Nature of logarithmic divergence in one loop lattice Feynman integrals

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We introduce a new approach to evaluating logarithmically divergent one-loop lattice Feynman integrals and use it to rigorously prove, under mild general conditions, that these always have the following expected and crucial structure:

\[ I(p, m, a) = f(p, m) \log(a\mu) + g(p, m, \mu) \]

up to terms which vanish for lattice spacing \( a \rightarrow 0 \). Here \( p \) and \( m \) denote collectively the external momenta and masses, and \( \mu \) is an arbitrarily chosen mass scale. The factor \( f(p, m) \) is shown to coincide with the analogous factor in the corresponding continuum integral when the latter is regularized either by momentum cut-off or dimensional regularization. This is essential in order for the one-loop lattice QCD beta-function to coincide with the continuum one.