Low-Energy Compton $\gamma X \to \gamma X$: Theory–Experiment Synergies

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Nucleon Polarisabilities: Stiffness of Constituents in Elmag Fields
<small>cf. Howell, Paolone, Zhao, Joosten, Yoshitaka,...</small>

LRP Deliverables: Unified picture into Δ region. <small>White Paper IJMP G49 (2022) 010502 [arXiv:2012.10843]</small>

On-par experimental/χEFT/lattice-QCD errors in non-trivial, fundamental hadron property.

Map ω-dependence. Nail down spin-polarisabilities. Clear signal of p-ndifferences: cross-validate ΔM_N.

LRP Input: Unique facilities & expertise. HIγS & MAMI crucial, complementing, university-based, US-led efforts.

LRP Need: Commensurate university-based theory support to continue exemplary synergy with experiment.

ω-dependent multipoles: scales, symmetries, mechanisms of interactions.

Clean, perturbative probe of χiral symmetry of pion-cloud and of $\Delta(1232)$.
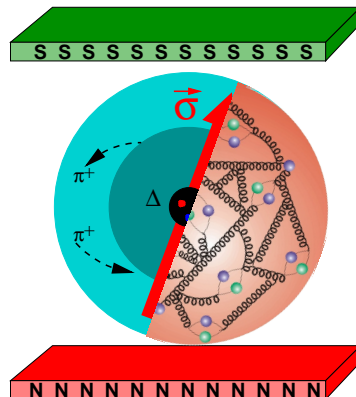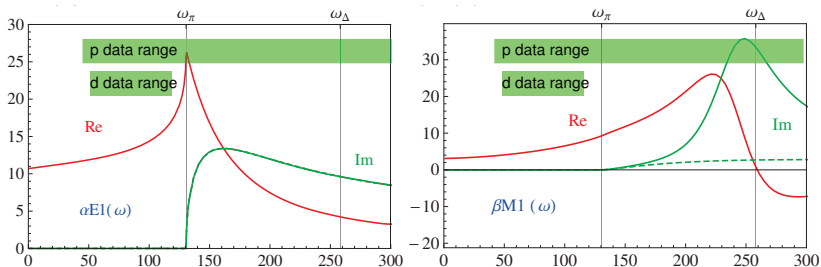
Scalar & Spin Polarisabilities are fundamental, nontrivial, relevant:

4 Spin-Pol.'s: nucleonic Faraday effect/bi-refringence: response of spin constituents; cf. JLab spin programme.

Status: Proton γ_is from MAMI (US-driven) by χEFT-based analysis, exp. error $\pm 20\%$; confirms χEFT predictions.

El./Mag. Scalar Pol.'s: $\alpha_{E1}^{\mathrm{p-n}} = -1.7 \pm 0.4_{\mathrm{tot}}$ from Cottingham Σ-Rule to explain elmag. p-n mass split.

$\rightsquigarrow$ Anthropic Principle: small change of m_π may nullify BBN. Gasser/Hoferichter/...1975/2015-22; hg/...EPJA52(2016)139

Status: exp. error dominates $\alpha_{E1}^{\mathrm{p-n}} = -0.9 \pm 1.6_{\mathrm{tot}}$. $\Longrightarrow$ Need better neutron data $\rightarrow$ light nuclei: HIγS, MAMI.

Data $\Longleftrightarrow$ χ**EFT as intermediary:** extract & extrapolate $\Longleftrightarrow$ **Lattice QCD**

Example: m_π-dep. of static electric polarisability α_{E1}

- ■,◆ p,n static α_{E1} fit to exp
- ▲ n: Alexandru/Lujan/... 2014
- ✕,+ p,n: Detmold et al. 2010
- ▼ n: Engelhardt 2007
- —,— p,n χEFT hg/... 2015

proton

α_{E1} [10^{-4}fm^3]

neutron

Not A Fit to Lattice Results!

m_π [MeV]

High flux, precision $\Longleftrightarrow$ limited resources, χEFT range

$\Longrightarrow$ χ**EFT for Experimental Design & Analysis:**

Bayesian Uncertainty Quantification

Pol'd beam+target: spin-$\frac{1}{2}$: 13 observables; spin-1: 30

Example: sensitivity of proton-Σ_{2x} to
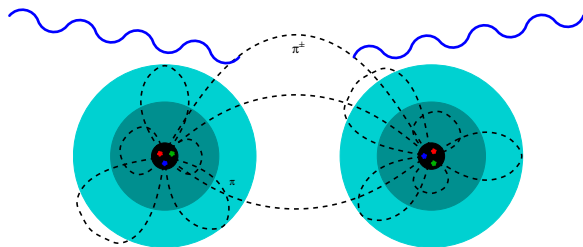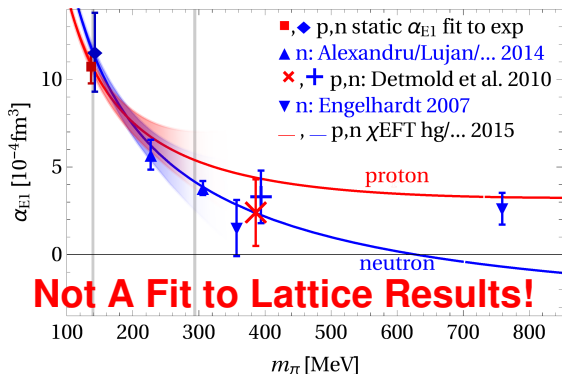
χ**EFT for neutron polarisabilities from light nuclei:**

reliably subtract nuclear binding from data✓,

systematically study charged-pion NN force

in d (near-done), ^{3,4}He (ongoing), ^{6}Li (upcoming).

$\pi^\pm$

ω_{lab}=288MeV

θ_{lab} [deg]

ω_{lab}=330MeV

θ_{lab} [deg]

ω_{lab} [MeV]