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Constructing Massive Vector Amplitudes from Consistency Conditions

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Based on the general principles of Lorentz symmetry and unitarity, we introduce two consistency conditions – on-shell gauge symmetry and strong massive-massless continuation – in constructing amplitudes of massive gauge theory with elementary particles. In particular we argue that on-shell gauge symmetry can be understood as a consequence of Lorentz symmetry, unitarity and massive-massless continuation. Based on these two conditions, combined with the little group transformation and consistent factorization, we construct 3-point and 4-point vector-boson/scalar amplitudes that correspond to renormalizable interactions, then analyze the underlying theories and models. Given the particle masses, almost all possible vertices, including those involving Goldstone modes, are uniquely fixed. The only exceptions are triple and quartic scalar self-couplings. In addition, all particle masses must have the same physical origin. If the number of vector bosons is smaller than 3, the underlying theories for the amplitudes are either massive gauge theories with spontaneous symmetry breaking (S.S.B.) or Stueckelberg theory. The necessary condition for the latter is that the scalars have equal masses. We also discuss different models depending on the number of scalars involved. If the number of vector bosons is larger than 3, the underlying theory must be Yang-Mills theory with S.S.B. In both Abelian and non-Abelian cases, the specific shape of the Higgs potential cannot be determined, which explains the fact that scalar self-couplings are undetermined, and the relations between the masses are generally nonlinear.

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