## Physics of Time-Symmetry

The equations of fundamental physics, excluding some high-energy processes, are time-symmetric, being the same whether time flows forwards or backwards. One of the best-known examples are the solutions to the electromagnetic wave equation. From these equations, the usual waves of electromagnetic radiation traveling forwards in time are called "retarded waves". But there is another possible solution which travels backwards in time called "advanced waves". Of course, we never notice this phenomenon in our world. However, physicists Richard Feynman and John Wheeler developed a theory called the "Wheeler-Feynman Absorber Theory", in which radiation is treated as an interaction (or handshake) between an emitter in past time and an abosrber in future time. Interaction between advanced and retarded waves inspired the Transactional Interpretation of quantum mechanics, in which wave function collapse is interpreted as being due to an interaction of advanced and retarded waves. The Transactional Interpretation makes the same physical predictions as standard quantum mechanics.

What gives us the arrow of time which we observe in our experience of the world? Many physicists believe this is due to the Second Law of Thermodynamics, i.e., the fact that the entropy of a thermal system cannot decrease, only increase. In other words, such systems are time-irreversible. However, a coherent quantum mechanical system would not be time-irreversible since an increase in entropy would not occur.

One of the fundamental properties of quantum mechanics is "entanglement", wherein groups of entities cannot be treated as

objects with separate properties but only as a whole. For example, if a system of two particles is prepared with total spin 0 and each particle can only have spin up or spin down, if one particle is measured as having spin down, then the other must have spin up. Note that entanglement is fundamentally *non-local*, in other words, the connection is faster-than-light or equivalently (according to relativity), goes backwards in time.

Though many people make the assumption that information cannot be transferred backwards-in-time or faster-than-light using quantum entanglement, this is not strictly theoretically or experimentally justified. Indeed, there has been some work into designing an entangled system which can transmit non-local information. Such a system may be realized technologically. What about temporal paradoxes? If we think of reality forming out of interaction between past and future, then interactions which would create temporal paradoxes would never form in the first place.

What evidence exists for backwards-in-time information transfer? Technological realization has been proving difficult but work is being done in this direction. Another direction is in quantum biology, since quantum coherence has recently been unexpectedly detected in warm and wet biological systems. Has evidence of retrocausal information transfer been found in biological systems (such as humans)? Indeed, a large number of studies have accumulated that support these effects