Renormalon subtraction and precision QCD

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Research Goal : Precision QCD prediction using pert. QCD → helps precision physics (ILC, HL-LHC,⋯)

🔑 OPE : factorization of UV(pert.) and IR(non-pert.) contributions of observable

Observable $A = \sum_i C_i(\alpha_s)\langle \mathcal{O}_i \rangle$ → The most use of pert. QCD calculation

💀 Renormalon problem : C_i has inevitable ambiguity δC_i (pert. is affected by non-pert.)

⟶ Pert. QCD is useless??

Our strategy : Renormalon subtraction in the framework of OPE

RF : Renormalon Free

$$A = C_0 + C_1\langle \mathcal{O}_1 \rangle + \cdots$$

$$C_0 = C_0^{\mathrm{RF}} + \delta C_0$$

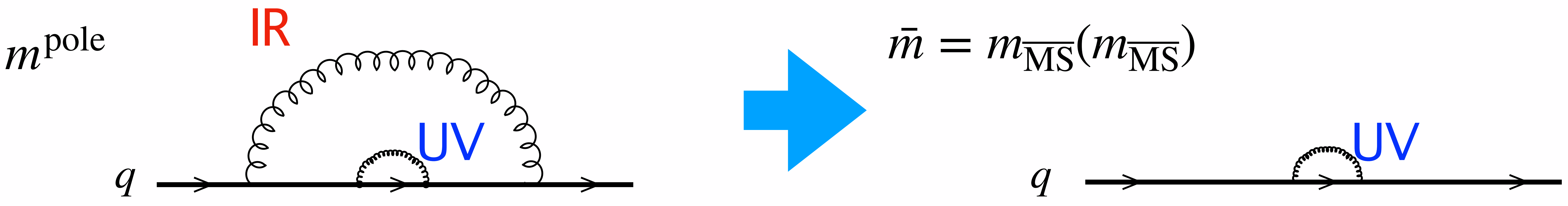
⟶ absorb δC_0 into $\langle \mathcal{O}_1 \rangle$

$$A = C_0^{\mathrm{RF}} + C_1 \langle \mathcal{O}_1 \rangle^{\mathrm{RF}} + \cdots$$

: precise prediction

Recent status of my research

◆ Renormalon subtraction of $m_{\rm pole}(\bar{m})$ in large-β_0 approx. YH, Sumino (2019)



◆ Formulation of generalized renormalon subtraction method

YH's master thesis (2020)

Applicable to a wide class of observables

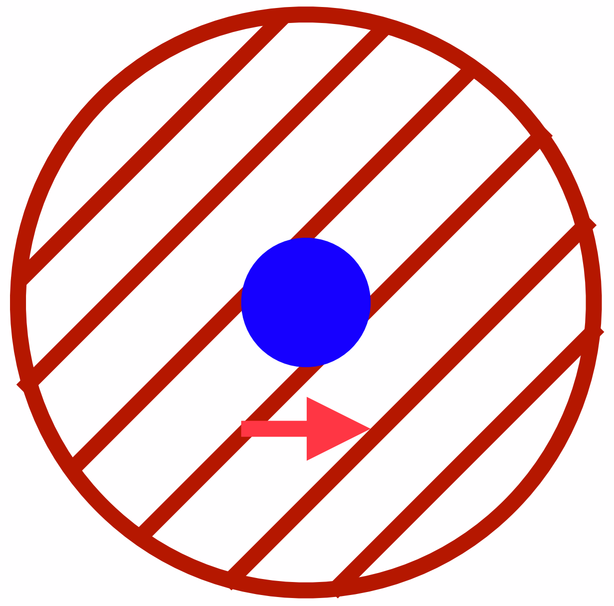
NEW ◆ Application of generalized renormalon subtraction method

YH, Sumino, Takaura (in prep.)

Observables : Adler function, B (D) meson mass, Decay width of B meson

Application : B (D) meson mass $M_H\,(H = B, D)$

$H = B, D$



OPE of M_H : (HQET)

$$M_H = m_{\text{pole}}^{\text{PT}}(\bar{m}) + \bar{\Lambda} + \frac{\mu_\pi^2}{2m_{\text{pole}}} + \cdots$$

renormalons

absorb

$$= m_{\text{pole}}^{\text{RF}}(\bar{m}) + \delta m_1 + \frac{\delta m_2}{\bar{m}} + \bar{\Lambda} + \frac{\mu_\pi^2}{2m_{\text{pole}}^{\text{RF}}} + \cdots$$

absorb

$$= m_{\text{pole}}^{\text{RF}}(\bar{m}) + \bar{\Lambda}^{\text{RF}} + \frac{\mu_\pi^{2,\text{RF}}}{2m_{\text{pole}}^{\text{RF}}} + \cdots$$

$\bar{\Lambda}$: light degrees of freedom of meson $\sim \mathcal{O}(\Lambda_{\text{QCD}})$

μ_π^2 : kinetic energy of b quark $\sim \mathcal{O}(\Lambda_{\text{QCD}}^2)$

$m_{\text{pole}}^{\text{RF}}(\bar{m})$: convergent series

$\bar{\Lambda}^{\text{RF}}, \mu_\pi^{2,\text{RF}}$: less ambiguous prediction

5-loop calculation achieve the NEXT precision of flavor physics

Research plan during GPPU curriculum

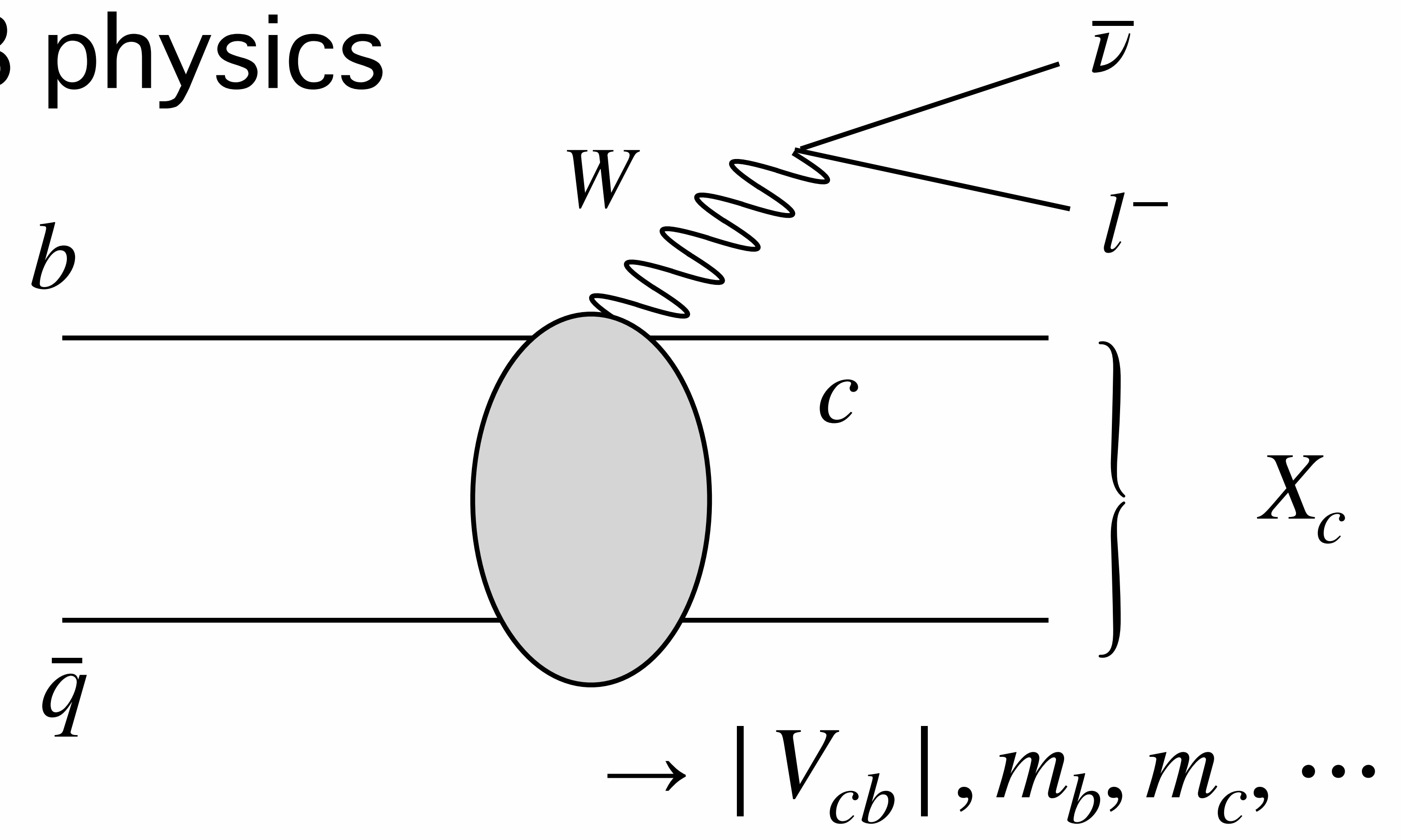
- Renormalon subtraction method

  : consistency checks, examinations

- Precise determination of fundamental parameters

  : $|V_{cb}|, m_b, m_c,$ non-pert. matrix elements

e.g. B physics



: could be useful for ILC physics

Overseas Training (online)

- 2,3-loop calculation of $q\bar{q} \rightarrow \gamma$ (done for 30 days)

  Supervised by M. Steinhauser (KIT)

- Practice of 4-loop calculation (future training plan)

Award and Grant

- 東北大学物理学専攻賞
- 学振DC2 (2021/4~)