UNIVERSITY OF NOTRE DAME
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CHARLES EDISON LECTURE SERIES

Quantum information, the ambiguity of the past, and the complexity of the present.

Charles Bennett, IBM Fellow
IBM Research

Tuesday, May 25, 2010
4:30PM - 5:30PM
Hayes-Healy 127

Abstract
Quantum theory, in particular the theory of entanglement, provides a coherent picture of the physical origin of randomness and the growth and decay of correlations, even in macroscopic systems exhibiting few traditional quantum hallmarks. It helps explain why the future is more uncertain than the past, and how correlations can become macroscopic and classical by being redundantly replicated throughout a system's environment. The most private information, exemplified by which path a particle takes through an interferometer, is not replicated, and exists only transiently: after the experiment is over no record remains anywhere in the universe of what ``happened''. At the other extreme is information that has been replicated and propagated so widely as to be infeasible to conceal and unlikely to be forgotten. Modern information technology has caused an explosion of such information, eroding privacy while making it harder for tyrants to rewrite the history of their misdeeds; and it is tempting to believe that all macroscopic information is permanent, making such cover-ups impossible in principle. But we argue, by comparing entropy flows into and out of the Earth with estimates of the planet's storage capacity, that most macroscopic classical information--for example the pattern of drops in last week's rainfall--is impermanent, eventually becoming nearly as ambiguous, from a terrestrial perspective, as the which-path information of an interferometer. Finally we discuss prerequisites for a system to accumulate and maintain in its present state, as our world does, a complex and redundant record of at least some features of its past. Not all dynamics and initial conditions lead to this behavior, and in those that do, the behavior itself tends to be temporary, with the system losing its memory as it relaxes to thermal equilibrium.

Charles Edison Lecture Series
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