

# MEASUREMENT TECHNIQUES

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## FUNDAMENTAL PROBLEMS IN METROLOGY

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The standard model (SM) is a gauge quantum theory of fundamental physical interactions: strong, electromagnetic, and weak. It includes quantum chromodynamics (QCD), quantum electrodynamics (QED), and weak interaction theory (WIT). In the latter two combined in a unified gauge electroweak interaction theory (EWIT, the Glashow, Weinberg, Salam theory). In this theory, the terms related to the interactions are introduced into the Lagrangian in a minimal fashion on the basis of the  $SU(3) \times U(2) \times U(1)$  local gauge symmetry group. A characteristic feature is that the coupling constant is dependent on the vector of momentum, which in turn is determined by the energies of the interacting particles. That dependence on the energy scale leads to the term "coupling constant" being arbitrary. That terminological inadequacy is increased when it is considered that the dependence of the coupling constants over intervals considerably greater than the characteristic ones of the processes is perfect; nonetheless, the term "constant" is employed in quotation marks or replaced by the term parameter.

Within the SM framework, values have been calculated for a large number of physical-process characteristics, and many of these theoretical results have now been confirmed by experiment. In spite of the impressive success, it is likely that the standard model is a passing one on the path to the creation of a more perfect and comprehensive theory. One factor indicating this is the considerable number of SM constants, along with the absence in the theory itself of any explanation for the existing values for the constants and the possible relations between them. Also, experimental data have been produced confirming the need to deviate from the SM framework such as the discovery of neutrino oscillations or nonzero neutrino masses [1], or the observation of new physical substances: dark matter and dark energy [2]. These circumstances in particular indicate the need to expand SM by including gravitation and massive neutrinos. Even in the framework of the existing theory of strong, electromagnetic, and weak interactions there are unresolved problems: the experimental confirmation of the existence of the Higgs boson, spontaneous violation of chiral symmetry, and the confinement of quarks and gluons [3].

We enumerate the SM constants, including those for the extended neutrino sector and the gravitational constant  $G$  (Table 1–6). These are particularly the coupling constants for the strong, electromagnetic, and weak interactions:  $\alpha_s$ ,  $\alpha_e$ , and  $\alpha_w$ .