Chiral Dynamics: 2 Photons and Few Nucleons

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Compton Scattering $\gamma X \to \gamma X$ Tests Low-Energy QCD

cf. Phillips, Howell, Ahmed, Tiburzi,...

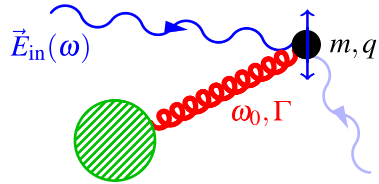
Phillips, Howell: **Polarisabilities: scales, symmetries & mechanisms** of interactions with & among constituents:

Clean, perturbative probe of χiral symmetry of pion-cloud

iso-spin breaking, $\Delta(1232)$ properties,

spin-constituents: nucleonic bi-refringence (Faraday effect).

Lattice-QCD gears up for results.



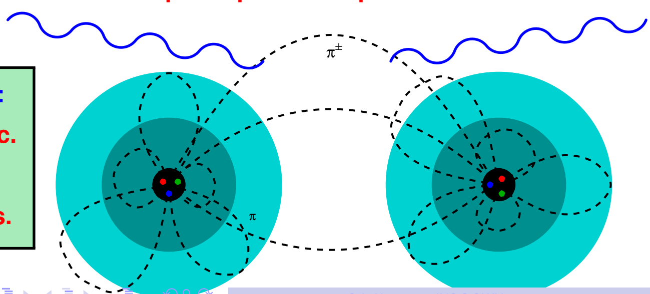
$$\mathcal{L}_{\text{pol}} = 2\pi \Big[\underbrace{\alpha_{E1}(\omega)\vec{E}^2 + \beta_{M1}(\omega)\vec{B}^2}_{\text{electric, magnetic scalar dipole}} + \underbrace{\gamma_{E1E1}(\omega)\vec{\sigma}\cdot(\vec{E}\times\dot{\vec{E}}) + \gamma_{M1M1}(\omega)\vec{\sigma}\cdot(\vec{B}\times\dot{\vec{B}}) + \dots}_{\text{spin-dependent dipole}} \Big]$$

Neutron polarisabilities from few-nucleon targets:

Subtract binding model-independently, systematic.

$+$ **Understanding of charged-pion NN force.**

$\Longrightarrow$ χ**EFT for $A = 0 - 6$ for reliable uncertainties.**

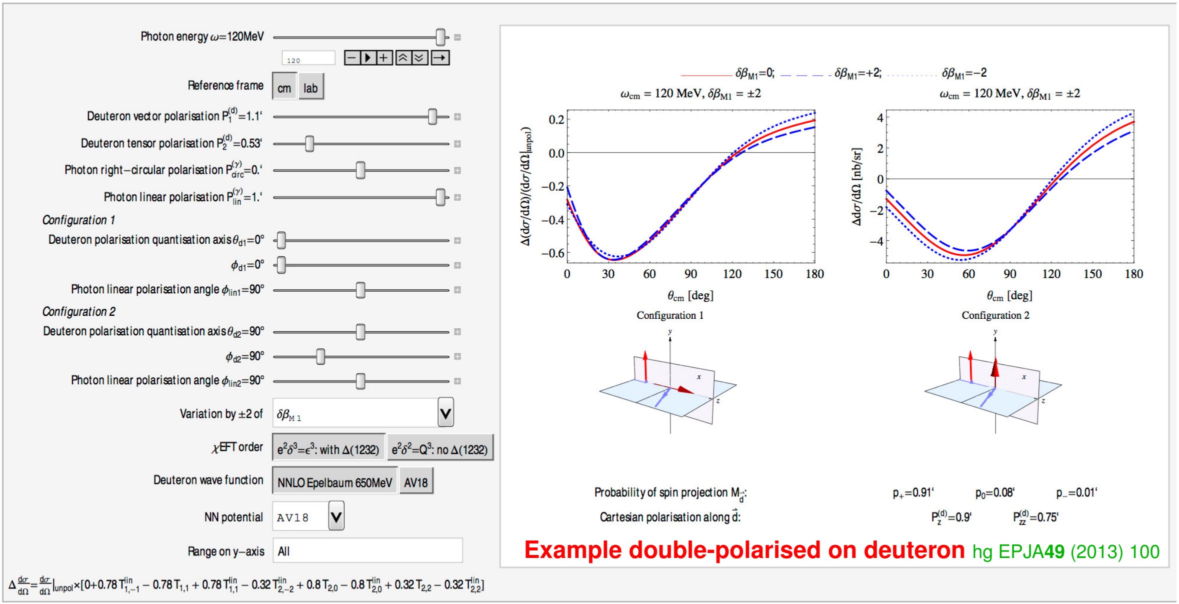


Guide, Support, Analyse, Predict Polarised Experiments

Unpol./linear/circular beam on scalar/vector/tensor target $\Longrightarrow$ 23 indep. deuteron observables

Constraints: rates, detector settings, partial beam/target polarisations, Sum rules,. . .

HIγS, MAMI: Exp. & theory collaborate on *observables with biggest impact* using *mathematica* notebooks.



Example double-polarised on deuteron hg EPJA**49** (2013) 100

Spin-polarisabilities to 20%: 80 to 200 MeV, 100% polarised: $\lesssim 10^7 \frac{\text{photons}}{\text{s MeV}} \times 1000$ hrs per observable.

χEFT Goals for Compton/Polarisabilities:

- **Comprehensive, unified picture into resonance region:**
  p: done; deuteron: done for $\omega \lesssim m_\pi$; ^{3}He: only $\omega \sim [80 - 120]$ MeV
- **Connect lattice-QCD and experiment with competitive errors.**
- **Continue close collaboration with US experimenters at HIγS, MAMI.**

Compton@χEFT Collaboration: hg, McGovern (U. Manchester), Phillips (Ohio U.), . . .

Deliverables: Extractions with Reproducible Error Estimates

– **Identify proton-neutron difference: isospin breaking of pion cloud, μH,. . .**

– **Extract spin-polarisabilities to $\lesssim 20\%$ accuracy.**

Intensity & Precision Frontier: *"At present, single and double polarised data is sorely missing."* Theory letter [arXiv:1409.1512]

Experiment: $\frac{d\sigma}{d\Omega} \propto$ (target-charge)$^{2\text{ to }1}$ $\Longrightarrow$ more & easier targets, better signals

Theory: Reliable extraction needs accurate description of binding & levels: **computational resources for $A \geq 3$.**

Find *sweet-spot* between competing forces: ^{3}He, ^{4}He, ^{6}Li (HIγS data!): *Find Most Cost-Effective!*

χEFT for few-N systems provides important answers with quantifiable errors (Compton is one example).