A Possible Resolution of the Black Hole Information Paradox

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Abstract: Nonlocal reduction of entangled states is clarified by considering the role of background independent scale-invariant quantum impedances in decay/decoherence of unstable elementary particles, providing simple resolution of the black hole information paradox.

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1. Introduction

Decay of the unstable particles offers the possibility of informing nonlocal reduction of entangled states. Both follow from phase decoherence (with the resultant complication that phase is not an observable in state reduction). Unlike entangled states, where unitary evolution of the two (or more) body wave function requires nonlocal phase coherence, in the case of the unstable particles the essential coherence is self-coherence.

The first concerted effort to understand the role of self-coherence in the unstable particle spectrum was implicit in S-matrix theory. That program, lacking both phase and mode information, was frustrated by the failure of the bootstrap to tie together the associated Feynman diagrams, and was superseded by QCD.

String theory eventually emerged as the logical successor to the S-matrix, with the requisite fundamental length shifting from the nucleon scale to that of the Planck particle. As in the case of any quantum measurement, each dimensional reduction in string theory yields an amplitude, with the corresponding loss of phase information.

Neither string theory nor QED/QCD provides satisfactory understanding of either state reduction or nonlocality.

2. Generalized Quantum Impedances and the Model

As every circuit designer knows, impedances govern the flow of energy. This is not a theoretical musing. It is particularly pertinent in quantum theory. A novel method for calculating mechanical impedances [1], both classical and quantum, was presented earlier [2, 3]. In that work a background independent version of Mach's principle emerged from a rigorous analysis of the two body problem, permitting simple and direct calculation of these impedances.

The two body problem is innately one-dimensional, populated by string-like topologies. The mechanical impedances can be converted to the more familiar electrical impedances by adding electric charge to these string-like objects [4].

This novel tool, this method of calculating impedances, is of no use to physics without a model to which it may be applied. The model adopted earlier [3–5] remains useful. It comprises

- quantization of electric and magnetic flux, charge, and dipole moment
- interactions between those three topologies - flux quantum, monopole, and dipole
- confinement of those quanta to a fundamental length, taken to be the Compton wavelength of the electron
- the photon

Calculated coupling impedances [3] of the interactions are shown in figure 1. The role of the resulting impedance network, the 'scattering matrix', in the phenomenology of the unstable particles was discussed in detail earlier [3–5].

3. Entanglement and State Reduction

Special relativity requires that no energy is transferred in the nonlocal collapse of entangled wavefunctions, that no work is done, no information communicated. In the family of quantum impedances those which are scale invariant, the Lorentz and centrifugal impedances (operative in the quantum Hall effect) satisfy this requirement.

The centrifugal force is in some sense a mechanical equivalent of the vector Lorentz force. Like the Lorentz force, it is perpendicular to the direction of motion, and hence can do no work. The centrifugal impedance is numerically equal to the scale invariant quantum Hall impedance, and is plotted in the figure (green dots). Either or both of these

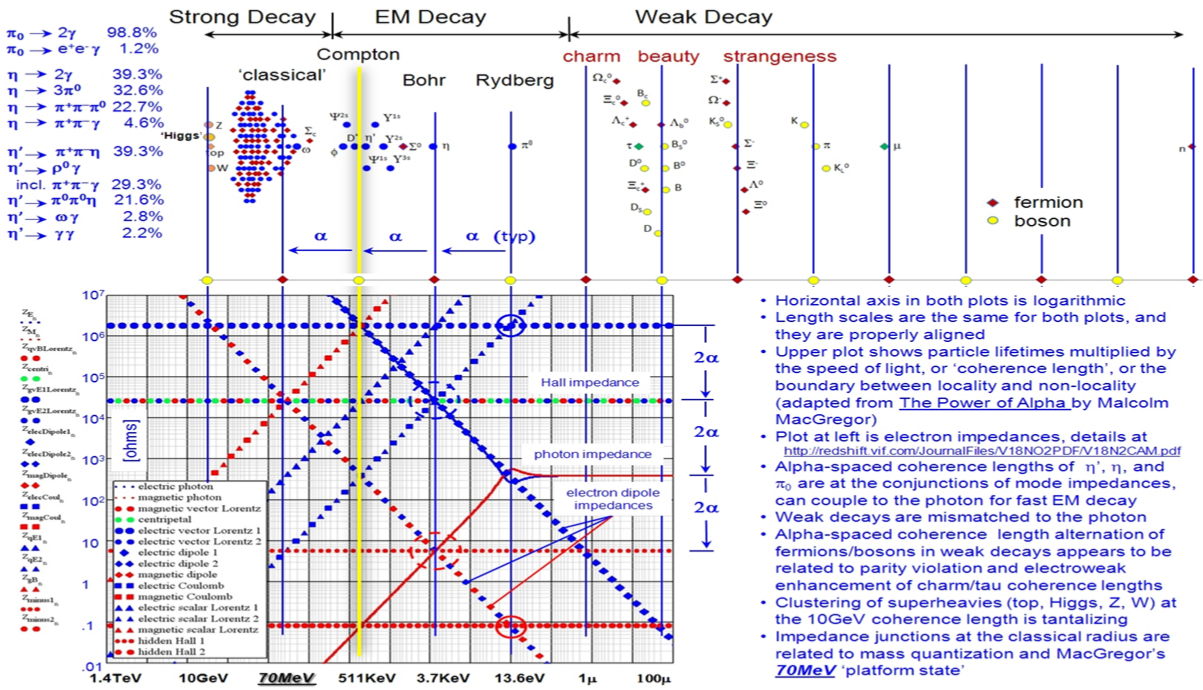

Fig. 1. Composite of 13.6eV photon [6] and background independent electron impedances [3], measured π_0, η, and η' branching ratios, and unstable particle coherence lengths [7].

two impedances might serve as the mechanism of nonlocal reduction of entangled states. From here it is a small step to collapse of the self-coherent wave function, via the Lorentz and centrifugal impedances of the Aharanov-Bohm effect.

4. The Black Hole Information Paradox

An earlier note [8] calculated the impedance mismatch between the electron and the Planck particle. This mismatch is precisely equal to the ratio of the gravitational and electromagnetic forces between these two particles, indicating that the quantum impedance approach is valid at the event horizon, and perhaps beyond, to the singularity (which is completely decoupled by the infinitely large impedance mismatch at the dimensionless 'point').

As regards the paradox, if the scale invariant impedances are valid at the event horizon and responsible for nonlocal state reduction, and the holographic principle applies, then the paradox is removed.

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