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Asymptotic Expansions in Limits of Large Momenta and Masses

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Abstract. Asymptotic expansions of renormalized Feynman amplitudes in limits of large momenta and/or masses are proved. The corresponding asymptotic operator expansions for the S-matrix, composite operators and their time-ordered products are presented. Coefficient functions of these expansions are homogeneous within a regularization of dimensional or analytic type. Furthermore, they are explicitly expressed in terms of renormalized Feynman amplitudes (at the diagrammatic level) and certain Green functions (at the operator level).

1. Introduction

Thirty years ago Weinberg described the leading large momentum behavior of Feynman amplitudes [44]. Logarithmic corrections were characterized by Fink [20], and Slavnov [32] proved that the large momentum asymptotic expansions are always performed in powers and logarithms of the expansion parameter. Recently Hurd applied the three expansion renormalization method (see [24] and references therein) and analyzed the large momentum asymptotic behavior in the coordinate-space language in terms of short-distance expansion of Feynman amplitudes $G_\Gamma(x_1, x_2, \ldots)$ at $x_1 \to x_2$.

In papers [4–6, 18, 25, 30] asymptotic expansions in various large momentum limits were obtained. A typical result is the expansion of a Feynman integral

$$F_\Gamma(\underline{Q}/\varrho, \underline{q}) \overset{\varrho \to 0}{\sim} \sum_{k,l} C_{k,l} \varrho^k \ln^l \varrho\,, \tag{1.1}$$

where $\underline{Q}(\underline{q})$ are large (small) momenta. However the coefficient functions $C_{k,l}$ in these papers are rather cumbersome. For instance, they are expressed in terms of numerous parametric integrals [4] or in terms of Mellin integrals [5, 6, 18, 25, 30]. At least, they are not naturally associated with renormalized and/or regularized Feynman amplitudes.