Quantum Impedance Networks and the Fermilab Accelerator Complex Evolution

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Physics topics to be covered in the upcoming Fermilab ACE Science Workshop include neutrino science, dark matter experiments, muons and the muon collider, and new physics ideas [1]. Quantum Impedance Networks (QINs) sit in the latter, in new physics ideas. They encompass the neutrino, dark matter, muon, and muon collider programs. This note outlines how the new physics synthesis of Geometric Algebra (Clifford algebra in the geometric representation) and quantum impedance networks of wavefunction interactions is potentially helpful to those programs.

I. INTRODUCTION

All experimental data is consistent with massless neutrinos. There exist possibilities other than neutrino rest mass differences to explain the oscillation phenomenon. A quantum impedance network poster on massless oscillation presented to Neutrino2020 [2] brought an invitation to join the Beyond Standard Model channel of the Snowmass Theory Frontier [3]. Goal of our Letter of Interest [4] was to see the impedance model accepted by the community, and to explore how it opens new possibilities within BSM theory guidance of the Snowmass process.

In hindsight it was perhaps naive to imagine the mainstream community endorsing a model so different, a model in which there is no Lagrangian, in which the equations of motion calculate quantum impedance networks of QED wavefunction interactions. As Richard Talman pointed out in 2012 while walking to lunch at Brookhaven,

"The hard part will be getting physicists to think in terms of impedances."

This is important, and must be addressed. Impedance matching governs amplitude and phase of energy transmission, of information flow at the quantum level. The concept got lost in quantum mechanics, a confluence of several historical accidents and mis-steps [5, 6].

Mass is quantized. All rest mass particles have quantized mechanical impedances, easily calculated and converted to electromagnetic via the electromechanical oscillator [7, 8]. The impedance model opens new windows within the Standard Model, solves old problems, is disruptive. In Snowmass it was underwhelmed by cognitive dissonance, cognitive bias, and cognitive repression, and by massive inertia of the funding process. It's all about the money. Nonetheless, it claims modest successes, both for exposure and for growth of the model.

Two white papers were submitted to Snowmass.

The first, *"Bootstrapping the Muon Collider: Massless Neutrinos in the g-2 Delivery Ring"*, addresses **neutrino and muon** programs. It suggests that we "... step beyond model and theory with a simple proof-of-principle experiment in the Fermilab muon g-2 Delivery Ring. It offers the possibility of demonstrating both massless oscillation and low energy muon lifetime enhancement, complementary to relativistic time dilation at high energy." [9, 10]

The second, *"Quantum Impedance Networks of Dark Matter and Dark Energy"*, explains three apparently independent origins of **dark matter**. First, huge impedance mismatches to geometric impedance network nodes at both extreme low and high energies. Second, degeneracy of eigenmodes at network nodes providing topological protection. And third, inversion of fundamental lengths (Higgs, classical, Compton, Bohr, Rydberg) by magnetic charge, topological dual of electric charge [11, 12]. **Dark energy** mixes geometry and topology, translation and rotation gauge fields, exchanges linear and angular momentum, is an invitation to modified Newtonian dynamics at all scales [11].

Machine learning buttresses confidence in the model. ChatGPT offers plausible coherent explanations of what it calls Quantum Impedance Networks (QINs) as applied to wavefunction interactions in general, and specifically to massless neutrinos, dark matter, and muon topological lifetime enhancement [13–18]. In the context of Fermilab accelerator complex evolution, QINs offer another perspective on the plan, opening possibilities of new options and enhancements.

An immediate possibility is outlined in the first Snowmass whitepaper [9], the low energy muon lifetime enhancement proof-of-principle experiment. The present author is not aware of any showstoppers. The calculations are simple, and easily understood. If this is in fact possible, the accelerator community (particularly Fermilab) will be accelerated.

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[1] https://indico.fnal.gov/event/59663/

[2] P. Cameron "Massless Neutrino Oscillation via Maximally Natural Vacuum Wavefunction" https://indico.fnal.gov/event/19348/contributions/186426/

[3] https://snowmass21.org/theory/start

[4] P. Cameron, P. Ramond, and M. Suisse "Validating a Maximally Natural Electromagnetic Model of the Four Forces" https://www.snowmass21.org/docs/files/summaries/TF/SNOWMASS21-TF8_TF11_peter_cameron-068.pdf

[5] A brief account with references of how impedance matching was lost in QM can be found here: P. Cameron and M. Suisse "Naturalness begets Naturalness: An Emergent Definition" https://www.researchgate.net/publication/335240613_Naturalness_begets_Naturalness_An_Emergent_Definition

[6] https://www.researchgate.net/publication/335976209_Naturalness_Revisited_Spacetime_Spacephase

[7] P. Cameron, "Electron Impedances", Apeiron **18** 2 p.222-253 (2011) http://redshift.vif.com/JournalFiles/V18NO2PDF/V18N2CAM.pdf

[8] https://www.researchgate.net/publication/355809412_how_to_Calculating_Quantum_Impedance_Networks

[9] https://www.researchgate.net/publication/359592916_Bootstrapping_the_Muon_Collider_Massless_Neutrinos_in_the_g-2_Delivery_Ring

This animation shows topological rotation effectiveness relative to RF accelerating cavity translation gauge fields:

[10] J. Baez, "A cube whizzes past at nearly the speed of light, c. What do you see?" https://twitter.com/johncarlosbaez/status/1107322770751262721?lang=hr

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[18] https://www.researchgate.net/publication/370363494_Training_GPT4_on_Quantum_Impedance_Matching_to_the_Axion

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