

Curriculum Vitae

Vlatko Vedral

Prof. Vlatko Vedral, PhD, DIC, MA

NATIONALITY: British

DATE OF BIRTH: 19th August 1971

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PROFESSIONAL HISTORY

- Professor of Quantum Information Science, University of Oxford & fellow at Wolfson College (June 2009-).
- Professor of Physics, NUS and Principal Investigator at CQT, Singapore (Dec 2007-).
- Centenary Professor of Quantum Information Science at Leeds University, (Oct 2004-May2009).
- Reader in Quantum Physics at Imperial College, Oct. 2003 – Oct. 2004.
- Governor's lecturer (permanent position) at Imperial College, Oct. 2000 – Oct. 2003.
- Senior College Lecturer at Keble College, Oxford, Oct. 2001 – Oct. 2003.
- Junior research fellow at Merton College, Oxford, Oct. 1998 – Oct. 2000.
- Elsag-Bailey post-doctoral research fellow in Oxford, April 1998 – Oct. 1998.

EDUCATION HISTORY

- PhD in physics at Imperial College of Science, Technology and Medicine (Title: "*Quantum Information Theory of Entanglement*", supervised by Prof. Sir Peter L. Knight, FRS), October 1995 - March 1998. Most of my thesis work is presented in my review article (V. Vedral, "The Role of Relative Entropy in Quantum Information Theory", Rev. Mod. Phys. 74, 197 (2002)).
- BSc in physics at Imperial College of Science, Technology and Medicine (Specialised in Theoretical Physics), 1992 - 1995.

AWARDS AND VISITING PROFESSORSHIPS

- The World Scientific (Physics Research) Medal and Prize, Singapore IOP, 2009.
- Royal Society Wolfson Research Merit Award, March 2007.
- Visiting Research Professor, University of Singapore, 2005-2007.
- Visiting Professor, University of Vienna, Jan. – July 2005.
- Senior Scientist, Schrödinger Institute, Vienna, Sept. – Dec. 2004.
- Finalist at the International competition for young researchers in honour of John Archibald Wheeler, Princeton, USA, March 2002.
- The Abdus Salam Award (Imperial College), June 1997.
- Overseas Research Student Award, Imperial College, Oct. 1995 – Oct. 1998.
- University of London Scholarship Award: The Knight Trust (London), 1996 - 1998.

RESEARCH SUPPORT

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|---|--|----------|
| • EC EQUIP (2000-2003) and TOPQIP (2003-2006) | | £201,000 |
| • EPSRC | Quantum Computation (2000-2003;2006-2009) | £300,000 |
| • Elsag spa | PhD studentship (1999-2003) | £60,000 |
| • Hewlett-Packard | Contribution to PhD Studentship (2001) | £ 6,000 |
| • QUIPROCONE | Collaborations (2000-2003) | £10,000 |
| • ESF & QUIPRO. | Summer School Organisation (2002) | £16,000 |
| • EPSRC | Quantum Information UK based Network (2003-2006) | £60,000 |
| • QIPIRC | EPSRC quantum computation network (2003-2006) | £160,000 |
| • SCALA | EU network (2006-2009) | £80,000 |

PROFESSIONAL SERVICES

- Referee for journals (including Nature, Phys. Rev., Proc. Roy. Soc., J. Mod. Opt.).
- Referee for EPSRC, Royal Society, Austrian Science Foundation and other international bodies.
- Examiner for PhD thesis and Junior Research Fellowships.
- Organizer of four international and two UK conferences.
- Assistant coordinator of EPSRC funded UK network "Quantum Interference" (2003-6).
- Advisory Panel Board Member for J. Phys A (2005-); advisor for Research assessment in UK
- I regularly review books for Nature, Contemp. Phys. and Prog. Q. Elect. & review book proposals for the Oxford University Press and Imperial College Press.
- Member of EPSRC and Canadian College of Reviewers (2005-) and Lifeboat Foundation advisory board (2006-).
- I have served on many University committees regarding hiring, promotional, administrative and teaching decision making.
- Member of IOPP Science Advice Committee (2009-)

PUBLIC SERVICE

I have participated in many public events, among which are:

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|--|---|----------------|
| 1. BBC radio | I have weekly 2 hour long show on science | 2006 - |
| 2. Financial Times: | Interview on the current state of QC | 1998 |
| 3. Science Now: | 2 Interviews about entanglement | 1999/00 |
| 4. German Radio: | Interview on my views on Quantum Mechanics | 2003 |
| 5. New Scientist: | Articles (an invitation for 50-years special issue) | 02/03/04/06/07 |
| 6. "Unlimited" theatre: | Theatre plays based on my consultations | 2006/07 |
| 7. Discovery Channel | Interview | 2008/09 |
| 8. Straits Times (two articles in the science section) | | 2008/09 |

TEACHING

- **Undergraduate:** Quantum Mechanics, Relativity, Optics, Quantum Optics, Mathematics, Thermodynamics, Statistical Mechanics, Analytical Mechanics and Electro-magnetism at Oxford (Merton College and Keble College), Imperial College and Leeds since 1998 (2 courses per year on average). Academic and personal tutor as well as project supervision.
- **Postgraduate lecture courses:** Quantum Computation and Quantum Optics (Imperial College 2000-2003, Heidelberg 2003, Vienna 2004 & Vienna 2005, Singapore 2008/09).
- **Books:** "Modern Foundations of Quantum Optics" (Imperial College Press, March 2005) and "Introduction to Quantum Information Science" (Oxford University Press, October 2006). I have contributed to 4 other books on quantum information and computation.

SUPERVISION

- 18 students have so far received PhDs under my supervision. I have supervised numerous undergraduate research projects in UK and US (including students from the SURF Caltech exchange program as well as the Stanford University).

PUBLICATIONS AND TALKS

- I have published over 140 papers including 29 Phys. Rev. Letters, 4 Nature papers, invited "News and Views", "Essays" and Insights" for Nature, and six invited reviews on quantum information, including 3 Reviews of Modern Physics. Total citation number about 6000 (h factor = 37).
- I have delivered over 150 invited lectures (plenary talks at various conferences, annual meetings of physical societies, tutorial and technical lectures at the leading universities and research centres in Europe, North America and Asia); I have been invited to give many public lectures (most recently and notably at the international Café Scientifique, 2007).

LIST OF PUBLICATIONS:

1. V. Vedral, A. Barenco and A. Ekert., Quantum Networks for Elementary Arithmetic Operations, *Phys. Rev. A* 54, 147 (1996).
2. M. Plenio, V. Vedral and P. Knight, Computers and communication in the quantum world, *Phys. World* 9, 19 (1996).
3. M.B. Plenio, V. Vedral and P.L. Knight, Quantum error correction in the presence of spontaneous emission, *Phys. Rev. A* 55, 67 (1997).
4. V. Vedral, M.B. Plenio, M.A. Rippin and P.L. Knight., Quantifying entanglement, *Phys. Rev. Lett.* 78, 2275 (1997).
5. V. Buzek, V. Vedral, M.B. Plenio, P.L. Knight and M. Hillery, Broadcasting of entanglement via local copying, *Phys. Rev. A* 55, 3327 (1997).
6. M.B. Plenio, V. Vedral and P.L. Knight, A fault-tolerant error correction network, *Phys. Rev. A* 55, 4593 (1997).
7. V. Vedral, M. Rippin and M.B. Plenio, Quantum correlations, local interactions and error correction, *J. Mod. Opt.* 44, 2185 (1997).
8. K. Jacobs, P. L. Knight and V. Vedral, Determining the state of a single cavity mode from photon statistics, *J. Mod. Opt.* 44, 2427 (1997).
9. P.L. Knight, M.B. Plenio and V. Vedral, Decoherence and quantum error correction, *Phil. Trans. Roy. Soc. London* 355, 2381 - 2385 (1997).
10. V. Vedral, M. B. Plenio, K. Jacobs and P.L. Knight, Statistical inference, distinguishability of quantum states, and quantum entanglement, *Phys. Rev. A* 56, 4452 (1997).
11. S. Bose, V. Vedral, and P.L. Knight, Multiparticle Schemes for Entanglement Swapping, *Phys. Rev. A* 57, 822 (1998).
12. V. Vedral and M.B. Plenio, Entanglement measures and purification procedures, *Phys. Rev. A* 57, 1619 (1998).
13. M. Murao, M.B. Plenio, S. Popescu, V. Vedral and P.L. Knight, Quantum state distillation for multiparticle entanglement, *Phys. Rev. A* 57, R4075 (1998).
14. S. Bose, P.L. Knight, M. Murao, M.B. Plenio, V. Vedral, Implementations of Quantum Logic: Fundamental and Experimental Limits, *Phil. Trans. Roy. Soc. London* 356, 1823 (1998).
15. V. Vedral and M.B. Plenio, Basic Concepts of Quantum Computation, *Progress in Quantum Electronics* 22, 1 (1998).
16. M.B. Plenio and V. Vedral, Entanglement in Quantum Information Theory, *Contemporary Physics* 39, 431 (1998).
17. P. T. Landsberg and V. Vedral, Distributions and Channel Capacities in Generalized Statistical Mechanics, *Phys. Lett. A* 247, 211 (1998).
18. S.F. Huelga, P.L. Knight, C. Macchiavello, M.B. Plenio and V. Vedral, Entanglement in Frequency Standards and Quantum Information Theory, *Applied Physics B* 67, 723 (1998).

19. M. Murao, D. Jonathan, M.B. Plenio and V. Vedral, Quantum telecloning and multiparticle entanglement, *Phys. Rev. A* 59, 156 (1999).
20. P.L. Knight, M. Murao, M.B. Plenio, and V. Vedral, Ion Trap Quantum Gates, Decoherence and, Error Correction, *Chaos, Solitons and Fractals* 10, 1612 (1999).
21. S. Bose, M.B. Plenio and V. Vedral, Mixed state dense coding and its relation to entanglement measures, *J. Mod. Opt.* 47, 291 (2000).
22. S. Bose, V. Vedral and P. L. Knight, Purification via Entanglement Swapping and Measures of Entanglement, *Phys. Rev. A* 60, 194 (1999).
23. V. Vedral, Landauer's principle, error correction and entanglement, *Proc. Roy. Soc. London A* 456, 969 (2000); also in "Maxwell's Demon II", edited by H. S. Leff and A. F. Rex (2002).
24. J. A. Jones, V. Vedral, A. Ekert and G. Castagnoli, Geometric Quantum Computation, *Nature* 403, 869 (2000).
25. S. Bose, P.L. Knight, M. B. Plenio and V. Vedral, Teleportation with cavities, *Phys. Rev. Lett.* 83, 5158 (1999).
26. V. Vedral, Bound entanglement assisted distillation, *Phys. Lett. A* 262, 121 (1999).
27. L. Henderson, L. Hardy and V. Vedral, Two state teleportation, *Phys. Rev. A* 61, 062306 (2000).
28. L. Henderson and V. Vedral, Information, relative entropy of entanglement, and irreversibility, *Phys. Rev. Lett.* 84, 2263 (2000).
29. M. Murao, M.B. Plenio and V. Vedral, Quantum information broadcasting, *Phys. Rev. A* 61, 032311 (2000).
30. S. Bose and V. Vedral, Mixedness and teleportation, *Phys. Rev. A (Rapid)* 61, 040101 (2000).
31. G. Falci, R. Fazio, G. M. Palma, J. Siewert and V. Vedral, Detection of geometrical phases in superconducting nanocircuits, *Nature* 407, 355 (2000).
32. S. Bose, L. Rallan and V. Vedral, Communication Capacity of quantum computation, *Phys. Rev. Lett.* 85, 5448 (2000).
33. E. Sjoqvist, A. K. Pati, A. Ekert, J. S. Anandan, M. Ericsson, D. K. L. Oi, V. Vedral, Geometric phases for mixed states in interferometry, *Phys. Rev. Lett.* 85, 2845 (2000).
34. A. Ekert, M. Ericsson, P. Hayden, H. Inamori, J. Jones, D. K. L. Oi, V. Vedral, Geometric quantum computation, *J. Mod. Opt.* 47, 2501 (2000).
35. I. Fuentes-Guridi, S. Bose and V. Vedral, Proposal for measurement of harmonic oscillator Berry phase in ion traps, *Phys. Rev. Lett.* 85, 5018 (2000).
36. J. Walgate, T. Short L. Hardy and V. Vedral, Local distinguishability of multipartite orthogonal quantum states, *Phys. Rev. Lett.* 85, 4972 (2000).
37. A. Beige, S. Bose, D. Braun, S. F. Huelga, P. L. Knight, M. B. Plenio and V. Vedral, Entangling Atoms and Ions in Dissipative Environments, *J. Mod. Opt.* 47, 2583 (2000).
38. G. Falci, R. Fazio, G. M. Palma, J. Siewert and V. Vedral, Geometric Quantum Computation with Josephson Qubits, *Physica C* 352, 110 (2001).
39. M. Murao and V. Vedral, Information concentration using Bound entanglement, *Phys. Rev. Lett.* 86, 352 (2001).

40. M. C. Arnesen, S. Bose and V. Vedral, Thermal Entanglement in 1D Heisenberg Model, Phys. Rev. Lett. 87, 017901 (2001).
41. S. Bose, P.L. Knight, M.B. Plenio MB and V. Vedral, Teleportation via decay, PRAMANA-J PHYS 56, 383 (2001).
42. D. Gunlycke, S. Bose, V. Kendon and V. Vedral, Thermal Concurrence Mixing in 1D Ising Model, Physical Review A 64, 042302 (2001).
43. H. Inamori, L. Rallan and V. Vedral, Incoherent eavesdropping in E91, J. Phys. A. 34, 6913 (2001).
44. M. B. Plenio and V. Vedral, Bounds on relative entropy of entanglement for multi-party systems, J. Phys. A. 34, 6997 (2001).
45. L. Henderson and V. Vedral, Classical, quantum and total correlations, J. Phys. A 34, 6899 (2001).
46. S. Bose, I. Fuentes-Guridi, P. L. Knight and V. Vedral, Initial purity as an enforcer of entanglement, Phys. Rev. Lett. 87, 050401 (2001); erratum, 87, 279901 (2001).
47. H. Azuma, S. Bose and V. Vedral, Entanglement in globally phase shifted states, Phys. Rev. A 64, 062308 (2001).
48. V. Vedral, Quantum Information from The Relative Entropy, Rev. Mod. Phys., 74, 197 (2002).
49. Y. Omar, N. Paunkovic, S. Bose and V. Vedral, Spin-Space Entanglement transfer due to particle statistics, Phys. Rev. A 65, 062305 (2002).
50. N. Paunkovic, Y. Omar, S. Bose and V. Vedral, Entanglement Concentration using Quantum Statistics, Phys. Rev. Lett. 88, 187903 (2002).
51. J. Dunningham, S. Bose, L. Henderson, V. Vedral and K. Burnett, Entanglement Swapping in Bose Einstein condensates, Phys. Rev. A 65, 064302 (2002).
52. V. Vedral and E. Kashefi, Uniqueness of Entanglement Measure and Thermodynamics, Phys. Rev. Lett. 89, 037903 2002.
53. E. Kashefi, A. Kent, K. Banaszek and V. Vedral, On the power of Quantum Oracles, Phys. Rev. A 65, 050304 (2002).
54. E. Kashefi, H. Nishimura and V. Vedral, A note on one-way quantum permutations, Quant. Info. Process. 2, 379 (2002).
55. I. Fuentes-Guridi, A. Carollo, S. Bose and V. Vedral, Vacuum Induced Spin-1/2 Berry phase, Phys. Rev. Lett. 89, 220404 (2002).
56. I. Fuentes-Guridi, J. Pachos, S. Bose, V. Vedral and S. Choi, Geometric Phases of Macroscopic Spin in Bose-Einstein Condensates, Phys. Rev. A 66, 022102 (2002).
57. J. S. Anandan, Erik Sjoqvist, A. K. Pati, A. Ekert, M. Ericsson, D. K. L. Oi, V. Vedral, Reply to "Singularities of the mixed state Berry phase", Phys. Rev. Lett. 89, 268902, (2002).
58. V. Vedral, Classical correlations and entanglement in quantum measurements, Phys. Rev. Lett. 90, 050401 (2003).
59. V. Vedral, Untangling Entanglement, Nature 420, 271 (2002).
60. A. Carollo, I. Fuentes-Guridi, M. Santos and V. Vedral, Geometric phase in Open Systems, Phys. Rev. Lett. 90, 160402 (2003).

61. V. Vedral, Entanglement in the second quantised formalism, *Central Eu. J. Phys.* 2, 289 (2003); Chosen as the paper of 2003 by the journal.
62. V. Vedral, Geometric Phases and Topological Quantum Computation, *Int. J. Q. Info.* 1, 1 (2003).
63. D. Markham and V. Vedral, Classicality of spin coherent states via entanglement and distinguishability, *Phys. Rev. A* 67, 042113 (2003).
64. M. Williamson and V. Vedral, Eavesdropping on realistic quantum cryptography, *J. Mod. Opt.* 50, 1989 (2003).
65. V. Vedral, Entanglement hits the big time, *Nature* 425, 28 (2003).
66. S. Bose, A. Carollo, I. Fuentes-Guridi I and V. Vedral, Vacuum induced Berry phase: theory and experimental proposal, *J. Mod. Opt.* 50, 1175 (2003).
67. A. Carollo, M. F. Santos and V. Vedral, Berry phase in Cavity QED, *Phys. Rev. A* 67, 063804 (2003).
68. L. Rallan and V. Vedral, Energy Requirements for Quantum Data Compression and 1-1 Coding, *Phys. Rev. A* 68, 042309 (2003).
69. J. Pachos and V. Vedral, Topological Quantum Gates with Quantum Dots, *Jour. of Opt. B* (special issue on Quantum Computing) 5, S643 (2003).
70. S. Bose, A. Ekert, Y. Omar, N. Paunkovic and V. Vedral, Optimal State Discrimination Using Particle Statistics, *Phys Rev A A* 68, 052309 (2003).
71. F. Morikoshi, M. Santos and V. Vedral, Accessibility of physical states and non-uniqueness of entanglement measure, *J. Phys. A* 37, 5887 (2004).
72. D. Markham, M. Muraio and V. Vedral, Entanglement Generation from Thermal Spin States via Unitary Beam Splitters, *Phys. Rev. A* 70, 062312 (2004).
73. A. Carollo, I. Fuentes-Guridi, M. Santos and V. Vedral, Spin-1/2 geometric phase driven by decohering quantum fields, *Phys. Rev. Lett.* 92, 020402 (2003).
74. J. Hartley and V. Vedral, Entropy as a function of Geometric Phase, *J. Phys. A* 37, 11259 (2004).
75. V. Vedral, Mean Field Approximations and Multipartite Thermal Correlations, *New J. Phys.* 6, 10 (2004).
76. V. Vedral, High temperature macroscopic entanglement, *New J. Phys* 6, 102 (2004).
77. R. Serra, A. Carollo, M. Santos and V. Vedral, Anyons and transmutation of statistics via a vacuum-induced Berry phase, *Phys. Rev. A* 70, 044102 (2004).
78. K. Maruyama, F. Morikoshi and V. Vedral, Thermodynamical detection of entanglement by Maxwell's demons, *Phys. Rev. A* 71, 012108 (2005).
79. C. Brukner and V. Vedral, Thermodynamical witnesses to quantum entanglement, *Int. J. Quant. Info.* (2006).
80. C. Brukner, S. Taylor, S. Cheung and V. Vedral, Entanglement in time and temporal communicational complexity, *AIP Conference Proc.* 734, 281 (2004).
81. V. Viguie, K. Maruyama and V. Vedral, Work extraction from tripartite entanglement, *New J. Phys.* 7, 195 (2005).

82. C. Brukner, V. Vedral and A. Zeilinger, Crucial role of entanglement in bulk properties of solids, *Phys. Rev. A* 73, 012110 (2006).
83. K. Maruyama, C. Brukner and V. Vedral, Thermodynamical cost of accessing quantum information, *J. Phys. A* 38, 7175 (2005).
84. P. Walther, K. J. Resch, T. Rudolph, E. Schenck, H. Weinfurter, V. Vedral, M. Aspelmeyer, A. Zeilinger, Experimental one way quantum computing, *Nature* 343, 169 (2005).
85. M. Tame, M. Paternostro, M. S. Kim, V. Vedral, Toward a more economical cluster state quantum computation, *Int. J. Quant. Info.* 4, 689 (2006).
86. C. Lunke, C. Brukner and V. Vedral, Natural multiparticle entanglement in a Fermi gas, *Phys. Rev. Lett.* 95, 030503 (2005).
87. M. Tame, M. Paternostro, M. S. Kim, V. Vedral, Quantum Information processing with noisy cluster states, *Phys. Rev. A* 72, 012319 (2005).
88. B. Hiesmayr and V. Vedral, Thermodynamical versus optical complementarity, submitted to *J. Phys. A*. (2005).
89. M. Wiesniak, V. Vedral and C. Brukner, Magnetic susceptibility as a macroscopic witness of entanglement, *N.J. Phys.* 7, 258 (2005).
90. D. Cavalcanti, M. F. Santos, M. O. Terra Cunha, C. Lunke and V. Vedral, Increasing identical particle entanglement by fuzzy measurements, *Phys. Rev. A* 72, 062307 (2005).
91. A. Ferreira, A. Guerreiro and V. Vedral, Entanglement due to radiation pressure, *Phys. Rev. Lett.* 96, 060407 (2006).
92. C. Rogers and V. Vedral, Second Quantized Quantum Turing Machine, submitted to *Phys. Rev. Letters* (2005).
93. J. Kofler, V. Vedral, M. S. Kim and C. Brukner, Collective Entanglement Witnesses for a Linear Harmonic Chain", *Physical Review A* 73, 052107 (2006).
94. M. Wiesniak, V. Vedral and C. Brukner, Third Law of Thermodynamics and quantum entanglement, submitted to *N. J. Phys.* 7, (2005).
95. V. Vedral, Better than a perfect match, *Nature* 439, 397 (2006).
96. J. Anders, D. Kaszlikowski, T. Oshima, C. Lunke and V. Vedral, *N. J. Phys.* 8, (2006).
97. A. Carollo, M. Santos and V. Vedral, Coherent evolution via reservoir driven holonomy, *Phys. Rev. Lett.* 96, 020403 (2006).
98. A. Carollo, A. Lozinski, G. M. Palma, M. Santos and V. Vedral, Geometric phase induced by a cyclically evolving squeezed vacuum reservoir, *Phys. Rev. Lett.* 96, 150403 (2006).
99. M. S. Tame, M. Paternostro, M. S. Kim, V. Vedral, Natural three-qubit interactions in one-way quantum computing, *Phys. Rev. A* 73, 022309 (2006)
100. C. Brukner, N. Paunkovic, T. Rudolph, V. Vedral, Entanglement Assisted Orientation in Space, *Int. J. Quant. Info.* 5, 53 (2007).
101. G. de Chiara, C. Brunner, R. Fazio G. M. Palma and V. Vedral, A scheme for entanglement extraction from a solid, *N. J. Phys* 8 (2006).
102. M. Terra Cunha and V. Vedral, How to Extract Entanglement from a Piece of Solid or a Bunch of Neutrons, *Acta Physica Hungarica A* 26, 261-268 (2006).

103. D. Vitali, S. Gigan, A. Ferreira A, et al. and V. Vedral, Optomechanical entanglement between a movable mirror and a cavity field, *Phys. Rev. Lett.* 98, 030405 (2007).
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105. J. Anders J, V. Vedral, Macroscopic entanglement and phase transitions, *OPEN SYSTEMS & INFORMATION DYNAMICS* 14, 1 (2007).
106. J. Hide, W. Son, I. Lawrie and V. Vedral, Witnessing Macroscopic Entanglement in a Staggered Magnetic Field, *Phys. Rev. A* 76, 022319 (2007).
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109. J. Dunningham and V. Vedral, Nonlocality of a single particle, *Phys. Rev. Lett.* 99, 180404 (2007).
110. A. Chandran, D. Kaszlikowski, A. Sen De, U. Sen and V. Vedral, Regional versus Global Entanglement in Resonating-Valence-Bond states, *Phys. Rev. Lett.* 99, 170502 (2007).
111. L. Amico, R. Fazio, A. Osterloh and V. Vedral, Entanglement in Many-Body Systems, *Rev. Mod. Phys.* 80, 517 (2008).
112. V. Vedral, Quantumness without quantumness: entanglement as classical correlations in higher dimensions, *J. Mod. Opt.* 54, 1 (2007).
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114. M. O. Terra Cunha, J. A. Dunningham and V. Vedral, Entanglement in single particle systems, *Proc. Roy. Soc. A* 463 (2005): 2277 (2007).
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