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The Career of Bernard d'Espagnat

2009 Templeton Prize Laureate

When the Templeton Prize engages scientific questions, it seeks especially to focus on accomplishments that involve the advancement of knowledge in areas where new scientific insights illuminate topics and debates that are of broadly spiritual significance. When focused on scholarly activity, it seeks to highlight the work of persons who have pursued new and rigorous perspectives, scientific and otherwise, in order to advance humane understanding of the "Big Questions" of existence.

The 2009 Templeton Prize recognizes a scientist-philosopher whose career exemplifies a rare combination: creative spiritual vision and technical dedication to rigor in scientific work. Bernard d'Espagnat played a key role in encouraging the early emergence of "Bell test experiments" in physics, especially as performed by Alain Aspect and his collaborators and published in 1981 and 1982. These experiments led to the crucial discovery of the phenomenon of "non-local entanglement" in quantum mechanics.

I. D'Espagnat recognized very early the deep philosophical importance of developing an experimental test of what is now known as quantum mechanical "non-local entanglement."

This recognition was based on specific theoretical ideas first put forward in 1964 by the brilliant physicist John Bell (1928-1990), with whom he worked at CERN:

On Bell: http://en.wikipedia.org/wiki/John_Stewart_Bell
On Bell's theorem & inequalities: http://en.wikipedia.org/wiki/Bell's_Theorem ; http://plato.stanford.edu/entries/bell-theorem/
On Bell test experiments: http://en.wikipedia.org/wiki/Bell_test_experiments

The following chronological series of publications shows d'Espagnat's technical writing and conference-organizing activity, inspired directly by John Bell's important breakthrough work and focused on developing experimental resolution of the issues raised by Bell's theoretical insights:

Bell, J. S. (1964). "On the Einstein Podolsky Rosen paradox." Physics 1: 195.

Bell, J. S. (1966) “On the problem of hidden variables in quantum mechanics.” Rev. Mod. Phys. 38, 447 (due to an error of the editor of the RMP, this paper appeared in 1966 rather than as initially scheduled in 1964)

d.Espagnat, B. (1965 book). *Conceptions de la physique contemporaine*. *Les interprétations de la mécanique quantique et de la mesure*. Paris : Hermann

Clauser, J.F., Horne, M. A., Shimony, A., and Holt, R.A. (1969) "Proposed Experiment to Test Local Hidden Variable Theories." Phys. Rev. Lett. 23, 880-4.

d’Espagnat (1971 book) *Conceptual Foundations of Quantum Mechanics*. Addison-Wesley, Reading, Mass. 2nd edition: 1976.

d'Espagnat, B. (Editor, 1971 book) *Foundations of Quantum Mechanics: Proceedings of the International School of Physics “Enrico Fermi” Course 49* (held in Varenna in 1970). An intellectually highly significant meeting organized by Bernard D’Espagnat and involving John Bell, Eugene Wigner, and several others who played key roles in the emergence of the Bell test experiments agenda. Academic Press, New York. Bell’s chapter is: “Introduction to the hidden variable question.” Proceedings of the International School of Physics 'Enrico Fermi', Course IL, Foundations of Quantum Mechanics (1971) 171–81.]

Freedman S.J. and Clauser, J.F. (1972) “Experimental test of local hidden-variable theories.” Phys. Rev. Lett. 28, 938 (1972). (The 1st early-stage “Bell test” experiment.)

Clauser, J.F., and Horne, M. A., (1974) “Experimental consequences of objective local theories.” Phys. Rev. D 10, 526-535 (1974)

d’Espagnat, B. (1975). “Use of Inequalities for the Experimental Test of a General Conception of the Foundations of Microphysics.” Physical Review 11D (6): 1424-35.

Clauser, J. F. (1976), “Experimental investigation of a polarization correlation anomaly.” Physical Review Letters 36, 1223-1226.

Aspect, A. (1976). “Proposed experiment to test the non-separability of quantum mechanics.” Physical review, D(14):1944-1951.

Clauser, J. F., and Shimony, A (1978). “Bell's theorem: experimental tests and implications.” Reports on Progress in Physics 41, 1881

D’Espagnat, B. (1978). “Use of Inequalities for the Experimental Test of a General Conception of the Foundations of Microphysics.” II Physical Review 18D: 349-358.

II. D'Espagnat was an early interpreter of the deep philosophical significance of this experimental research agenda in physics:

D'Espagnat, B. (1979 book). *À la recherche du réel, le regard d'un physician*. Paris: Gauthier-Villars, 1979. (Published in English as *In Search of Reality, the Outlook of a Physicist*. New York: Springer-Verlag, 1983.

D'Espagnat, B. (1979). "The Quantum Theory and Reality." Scientific American 241:5, November 1979.

III. The writings of the winner were one important source of the vision that took a somewhat odd-seeming philosophical agenda with links to spiritually significant questions (such as "What is the deepest ground of the reality nature within which we participate?) and transformed it into a novel experimental agenda in physics. This led to a huge discovery in physics, in particular the experimental results published by Alain Aspect and his collaborators in 1981 and 1982.

The results of these important definitive experiments (see below for the specific publications) provided a vital impetus for the growth and development of the thriving contemporary field of research in "Quantum Information Science." In turn, this new field of inquiry in physics provides new perspectives and resources for philosophy and for philosophical theology.

(1981). Aspect et al., "Experimental Tests of Realistic Local Theories via Bell's Theorem." Phys. Rev. Lett. 47, 460 (1981)

(1982a). Aspect et al., "Experimental Realization of Einstein-Podolsky-Rosen-Bohm Gedanken experiment: A New Violation of Bell's Inequalities." Phys. Rev. Lett. 49, 91 (1982),

(1982b). Aspect et al., "Experimental Test of Bell's Inequalities Using Time-Varying Analyzers." Phys. Rev. Lett. 49, 1804 (1982),

IV. The winner continued work as a physicist-philosopher emphasizing the deep philosophical significance of these results (violation of Bell's inequalities) in influential further writings which have been a part of the early-stage impetus for the rise of a new highly technical and thriving professional field of the philosophy of quantum mechanics.

D'Espagnat, B. (1982 book). *Un atome de sagesse: propos d'un physicien sur le réel voile* (An Atom of Wisdom: Writings by a Physicist on Veiled Reality). Paris: Le Seuil.

D'Espagnat, B. (1985 book). *Une incertaine réalité, le monde quantique, la connaissance et la durée* (An Uncertain Reality, the Quantum World, Knowledge and Durability). Paris: Gauthier-Villars, 1985. Published in English as *Reality and the Physicist: Knowledge, Duration and the Quantum World.* Cambridge: Cambridge University Press, 1989.

D'Espagnat, B. (1994 book). *Le réel voilé, analyse des concepts quantiques*. Paris: Fayard. Published in English as *Veiled Reality, An Analysis of Present-Day Quantum Mechanical Concepts*. Reading, Mass.: Addison-Wesley, 1995; Boulder, Col.: Westview Press, reprint 2003.

V. The Templeton Prize especially seeks to recognize intellectual vision and excellence whereby scientific discoveries are stimulated following from passion and skill to advance of learning about matters involving big questions that have a spiritual context and significance. While the laureate was not the discoverer of the violation of Bell's inequalities, his role as a vision catalyst in the development of the experimental agenda was highly significant in the transformation of a field of research from one that initially seemed purely speculative and philosophical in nature, to one that became rigorously experimental.

After the passage of almost 40 years since the 1970 Varenna International Summer School in Physics, it now appears that d'Espagnat's early and enthusiastic vision for doing experiments to confirm the phenomenon of "quantum non-locality" (QNL) has been spectacularly confirmed by results.

At the present time, these results have expanded spectacularly to include the rapidly growing field of "quantum information science", totally unimaginable in 1970. This huge breakthrough in physics has yet to be recognized by the Nobel Prize in Physics. (John Bell passed away in 1990. His death removed him from consideration.) However, it is not unlikely that in the future recognition of the profound significance of the discovery of QNL will expand both in physics and in philosophy.

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