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Generation of Entanglement Outside of the Light Cone JAMES FRANSON, University of Maryland, Baltimore County — Although it may seem counterintuitive, correlations, entanglement, and mutual information can all be generated at two distant locations in less time than it would take for light to travel between them. These effects are due to the fact that the Feynman propagator, which is proportional to the probability amplitude to emit a photon at one location and then annihilate it at another location, has nonzero values outside of the forward light cone. It should be emphasized that this does not allow messages to be transmitted faster than the speed of light, which would violate causality. These effects are illustrated by considering two distant atoms, one of which is initially in its excited state and the other in its ground state. The probability amplitude for the two atoms to exchange a photon and make a transition to the other state is calculated using perturbation theory and commutator techniques, which gives a result proportional to the Feynman propagator. These effects can be interpreted as being due to the propagation of virtual photons outside of the light cone or as a transfer of pre-existing entanglement from the quantum vacuum.

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