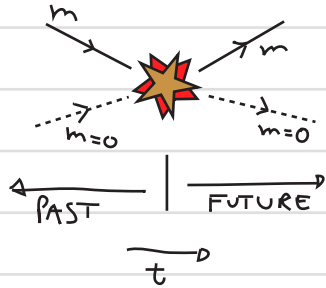**1**   Read section 5.1 of M. Schwartz book on QFT (where he also gets expressions for cross-sections and decay widths following a different logic to Peskin's - which we followed)

2   Consider the following $2 \rightarrow 2$ scattering:

where a massless particle scatters off a massive one (of mass m). Suppose you know the interaction behind it, and it gives you:

$$i\mathcal{M} = i\lambda \qquad\qquad \lambda \in \mathbb{R}$$

calculate the total cross section σ (the answer should be given in terms of λ and E_{CM})

3   The following Lagrangian:

$$\mathcal{L} = \frac{1}{2}\left(\partial_\mu \phi\right)^2 + \frac{1}{2}\left(\partial_\mu \varphi\right)^2 - \frac{1}{2}M^2\phi^2 - \frac{1}{2}m^2\varphi^2 - \nu\,\phi\,\varphi\,\varphi \qquad (M, m, \nu \in \mathbb{R})$$

Describes a system with two real fields, whose excitations are particles with masses m (for field φ) and M (for ϕ). The model also allows ϕ-particle to decay into two φ-particles, depending on the relation between M and m. Assuming:

$$|\mathcal{M}(\phi \rightarrow \varphi\varphi)| = \nu$$

(a) Obtain the lifetime of ϕ

(b) Notice what happens when $M \rightarrow 2m$ $(M > 2m)$