Introduction and goals of the workshop

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Outline

› Introduction
› Goals of the workshop
› Practical information
Electromagnetic dipole moments

Electromagnetic dipole moments are static properties of particles, never measured for short-lived charm, beauty baryons, and $\tau$ lepton.

\[ \delta = \text{electric dipole moment (EDM)} \quad \delta = d\mu_N \frac{S}{2} \]

- EDM searches are sensitive to new physics. Violation of P, T and CP via CPT theorem.

\[ \mu = \text{magnetic dipole moment (MDM)} \quad \mu = g\mu_N \frac{S}{2} \]

- MDM provide stringent test of the Standard Model for leptons and QCD models for baryons.
Status of EDM measurements

- **SM–CKM**
- **SM–Ω**
- $d^{(expected)}$
- $d^{(meas)}$

### EDM (e.cm)

- $10^{-43}$
- $10^{-40}$
- $10^{-37}$
- $10^{-34}$
- $10^{-31}$
- $10^{-28}$
- $10^{-25}$
- $10^{-22}$
- $10^{-19}$
- $10^{-16}$

<table>
<thead>
<tr>
<th>PID</th>
<th>CERN-PBC-REPORT-2018-007</th>
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<tbody>
<tr>
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<tr>
<td>$Λ^0$</td>
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<tr>
<td>$Λ^+_c$</td>
<td>10^{-25}</td>
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<tr>
<td>$Ξ^+_c$</td>
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MDM physics motivations

- Test of the Standard Model with leptons, *i.e.* muon g-2
- Measurement of MDM of particles and antiparticles for test of CPT symmetry
- For baryons provide experimental anchor points for testing low-energy QCD models, related to non-perturbative QCD dynamics
- Test of baryon substructure
Muon g-2 and CPT tests

- Muon g-2: precision SM test. Accuracy of measurements matched by accuracy of calculations

- Significant CPT tests performed in few particle systems

<table>
<thead>
<tr>
<th>Particle</th>
<th>((g^+-g^-)/g)</th>
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<tr>
<td>electron</td>
<td>((-0.5\pm2.1)\cdot10^{-12})</td>
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<tr>
<td>muon</td>
<td>((-1.1\pm1.2)\cdot10^{-9})</td>
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<tr>
<td>proton</td>
<td>((0.3\pm0.8)\cdot10^{-6})</td>
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Tau $g-2$ and EDM

From A. Lusiani talk at European Strategy Update, Granada - May 19

BelleII prospects on tau $g-2$ and EDM

- Chen, Wu 2018, simulation of just statistical errors
- $\Delta |d_T^{NP}| = 2.04 \cdot 10^{-19} \text{ e cm}, \quad \Delta |a_T^{NP}| = 1.75 \cdot 10^{-5}$
  (beware: here one actually measures NP pointlike contributions)
MDM of heavy baryons

Provide experimental anchor points for heavy baryon MDM model predictions. Trigger further theory activity.
Goals of the workshop
Study EMD/MDM at LHC(b)

- Discuss the proposals for directly probing MDM/EDM of unstable particles at LHC(b)
  - charm (beauty) baryons: fixed-target production and spin precession in bent crystals with LHCb
  - strange baryons: $pp$ production and spin precession in LHCb dipole magnet
  - tau lepton: dedicated experiment with bent crystals. Possible preparatory studies in LHCb
Pospelov’s comments on charm MDM/EDM

- In light hadrons, most of the MDM is generated by light “valence” quarks, and it scales as \((eQ_q/m_{\text{const quark}})\) where \(m_{\text{const quark}}\) is the mass of the constituent light quarks (i.e. mass of a light quark “dressed” by QCD to be \(\sim 300\) MeV).

- Therefore, to start seeing MDM of charm, one needs to measure to accuracy better than \(m_{\text{const quark}}/m_{\text{charm}}\).

- Acceptable result: 10\% measurement of the MDM
  Desirable result: few\% measurement of the MDM.

- Achieving a result better than \((10^{-17} - 10^{-18})\) e cm would be a milestone showing that charmed EDM can probe beyond the weak scale.

- \textit{Truly interesting} [for me] benchmark would start from \textit{just above} the indirect limits, at \(10^{-20}\) e cm benchmark.
The proposals have been mentioned and endorsed in the Physics Briefing Book. See [http://cds.cern.ch/record/2691414](http://cds.cern.ch/record/2691414).

The physics reach of the LHC complex can greatly be extended at a very limited cost with the addition of an ambitious and long term LHC-FT research program. The efforts of the existing LHC experiments to implement such a programme, including specific R&D actions on the collider, deserve support.

In addition, double crystal LHC-FT experiments give access to studies beyond QCD, such as MDM and EDM of heavy baryons.
The proposals have been mentioned and endorsed in the Physics Briefing Book. See http://cds.cern.ch/record/2691414
Main topics of discussion

- **Physics** program
- **Channeling** and spin precession in bent crystals
- **Spin** precession in LHCb magnet
- **Machine** layout
- **Experimental** techniques
- **R&D** in progress
Work in collaboration

- Crucial to join effort and expertises of different communities to transform the proposal into an experiment:
  - theorist
  - experimentalist
  - bent crystals
  - machine
  - engineering
Contributions to the project

- Setup a collaborative **framework**
- **Critical items** for the experiment and crucial contributions
- Identify areas of **interest** and expertise
- **Responsibilities**
- **Timeline**
Let’s start the meeting and fruitful discussions!
Practical information

- Register at the workshop and wear the badge
- Wi-Fi: eduroam
- Lunches and coffee breaks are provided
- Visit of Ca’ Granda at 18:00
- Welcome cocktail this evening at 19:00 (Loggiato)
- Scientific secretariat: Noemi De Lorenzo