

# The Stueckelberg Off-Mass Shell Model for Particle Interaction as Template for New Insight into Hidden Dimensions of Time and Mass

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**Abstract:** Time, space, energy and mass form the four-fold conceptual basis for gauging physical reality. Through a reappraisal of the manifest covariant Stueckelberg off-mass shell model and its recent key extension by Horwitz and Piron, this paper will seek to reveal fresh important perspectives on the four yardsticks of physical reality alluded to above, as they are applied in both classical and quantum mechanics. In particular, it will be demonstrated how the conceptual foundations of these branches of *causal linear* physics can be formulated under the off-mass shell ansatz to disclose the common structural edifice of a time-symmetric (*acausal*) mechanics that is fueled by the primordial dynamic *non-linear* multidimensional quantum engine which underpins the extant *causal* wheelwork of nature. In this regard, it will be shown how the recently discovered phenomenon designated as “entanglement in time” can only be adequately explicated via the off-mass shell model, and is beyond the scope of current standard on-shell models of non-relativistic quantum field theory. The off-mass shell model will also be shown to possibly provide satisfying conceptual reasons for documented empirical phenomena currently beyond the reach of orthodox paradigms, such as low-energy nuclear reactions (LENR), and reveals new perspectives on gravitation as well, supporting the revolutionary worldview of the possible non-singular nature of the “black hole” entity, and the associated revelation of general relativity as being an approximation of a more over-arching eikonal gravitational equation of quantum nature. Experimental tests will be advanced to test the off-mass hypothesis with the unprecedented aim of placing various poorly understood phenomena in particle physics squarely in the arena of the manifest covariant Stueckelberg theory. These include neutrino flavor oscillations, K-meson interactions, new insight into tachyon/bradyon dynamics, and a new high-temperature Bose-Einstein condensate (BEC) which is predicted to exist. This last is most important since in a more direct practical sense, it might herald the development of future technology that incorporates the BEC as an integral operating component in the first hybrid matter/non-matter energy-efficient mechanical, optical and electrical systems, implying novel engineering protocols amenable to all the tools of non-linear and quantum optics.