BLACK HOLES AND UNPREDICTABILITY

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Although gravity is the weakest interaction known to physics, it has the advantages of being long range, attractive and universal, i.e. it couples to everything in the same way. This means that in a sufficiently large body the gravitational field of all the particles add up and can dominate all other forces leading to gravitational collapse and a singularity of spacetime. A singularity is a place where space and time come to an end and all the laws of physics break down. At first it seemed that this breakdown of physics did not matter too much because the singularities would be simply hidden in black holes. According to the classical theory of general relativity, the intense gravitational field around a black hole would prevent any particles or light signals from the singularity escaping from the black hole. Thus an outside observer would not be affected by the breakdown of predictability which occurred at the singularity. However, about three years ago I discovered that black holes are not completely black: quantum effects allow particles and radiation to tunnel out of them. This radiation has an added degree of randomness over and above that normally associated with quantum mechanics.

In classical, i.e. non-quantum physics, one can definitely predict both the position and velocity of a particle. In ordinary quantum mechanics one can predict with certainty <u>either</u> the position <u>or</u> the velocity but not both. In the case of particles emitted by a black hole however, neither the position nor the velocity can be definitely predicted. All one can do is give the <u>probabilities</u> that particles will be emitted in certain modes. The reason this breakdown in predictability occurs is that information about the quantum state of the system is, like baryon number, being lost down the black hole. Equivalently one could say that new random information ia entering our universe from regions (either singularities or 'wormholes' leading to other universes) about which we have no knowledge.