Geometric Electron Model (dK–G–K–Sp): Technical Note & Experimental Predictions for Spin-Dependent Asymmetry A_n

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1. Introduction

This technical note presents a falsifiable prediction derived from a geometric electron model built from four internal structural elements:

$$(dK,\ G,\ K,\ Sp_{1/2}),$$

where dK is the internal circulation, G the Möbius-type transmission, K the boundary ring, and Sp_1 / Sp_2 encode the boundary gluing responsible for electric charge. A global orientation axis O is assumed to be a property of the underlying geometrical background. The observable spin corresponds not to an internal rotation but to the projection of a local orientation vector ST onto O:

$$\text{spin} = \text{sgn}\big(ST \cdot O\big).$$

In the vicinity of heavy nuclei, strong electromagnetic fields and nuclear deformation tilt the local axis,

$$O \to O_{\text{local}}(Z, \beta_2, \beta_3, r),$$

modifying spin projection and therefore the beam-normal single-spin asymmetry

$$A_n = \frac{\sigma_\uparrow - \sigma_\downarrow}{\sigma_\uparrow + \sigma_\downarrow}.$$

This mechanism is absent in standard two-photon exchange (TPE) theory and naturally produces Z- and energy-dependent deviations observed in recent measurements, including the 2025 PRL result for ^{208}Pb.

2. Mechanism: Local Tilt of the Geometric Axis

The electron's internal state (dK, ST) is fixed, but the observable spin depends on the local projection onto O_{local}. For a nucleus with charge Z and quadrupole deformation β_2:

$$O_{\text{local}} = O_{\text{global}} + \delta O(Z, \beta_2, \beta_3),$$

where:

$$\delta O \propto Z\,\nabla E(r) + f(\beta_2, \beta_3).$$

The experimentally accessible quantity is the reduction of spin-flip contrast:

$$A_n(Z) \approx A_n^{\rm TPE} \cdot \cos\big(\theta(Z, \beta_2, \beta_3)\big),$$

where θ is the tilt between global and local geometric axes.

Thus: - large Z increases θ, - deformation increases θ, - non-monotonic dependence on beam energy arises because different energies probe different radii r with different $O_{\rm local}(r)$.

3. Key Predictions

Prediction A: Suppression of $|A_n|$ with increasing Z

$$|A_n|\big(C, O, Si\big) \approx \text{TPE}, \quad |A_n|\big(Sn\big) < \text{TPE}, \quad |A_n|\big(Pb\big) \ll \text{TPE}.$$

The model predicts even stronger suppression for:

$$\text{Bi, Th, U.}$$

Prediction B: Enhancement via deformation

Large β_2, β_3 yields an additional geometric contribution:

$$\theta \to \theta + \theta_{\rm def}.$$

Candidates with anomalously low $|A_n|$:

$$^{238}\text{U},\ ^{232}\text{Th},\ ^{178}\text{Hf},\ \text{Dy/Er/Yb isotopes.}$$

Prediction C: Weakly deformed heavy nuclei

For W, Pt, Au:

$$|A_n| < A_n^{\rm TPE}, \text{ but } |A_n| \neq 0.$$

Prediction D: Non-monotonic dependence on energy

Different beam energies probe different r within the Coulomb field:

- energies where $A_n \approx 0$ (PREX regime),
- energies where A_n reappears (PRL 2025),
- possible **sign flips** for $Z \gtrsim 82$.

Prediction E: No anomaly for light and medium nuclei

$$C, O, Si, Ar, Ca, Fe, Ni, Cu: \quad A_n \approx \text{TPE (within 10–20\%).}$$

4. Measurement Targets

Table 1 specifies concrete, falsifiable measurement points for upcoming experiments at MAMI, MESA, and JLab.

Table 1: Recommended measurement points for testing geometric-axis tilt effects. Energies correspond to accessible ranges at MAMI/MESA (low) and JLab (high).

Nucleus	Z	**Deformation**	**Energies [MeV]**	**Model Expectation**
^{12}C, ^{28}Si	6–14	small	200–600	$\approx$ TPE (control)
^{120}Sn	50	small	300–700	mild suppression
^{208}Pb	82	spherical	300, 570, 1060	suppression; energy structure
^{209}Bi	83	spherical	300–700	stronger suppression than Pb
^{232}Th	90	large β_2	200–700	strong suppression; possible sign flip
^{238}U	92	large β_2	200–700	strongest suppression; sign flip likely
^{197}Au	79	small β_2	300–700	partial suppression only
^{184}W	74	small β_2	300–700	partial suppression

5. Falsifiability

The geometric model is falsified if:

- $|A_n|$ for Bi, Th, or U is not lower than for Pb,
- W, Pt, Au match TPE with no suppression,
- no non-monotonic or sign-changing behavior is observed in Pb/Bi/Th/U,
- light nuclei show deviations larger than 20%.

6. Conclusion

If the predicted suppression patterns and energy-dependent structures of A_n are confirmed, it would imply that the observable electron spin is sensitive to local geometric-axis distortions generated by heavy nuclei. Such a mechanism lies outside current TPE theory and would represent a new geometric contribution to spin-dependent scattering.