Let's consider further the physical significance of the 4th order correction to ABC Theory. We begin by writing the full transition amplitude to 4th order, meaning we have to include both the 2nd and 4th order terms.

$$S_{fi} = (-ig)^2 (2\pi)^4 \delta^4(p_A' + p_B' - p_A - p_B) \left[\frac{i}{q^2 - m_c^2} + \frac{i}{q^2 - m_c^2} \left(-i \Pi_c^{[2]}(q^2)\right) \frac{i}{q^2 - m_c^2} \right]$$

From here we could plausibly add more bubbles ad infinitum. It then becomes an infinite geometric series.

$$S_{fi} = (-ig)^2 (2\pi)^4 \delta^4(p_A' + p_B' - p_A - p_B) \left[\frac{i}{q^2 - m_c^2} (1 + r + r^2 + \cdots) \right]$$

$$r \equiv \frac{\Pi_c^{[2]}(q^2)}{q^2 - m_c^2}$$

$$\Rightarrow S_{fi} = (-ig)^2 (2\pi)^4 \delta^4(p_A' + p_B' - p_A - p_B) \left[\frac{i}{q^2 - m_c^2} \cdot \frac{1}{1 - \frac{\Pi_c^{[2]}(q^2)}{q^2 - m_c^2}} \right]$$

$$\Rightarrow S_{fi} = (-ig)^2 (2\pi)^4 \delta^4(p_A' + p_B' - p_A - p_B) \left[\frac{i}{q^2 - m_c^2 - \Pi_c^{[2]}(q^2)} \right]$$

IMPORTANT: The geometric series only converges for $r < 1$, but $\Pi_c^{[2]}(q^2)$ diverges! This anticipates the renormalization technique still to be discussed.

Recall that free particles are subject to the mass-shell condition. That is, for the 4-vector q

$$q^2 = m^2.$$

Virtual particles, internal lines in Feynman diagrams, exist for short enough time periods to have off-shell energies allowed by the Uncertainty Principle.

In the vacuum, a particle must be assumed to be constantly undergoing these loop interactions. As loop processes are virtual, they cannot be detected directly; they also cannot be turned off. So the physically detectable mass of a particle is not the m_i parameter from the Lagrangian. Rather, we see in the denominator of S_{fi} above that the physically detected "mass" is actually defined by

$$q^2 - m_i^2 - \Pi_i(q^2) = 0.$$

$$\text{"physical mass"} \equiv m_i^2 + \Pi_i(q^2)$$