Two-loop Electroweak Logarithms

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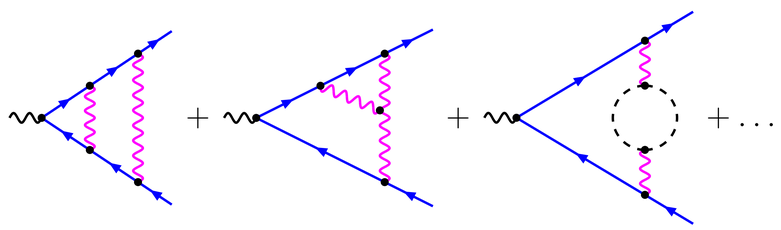
Electroweak precision physics at high energies

- experimentally up to now at energies $\sqrt{s} \sim M_{W,Z}$
- LHC & ILC $\rightsquigarrow$ new energy domain $\sqrt{s} \sim$ TeV $\gg M_{W,Z}$
  $\Rightarrow$ large logarithms $\ln(s/M_{W,Z}^2)$ in virtual corrections
- 2-loop corrections $\sim 1\% \rightarrow$ important for LHC & ILC

Vector form factor F

$\hookrightarrow$ fermion scattering amplitude in an external Abelian field

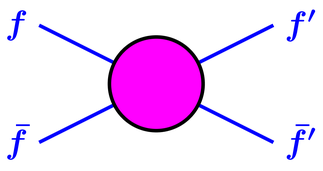
2-loop corrections with weak gauge bosons and Higgs:



$$F^{(2)} = \frac{9}{32}\ln^4 + \frac{5}{48}\ln^3 + \left(\frac{7}{8}\pi^2 - \frac{691}{48}\right)\ln^2 \quad \textbf{agreement with [3]}$$

$$+ \left(\frac{13}{2}\sqrt{3}\,\mathrm{Cl}_2\left(\frac{\pi}{3}\right) + \frac{15}{4}\sqrt{3}\pi - \frac{61}{2}\zeta_3 - \frac{11}{24}\pi^2 + \frac{167}{4}\right)\ln \quad \textbf{new result}$$

Four-fermion scattering $f\bar{f} \rightarrow f'\bar{f}'$



$$\mathcal{A} \sim F^2\,\tilde{\mathcal{A}}$$

High energy limit: $s, |t|, |u| \gg M_{W,Z}^2$

- leading logarithms $\rightarrow$ form factor F^2
- reduced amplitude $\tilde{\mathcal{A}}$ can be extracted from massless QCD calculations

Two-loop SU(2) cross section

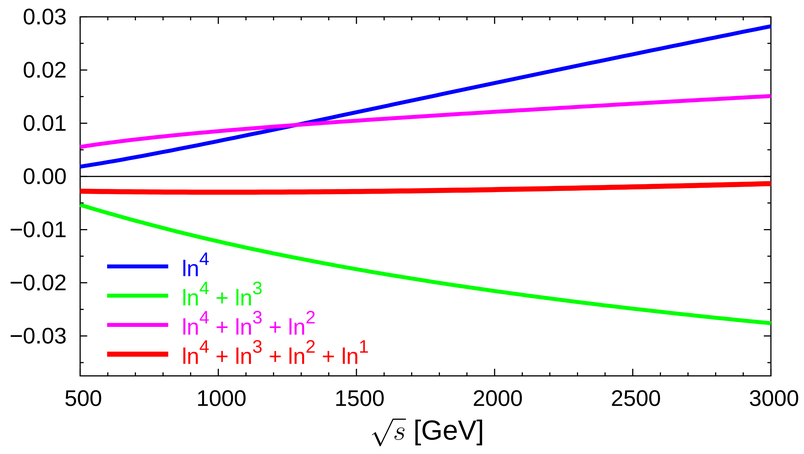
$$\sigma^{(2)} = \frac{9}{2}\ln^4 - \frac{449}{6}\ln^3 + \left(\frac{37}{3}\pi^2 + \frac{4855}{18}\right)\ln^2 \quad \text{for f \& f' of the same isospin}$$

$$+ \left(26\sqrt{3}\,\mathrm{Cl}_2\left(\frac{\pi}{3}\right) + 15\sqrt{3}\pi - 122\zeta_3 + \frac{1571}{18}\pi^2 + \frac{34441}{216}\right)\ln$$

Electroweak cross sections

- heavy W and Z bosons $\leftrightarrow$ massless photon $M_\gamma = 0$:
  1. evaluate all corrections with equal masses $M_\gamma = M_W = M_Z = M$
  2. factorize QED corrections with $M_\gamma = M$
- $M_Z \neq M_W$: expansion around $M_Z \approx M_W$

Example: $\sigma^{(2)}(e^-e^+ \rightarrow \mu^-\mu^+) = 1.42\ln^4 - 20.33\ln^3 + 112.57\ln^2 - 314.05\ln$



References

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1) B. Feucht has changed his name to B. Jantzen.