Bubble integrals

The definition of the bubble integral is as follows

\[ I_2^{(D)}(q^2; m_1^2, m_2^2) = \frac{\mu^{4-D}}{i\pi^{D/2} r_\Gamma} \int d^D l \frac{\Gamma}{(l^2 - m_1^2 + i\varepsilon)((l + q)^2 - m_2^2 + i\varepsilon)} \]

\( \mu \) is a scale introduced so that the integrals preserve their natural dimensions, despite excursions away from \( D = 4 \).

Using Feynman parameters the integral becomes

\[ I_2^{(D=4-2\epsilon)}(q^2; m_1^2, m_2^2) = \mu^{2\epsilon} \frac{\Gamma(\epsilon)}{r_\Gamma} \int_0^1 da \left[ -a(1 - a)q^2 + am_2^2 + (1 - a)m_1^2 - i\varepsilon \right]^{-\epsilon} \]

\[ = \mu^{2\epsilon} \left[ \frac{1}{\epsilon} - \int_0^1 da \ln \left( -a(1 - a)q^2 + am_2^2 + (1 - a)m_1^2 - i\varepsilon \right) \right] + O(\epsilon) \]

The full results for the general integral \( I_2^{(D=4-2\epsilon)}(s; m_1^2, m_2^2) \) and some special cases are given.

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