M. Lewenstein, and J. I. Cirac, Phys. Rev. A **65**, 042327 (2002), quant-ph/0110174.
140. *Creation of a molecular condensate by dynamically melting a Mott-insulator*,  
D. Jaksch, V. Venturi, J.I. Cirac, C.J. Williams, and P. Zoller, Phys. Rev. Lett. **89**, 040402 (2002), cond-mat/0204137.
141. *Entanglement cost of bipartite mixed states*,  
G. Vidal, W. Dür, and J. I. Cirac, Phys. Rev. Lett. **89**, 027901 (2002), quant-ph/0112131.
142. *Interaction cost of non-local gates*,  
G. Vidal, K. Hammerer, J. I. Cirac, Phys. Rev. Lett. **88**, 237902 (2002), quant-ph/0112168.
143. *Optimal conversion of non-local unitary operations*,  
W. Dür, G. Vidal, and J. I. Cirac, Phys. Rev. Lett. **89**, 057901 (2002), quant-ph/0112124.
144. *Optimal simulation of two-qubit Hamiltonians using general local operations*,  
C. H. Bennett, J. I. Cirac, M. S. Leifer, D. W. Leung, N. Linden, S. Popescu, and G. Vidal, Phys. Rev. A **66**, 012305 (2002), quant-ph/0107035.
145. *Equivalence classes of non-local unitary operations*,  
W. Dür and J. I. Cirac, Phys. Quant. Inf. Comp. **2**, 240 (2002), quant-ph/0201112.
146. *Fermionizing a small gas of ultracold bosons*,  
B. Paredes, P. Zoller, and J. I. Cirac, Phys. Rev. A **66**, 033609 (2002), cond-mat/0203061.
147. *High-temperature superfluidity of fermionic atoms in optical lattices*,  
W. Hofstetter, J.I. Cirac, P. Zoller, E. Demler, and M.D. Lukin, Phys. Rev. Lett. **89**, 220407 (2002), cond-mat/0204237.
148. *The characterization of Gaussian operations and Distillation of Gaussian States*,  
G. Giedke and J.I. Cirac, Phys. Rev. A **66**, 032316 (2002), quant-ph/0204085.
149. *Holonomic quantum computation with neutral atoms*,  
A. Recati, T. Calarco, P. Zanardi, J. I. Cirac, and P. Zoller, Phys. Rev. A **66**, 032309 (2002), quant-ph/0204030.
150. *Three-dimensional theory for interaction between atomic ensembles and free-space light*,  
L.-M. Duan, J. I. Cirac, and P. Zoller, Phys. Rev. A **66**, 023838 (2002), quant-ph/0205005.
151. *Optimal simulation of nonlocal Hamiltonians using local operations and classical communication*,  
G. Vidal and J. I. Cirac, Phys. Rev. A **66**, 022315 (2002), quant-ph/0108076.
152. *On the effective size of certain "Schrödinger cat" like states*,  
W. Dür, C. Simon, and J. I. Cirac, Phys. Rev. Lett. **89**, 210402 (2002), quant-ph/0205099.
153. *Many particle entanglement in two-component Bose-Einstein Condensates*,  
A. Micheli, D. Jaksch, J. I. Cirac, and P. Zoller, Phys. Rev. A **67**, 013607 (2003), cond-mat/0205369.
154. *Reflections upon separability and distillability*,  
D. Bruss, J. I. Cirac, P. Horodecki, F. Hulpke, B. Kraus, M. Lewenstein, A. Sanpera, J. Mod. Opt. **49**, 1399 (2002), quant-ph/0110081.
155. *Characterization of non-local gates*,  
K. Hammerer, G. Vidal, and J. I. Cirac, Phys. Rev. A **66**, 062321 (2002), quant-ph/0205100.
156. *Simulation of quantum dynamics with quantum optical systems*,  
E. Jané, G. Vidal, W. Dür, P. Zoller, and J. I. Cirac, Quant. Inf. Comp. **3**, 15 (2003), quant-ph/0207011
157. *On the structure of a reversible entanglement generating set for three-partite states*,  
A. Acin, G. Vidal, and J. I. Cirac, Quant. Inf. Comp. **3**, 55 (2003), quant-ph/0202056.

158. *From Cooper pairs to Luttinger liquids with bosonic atoms in optical lattices*,  
B. Paredes and J. I. Cirac, Phys. Rev. Lett. **90**, 150402 (2003), cond-mat/0207040.
159. *Entanglement generation and Hamiltonian simulation in continuous-variable system*,  
B. Kraus, K. Hammerer, G. Giedke, and J. I. Cirac, Phys. Rev. A **67**, 042314 (2003), quant-ph/0210236.
160. *Trapping atoms in the vacuum field of a cavity*,  
C. Schön and J. I. Cirac, Phys. Rev. A **67**, 043813 (2003), quant-ph/0312068.
161. *Quantum computation with unknown parameters*  
J. J. Garcia-Ripoll and J. I. Cirac, Phys. Rev. Lett. **90**, 127902 (2003), quant-ph/0208143.
162. *Quantum-nonlocality in the presence of superselection rules and data hiding protocols*,  
F. Verstraete and J. I. Cirac, Phys. Rev. Lett. **91**, 010404 (2003), quant-ph/0302039.
163. *Separable states can be used to distribute entanglement*,  
T. S. Cubitt, F. Verstraete, and J. I. Cirac, Phys. Rev. Lett. **91**, 037902 (2003), quant-ph/0302168.
164. *Entanglement of formation for symmetric Gaussian states*  
G. Giedke, M. M. Wolf, O. Krueger, R. F. Werner, and J. I. Cirac, Phys. Rev. Lett., **91**, 107901 (2003), quant-ph/0304042.
165. *Entanglement transformations of pure Gaussian states*  
G. Giedke, J. Eisert, J. I. Cirac, and M. Plenio, Quant. Inf. and Comp. **3**, 211 (2003), quant-ph/03010
166. *Defect-Suppressed Atomic Crystals in an Optical Lattice*,  
P. Rabl, A. J. Daley, P. O. Fedichev, J. I. Cirac, and P. Zoller, Phys. Rev. Lett. **91**, 110403 (2003), cond-mat/0304026.
167. *Speed Optimized Two-Qubit Gates with Laser Coherent Control Techniques for Ion Trap Quantum Computing*,  
J. J. Garcia-Ripoll, P. Zoller, and J. I. Cirac, Phys. Rev. Lett. **91**, 157901 (2003), quant-ph/0306006.
168. *Entanglement Detection Based on Interference and Particle Counting*,  
G. Toth, C. Simon, and J. I. Cirac, Phys. Rev. A **68**, 062310 (2003), quant-ph/0306086.
169. *Spin dynamics for Bosons in an optical lattice*,  
J.J. García-Ripoll and J. I. Cirac, New J. of Phys. **5**, 76.1 (2003).
170. *How to manipulate cold atoms*,  
J. I. Cirac and P. Zoller, Science **301**, 176 (2003).
171. *Discrete entanglement distribution with squeezed light*,  
B. Kraus and J. I. Cirac, Phys. Rev. Lett. **92**, 013602 (2004), quant-ph/0307158.
172. *Entanglement versus Correlations in Spin Systems*,  
F. Verstraete, M. Popp, and J. I. Cirac, Phys. Rev. Lett. **92**, 027901 (2004), quant-ph/0307009.
173. *Diverging Entanglement Length in Gapped Quantum Spin Systems*,  
F. Verstraete, M. A. Martin-Delgado, and J. I. Cirac, Phys. Rev. Lett. **92**, 087201 (2004), quant-ph/0311087.
174. *Entanglement frustration for Gaussian states on symmetric graphs*,  
M. Wolf, F. Verstraete, and J. I. Cirac, Phys. Rev. Lett. **92**, 087903 (2004), quant-ph/0307060.
175. *Nonlocal resources in the presence of Superselection Rules*,  
N. Schuch, F. Verstraete, and J. I. Cirac, Phys. Rev. Lett. **92**, 087904 (2004), quant-ph/0310124.
176. *Multipartite Bound Information exists and can be activated*,  
A. Acin, J. I. Cirac, and Ll. Masanes, Phys. Rev. Lett. **92**, 107903 (2004), quant-ph/0311064.
177. *Adiabatic Time Evolution in Spin-Systems*,

- V. Murg and J. I. Cirac, Phys. Rev. A **69**, 042320 (2004), quant-ph/0309026.
178. *Variational Ansatz for the Superfluid Mott-insulator transition in optical lattices*,  
J.J. Garcia-Ripoll, J.I. Cirac, P. Zoller, C. Kollath, U. Schollwöck, and J. von Delft, Opt. Express **12**, 42-54 (2004)  
cond-mat/0306162.
179. *Gaussian Entanglement of Formation*,  
M. Wolf, G. Giedke, O. Krüger, R-F. Werner, and J. I. Cirac, Phys. Rev. A **69**, 052320 (2004), quant-ph/0306177.
180. *Theory of Plasmon-assisted Transmission of Entangled Photons*,  
E. Moreno, F. J. Garcia-Vidal, D. Erni, J. I. Cirac, and L. Martin-Moreno, Phys. Rev. Lett. **92**, 236801 (2004),  
quant-ph/0308075.
181. *Effective quantum spin systems with ion traps*,  
D. Porras and J. I. Cirac, Phys. Rev. Lett. **92**, 207901 (2004), quant-ph/0401102.
182. *Tonks-Girardeau gas in an optical lattice*, B. Paredes, A. Widera, V. Murg, O. Mandel, S. Fölling, I. Cirac, G. Shlyapnikov, T.W. Hänsch, and I. Bloch, Nature **429**, 277 (2004).
183. *Atomic quantum gases in Kagomé lattices*,  
L. Santos, M.A. Baranov, J. I. Cirac, H.-U. Everts, H. Fehrmann, and M. Lewenstein, Phys. Rev. Lett. **93**, 030601  
(2004), quant-ph/0401502.
184. *Non-additivity of quantum capacity for multiparty communication channels*,  
W. Dür, J. I. Cirac, and P. Horodecki, Phys. Rev. Lett., Phys. Rev. Lett. **93**, 020503 (2004), quant-ph/0403068.
185. *Quantum computation with cold bosonic atoms in an optical lattice*,  
J. J. Garcia-Ripoll and J. I. Cirac, Phil. Trans. R. Soc. Lond. A **361**, 1537 (2003).
186. *Quantum entanglement theory in the presence of superselection rules*,  
N. Schuch, F. Verstraete, and J. I. Cirac, Phys. Rev. A **70**, 042310 (2004), quant-ph/0404079.
187. *New frontiers in Quantum Information with atoms and ions*,  
J. I. Cirac and P. Zoller, Phys. Today **57**, 38 (2004).
188. *Matrix Product Density Operators: Simulation of finite-T and dissipative systems*,  
F. Verstraete, J. J. Garcia-Ripoll, and J. I. Cirac, Phys. Rev. Lett. **93**, 207204 (2004), cond-mat/0406426.
189. *Light-matter quantum interface*,  
K. Hammerer, K. Moelmer, E. S. Polzik, and J. I. Cirac, Phys. Rev. A **70**, 044304 (2004), quant-ph/0312156.
190. *DMRG and periodic boundary conditions: a quantum information perspective*,  
F. Verstraete, D. Porras, and J. I. Cirac, Phys. Rev. Lett. **93**, 227205 (2004), cond-mat/0404706.
191. *Adiabatic Path to Fractional Quantum Hall States of a Few Bosonic Atoms*,  
M. Popp, B. Paredes, and J. I. Cirac, Phys. Rev. A **70**, 053612 (2004), cond-mat/04050195.
192. *Implementation of Spin Hamiltonians in Optical Lattices*,  
J. J. Garcia-Ripoll, M. A. Martin-Delgado, and J. I. Cirac, Phys. Rev. Lett. **93**, 250405 (2004), cond-mat/0404566.
193. *Experimental demonstration of quantum memory for light*,  
B. Julsgaard, J. Sherson, J. I. Cirac, J. Fiurasek, E. S. Polzik, Nature **432**, 482 (Nov 2004), quant-ph/0410072.
194. *Ensemble quantum computation with atoms in periodic potentials*,  
K. Vollbrecht, E. Solano, and J. I. Cirac, Phys. Rev. Lett. **93**, 220502 (2004), quant-ph/0405014.
195. *Valence-bond states for quantum computation*,  
F. Verstraete and J. I. Cirac, Phys. Rev. A **70**, 060302 (2004), quant-ph/0311130.
196. *Bose-Einstein Condensation and strong-correlation behavior of phonons in ion traps*,  
D. Porras and J. I. Cirac, Phys. Rev. Lett. **93**, 263602 (2004), quant-ph/0409015

197. *Detection of vacuum entanglement in a linear ion trap*,  
A. Retzker, J. I. Cirac, and B. Reznik, Phys. Rev. Lett. **94**, 050504 (2005), quant-ph/0408059.
198. *Key distillation from Gaussian states by Gaussian operations*,  
M Navascues, J. Bael, J. I. Cirac, M. Lewenstein, A. Sanpera, A. Acin, Phys. Rev. Lett. **94**, 010502 (2005), quant-ph/0405047.
199. *Renormalization group transformations on quantum states*,  
F. Verstraete, J. I. Cirac, J. I. Latorre, E. Rico, and M. M. Wolf, Phys. Rev. Lett. **94**, 140601 (2005), quant-ph/0410227.
200. *Hilbert's 17th problem and the quantumness of states*,  
J. Korbicz, J. I. Cirac, J. Wehr, and M. Lewenstein, Phys. Rev. Lett. **94**, 153601 (2005), quant-ph/0408029.
201. *Quantum benchmark for storage and transmission of coherent states*,  
K. Hammerer, M. M. Wolf, E. S. Polzik, and J. I. Cirac, Phys. Rev. Lett. **94**, 150503 (2005), quant-ph/0409109.
202. *Localizable Entanglement*,  
M. Popp, F. Verstraete, M. A. Martin-Delgado, and J. I. Cirac, Phys. Rev. A **71**, 042306 (2005), quant-ph/0411123.

## 2.- Submitted

- Fermionic Atoms in Optical Superlattices*,  
B. Paredes, C. Tejedor, and J. I. Cirac, cond-mat/0306497.
- Renormalization algorithms for Quantum-Many Body Systems in two and higher dimensions*,  
F. Verstraete and J. I. Cirac, cond-mat/0407066.
- Coherent control of trapped ions using off-resonant lasers*,  
J. J. Garcia-Ripoll, P. Zoller, and J. I. Cirac, quant-ph/0411103.
- Efficient evaluation of partition functions of frustrated and inhomogeneous spin systems*,  
V. Murg, F. Verstraete, and J. I. Cirac, cond-mat/0501493.
- Sequential generation of entangled multi-qubit states*,  
C. Schön, E. Solano, F. Verstraete, J. I. Cirac, and M. Wolf, quant-ph/0501096.
- Reversible universal quantum computation within translation invariant systems*,  
K. G. H. Vollbrecht, J. I. Cirac, quant-ph/0502143.
- Quantum memory for non-stationary light fields based on controlled reversible inhomogeneous broadening*,  
B. Kraus, W. Tittel, N. Gisin, M. Nilsson, S. Kroll, J.I. Cirac, quant-ph/0502184.
- Spin squeezing inequalities and entanglement of  $N$  qubit states*,  
J. Korbicz, J.I. Cirac, M. Lewenstein, quant-ph/0504005.
- Variational matrix product state approach to quantum impurity models*,  
F. Verstraete, A. Weichselbaum, U. Schollwöck, J. I. Cirac, Jan von Delft, cond-mat/0504305.
- Renormalization algorithm for the calculation of spectra of interacting quantum systems*,  
D. Porras, F. Verstraete, J. I. Cirac, cond-mat/0504717.
- Matrix product states approximate ground states faithfully*,  
F. Verstraete J.I. Cirac