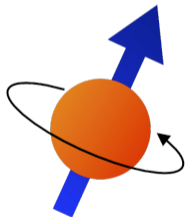


# Status and plans for analytic HLbL section



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# Bohr-Pauli and the tippe top



LUND  
UNIVERSITY

Analytic HLbL

Johan Bijnens

Introduction

HLbL

Planned  
chapters

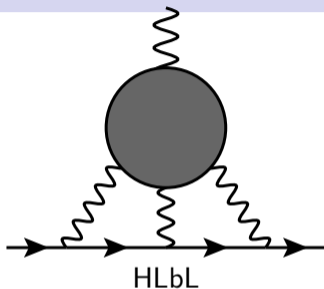


Niels Bohr, Wolfgang Pauli  
Inauguration of the new  
physics building in Lund 1951



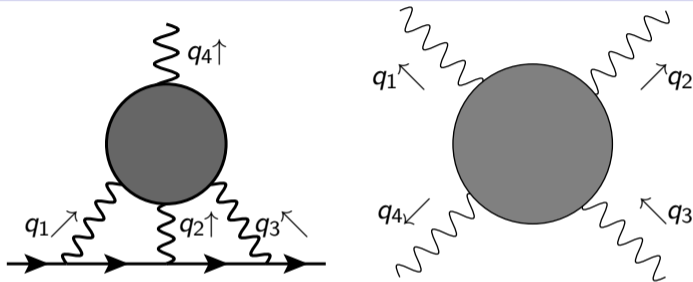
[https://en.wikipedia.org/wiki/Tippe\\_top](https://en.wikipedia.org/wiki/Tippe_top)

# Hadronic contributions



- Muon and photon lines, representative diagram
- The blobs are hadronic contributions
- There are higher order contributions of this type as well: known accurately enough

# HLbL: Hadronic light-by-light



- $=\Pi^{\mu\nu\lambda\sigma}(q_1, q_2, q_3)$  of four vector currents
- 6 variables
- Actually we really need  $\left. \frac{\delta\Pi^{\mu\nu\lambda\sigma}(q_1, q_2, q_3)}{\delta q_{4\rho}} \right|_{q_4=0}$
- Mixed:  $q_4$  at zero,  $q_1^2, q_2^2, q_3^2$  so three-variables, or  $Q_1^2, Q_2^2, Q_3^2$  ( $q_i^2 = -Q_i^2$ )
- Models, Dispersive methods, Lattice QCD

- “Long distance”: under good control
  - Dispersive method: Berne group around G. Colangelo
  - $\pi^0$  (and  $\eta, \eta'$ ) pole:  $93.8(4.0) \cdot 10^{-11}$
  - Pion and kaon box (pure):  $-16.4(2) \cdot 10^{-11}$
  - $\pi\pi$ -rescattering (include scalars below 1 GeV):  $-8(1) \cdot 10^{-11}$
- Charm (beauty, top) loop:  $3(1) \cdot 10^{-11}$
- “Short and medium distance” **Main source of the error**
  - Scalars, tensors:  $-1(3) \cdot 10^{-11}$
  - Axial vector:  $6(6) \cdot 10^{-11}$
  - Short-distance:  $15(10) \cdot 10^{-11}$
- $a_{\mu}^{\text{HLbL-Analytic}} = 92(19) \cdot 10^{-11}$



## Happened since then

- Many presentations in KEK21, Edinburgh 22, Berne 23
- More experimental inputs exist: talk by Christophe Redmer
- Short-distance improved considerably: talk by Nils Hermansson-Truedsson
- Holographic QCD improvements done: relevant for axials and short-distance talk by Anton Rebhan
- Intermediate distance: the axial vectors are important: talk by Maximilian Zillinger
- The pseudo-scalar pole contribution has been improved: talk by Simon Holz
- An alternative dispersive method that might be easier for multibody intermediate states: talk by Jan-Niklas Toelstede



# Planned chapters

Still in the discussion stage plus an update or a full new whitepaper also under discussion

- 1 Framework
- 2 Short-distance constraints
- 3 Dispersive
- 4 Holographic
- 5 Other+comparison
- 6 Combing short-distance with the other approaches
- 7 A new final number
- 8 Prospects for further improvements