A New Perspective on the Higgs Mass Unitarity Bound

Self-Healing

- A phenomenon recently described (2012) by Donoghue et al. in Chiral Perturbation Theory (CPT) and Effective Field Theory for Quantum Gravity.

- The idea that “apparent unitarity violation must be solved within the effective field theory without recourse to the new degrees of freedom” (Donoghue et al.)

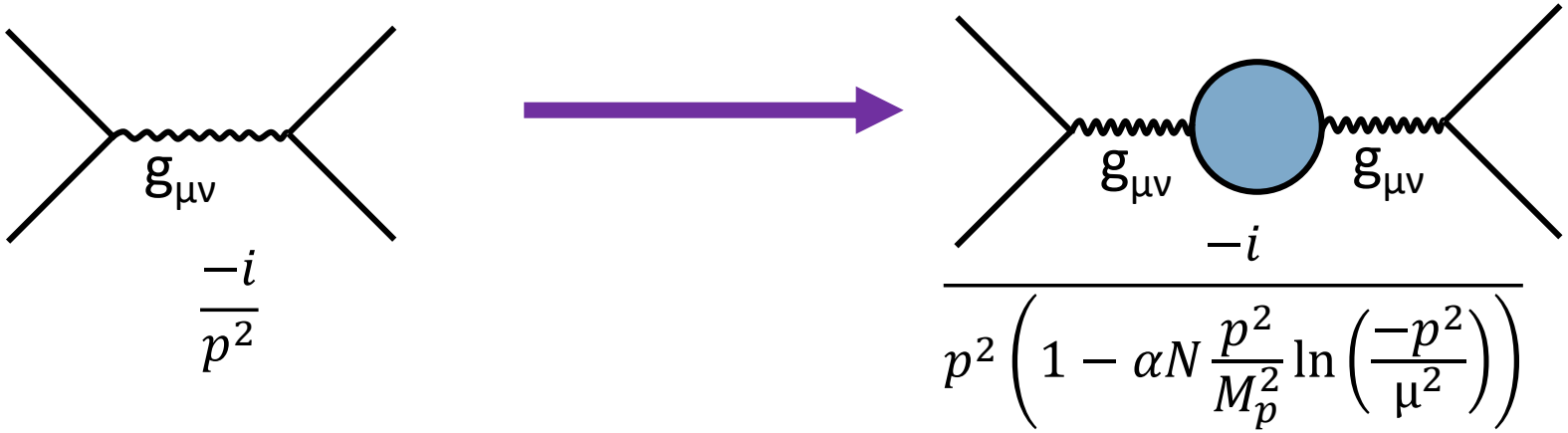
- In practice: self-healing implies resumming infinite series in perturbative expansions, a way which removes unitarity violation and energy growth of scattering amplitudes.

Motivating Questions & Purpose

- Is self-healing a general phenomenon of QFT's?
  - How may the phenomenon be realized in general QFT's?
- Is self-healing related to unitarity bounds?
  - Will self-healing techniques affect unitarity bounds?
- Purpose:
  - Try and realize self-healing in Electroweak interactions
  - What effect self-healing has on the Higgs mass unitarity bound
  - Gain a deeper understanding of the phenomenon and its relationship to QFT's

Realization of Self-Healing in EFT for QG

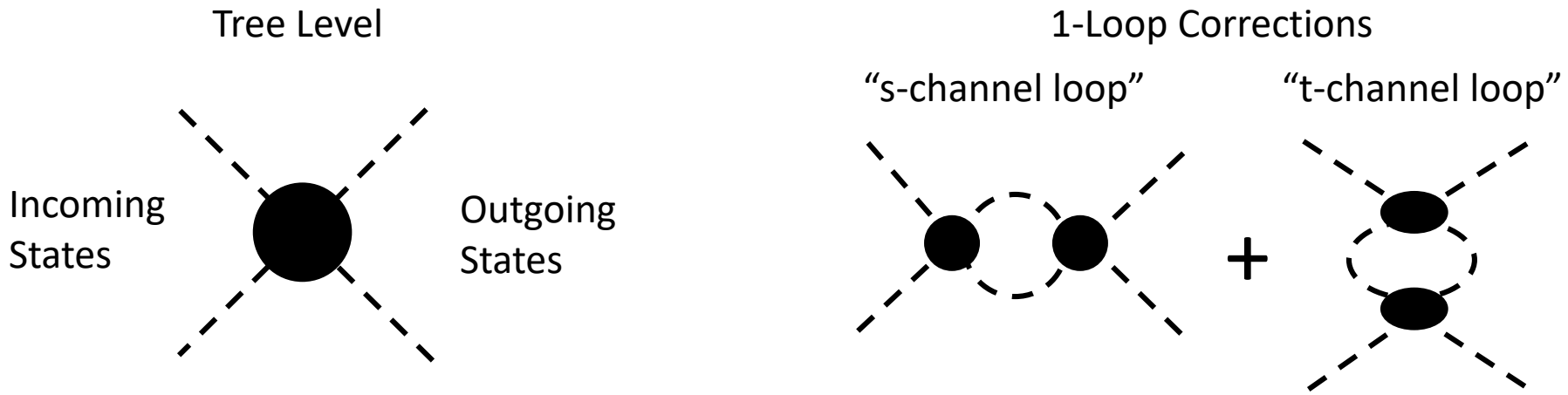
- Superposition of N particles (scalars, fermions, and vector bosons) incoming and outgoing
- Self-healing identified by Donoghue et al. as the resummation of the graviton propagator



- Modifies the energy growth of scattering amplitude from: E^2 to $1/\ln E$
- Modifies propagator from quadratic to quartic

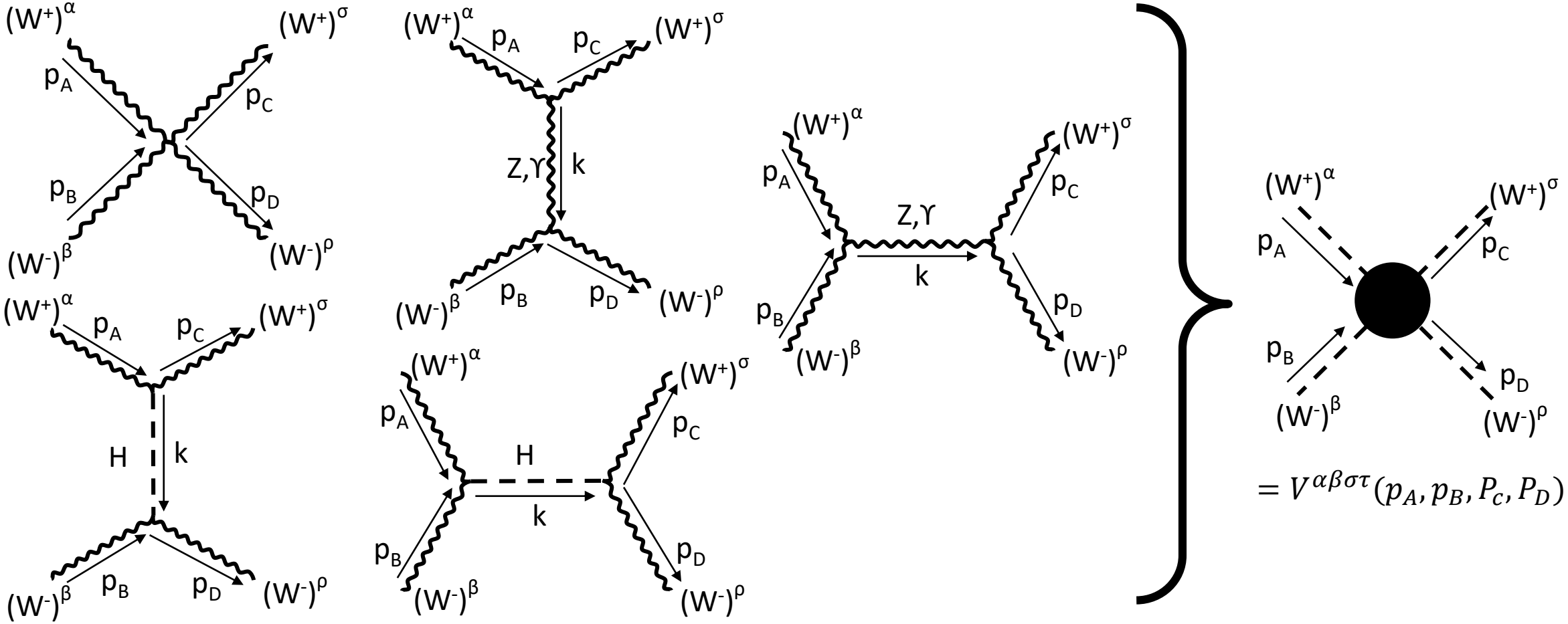
Realization of Self-Healing Effects

- Interpret self-healing as overall suppression of total scattering amplitudes
- Define a “scattering event” as the sum over various interaction types, i.e. an induced vertex function:



- Method reduces to propagator resummation for case considered in QG
- Behaviour of 1-loop corrections determines whether self-healing may occur

The W-Boson Scattering Event



Realizing Self-Healing in W-Scattering

- The self-healing phenomena may be realized for W-scattering by the following method:
  - Combine all possible tree-level processes into one scattering event
  - Resum the effects of all loops on this scattering event (i.e. loop corrections to induced vertex function)
  - Contract resultant “self-healed vertex function” with polarization tensors

- The “self-healed amplitude” for W-scattering becomes

$$\mathrm{M}_{SH} = \frac{-4\lambda}{1-5\frac{\lambda}{(4\pi)^2}\left[\ln\left(\frac{-s}{\mu^2}\right)+\ln\left(\frac{-t}{\mu^2}\right)\right]}\text{; for } |s|, |t| \gg m_H^2$$

  - Similar to the renormalized Higgs self-coupling
  - Returns the Higgs mass unitarity bound

Results and Conclusion of Thesis

- Self-healing may be realized in EW scattering amplitudes, and indeed all scattering amplitudes, for which the total scattering amplitude M, satisfies:
  - $Lim_{E\to\infty}\left|\frac{M_{tree}^2}{M_{1-loop}-M_{tree}}\right| < 1$
  - There exists a domain for which $\left|\frac{M_{1-loop}-M_{tree}}{M_{tree}}\right| < 1$

- The Higgs mass unitarity bound is the limit of self-healing for W-boson scattering

- Induced vertex functions useful for describing the self-healing phenomenon

The End