After the Seattle Meeting on HLBL in $(g_\mu - 2)/2$

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Outline

1. Motivation

2. Theory

3. Data

4. Conclusions

Motivation – I

Contribution	$a_\mu, 10^{-10}$
Experiment	$11659208.9 \pm 5.4 \pm 3.3 \ (6.3)$
QED	11658471.809 ± 0.015
Electroweak	$15.4 \pm 0.1_{\mathrm{had}} \pm 0.2_{\mathrm{Higgs}}$
Hadronic	693.0 ± 4.9
Hadronic, LO	692.3 ± 4.2
Hadronic, HO	-9.79 ± 0.09
Hadronic, LBL	10.5 ± 2.6
Theory	11659180.2 ± 4.9
Exp.–Theory	$28.7 \pm 8.0 \ (3.6\sigma)$

M. Davier et al., Eur. Phys. J. C71:1515 (2011)

Motivation – II

In the very optimistic scenario of e^+e^- experiments:

- KLOE measures $\mathcal{F}_\pi$ below 1 GeV to 0.5%

- CMD-3 and SND measure $\mathcal{F}_\pi$ below 1 GeV to 0.5%
  and continuum below 2 GeV to 2%

- Belle and BaBar measure $\mathcal{F}_\pi$ below 1 GeV to 0.5%
  and continuum below 2 GeV to (2-3)%

- Averaging with the current numbers gives the error of 2.6,
  i.e., LO and LBL are of equal importance or LBL limits accuracy

Institute of Nuclear Theory (UW organized a seminar with about 35 participants
working for 5 days

Form Factor Measurements – I

Form factors of pseudoscalars $(P = \pi^0, \ \eta, \ \eta')$
at all momentum transfers

The main source – $\gamma\gamma$ collisions:

- KLOE with a tagger - $\pi^0, \ \eta, \ \eta', \ f_0(980)$, both with two real γ and γ^*

- KEDR with a tagger - $\pi^0, \ \eta, \ \sigma_{\text{tot}}(\gamma\gamma \to h)$
  with real γ and tagged with $Q^2 < 4 \cdot 10^{-5} (3 \cdot 10^{-4} \ \text{GeV}^2$ at 1.8 (5) GeV

- BaBar and Belle - single-tag for $P = \pi^0, \ \eta, \ \eta'$,
  BaBar already studied all, for $\pi^0 \ Q^2 < 40 \ \text{GeV}^2$, Belle started

- Belle studied in the 0-tag mode with $Q^2 < 3 \ \text{GeV}^2$
  $\gamma\gamma \to \pi^0\pi^0, \ \pi^+\pi^-, \ K^+K^-, \ K^0_S K^0_S, \eta\pi^0, \ \eta\eta$

Form Factor Measurements – II

- Radiative decays:
  $\gamma^* \to V \to P\gamma;\ Q1^2 = m_V^2,\ Q2^2 = 0$
  KLOE – V=ϕ, $P = \pi^0,\ \eta,\ \eta'$; CMD-3,SND – $\rho^{(\prime)},\ \omega^{(\prime)},\ \phi^{(\prime)}$

- Dalitz decays of P:
  $P \to \gamma\gamma^* \to \gamma l^+ l^-;\ 4m_l^2 < Q1^2 < m_P^2,\ Q2^2 = 0, l = e, \mu$
  KLOE, CMD-3, SND – $P = \pi^0,\ \eta,\ \eta'$

- Double-Dalitz decays of P:
  $P \to \gamma^*\gamma^* \to l^+ l^- l^+ l^-;\ 4m_l^2 < Q1(2)^2 < (m_P - 2m_l)^2, l = e, \mu$
  KLOE, WASA, Mainz, JLab

- Dalitz decays of V:
  $\gamma^* \to V \to P\gamma^* \to Pl^+ l^-;\ 4m_l^2 < Q1^2 < (m_V - m_P)^2,\ Q2^2 = 0, l = e, \mu$
  KLOE, CMD-3, SND – $P = \pi^0,\ \eta,\ \eta'$

Form Factor Measurements – III

- Primakoff effect $(\gamma^{(*)} A \to P\ A')$

  JLab, Mainz; Interpretation problems

- Rare decays of π^0, $\eta \to e^+ e^-$, $\mu^+ \mu^-$

Particle	π^0	η
$e^+ e^-$	$(6.44 \pm 0.25 \pm 0.22) \cdot 10^{-8}$	$< 2.7 \cdot 10^{-5}$
$\mu^+ \mu^-$	–	$(5.7 \pm 0.7 \pm 0.5) \cdot 10^{-6}$
$e^+ e^- \gamma$	$(1.140 \pm 0.024 \pm 0.033) \cdot 10^{-2}$	$(7.10 \pm 0.64 \pm 0.46) \cdot 10^{-3}$
$\mu^+ \mu^- \gamma$	–	–
$e^+ e^- e^+ e^-$	$(3.46 \pm 0.19) \cdot 10^{-5}$	$< 6.9 \cdot 10^{-5}$

Conclusions

- There are 5-6 different approaches (even more groups),
  hot disputes but very close numbers

- Obvious progress of lattice calculations

- There is real interest to all possible experiments: $\gamma^{(*)}\gamma^{(*)} \to \pi^0, \eta, \eta'$,
  radiative and Dalitz decays of vector and pseudoscalar mesons, $\pi^0 \to e^+e^-$
  and KLOE has very good opportunities everywhere!

- An arxiv preprint expected in April,
  a detailed summary paper to appear in 6 months