Part 1. Q/FS lattices

- Description of 'spin-orbit motion,' as in:
  1. Form of **equation** (TBMT) $\rightarrow$
  2. Form of **solution** ($\vec{s}(t) = \vec{s}_{homo}(t) + \vec{s}_{inhomo}(t)$) $\rightarrow$
  3. Form of **observable** (Ω_{meas}).

  * Problematic aspects of the observable:
    - mixing of irrelevant components into measured signal $\Rightarrow$ $\boxed{\Omega_{\text{meas}} \neq \Omega_x.}$

Part 2. Problem statement

- Experimental conditions:
  1. bounds on component mixing (*);
  2. requirements for enabling the CW/CCW Comparison methodology (see Part 3.).
- Devices (reflects 'Experimental conditions'):
  1. Minimization solenoid;
  2. Calibration solenoid.
- Precision requirements
  1. Decoherence.

Part 3. Imperfect ring

Comparison methodology $\rightarrow$

Reproduction of experimental conditions $\rightarrow$

Calibration of Ω_x by Ω_y $\Rightarrow$

- Study imperfections [1] *as relevant for* a) Observable, b) Calibration:

O1. (Tilt) introduction of MDM precession in the *signal plane* $\Rightarrow$ $\boxed{\Omega_x \neq \Omega_x^{\text{EDM}};}$ [2]

C1. (Tilt) Different relationship between Ω_x^{MDM} and Ω_y^{MDM} for the same $(\vec{x}, \Delta\gamma_s)$ point $\Rightarrow$

$$\boxed{\exists \epsilon > 0 \forall \delta > 0 \ \Delta|\Omega_y^{\text{MDM}}| < \delta \wedge \Delta|\Omega_x^{\text{MDM}}| > \epsilon;}$$

- Study how much the relationship between Ω_y^{MDM} and Ω_x^{MDM} changes from CW to CCW under a given $\sigma[\text{tilt}]$. **Quantify** $\epsilon(\sigma[\text{tilt}])$.

C2. (Injection) variation of the injection point $\Rightarrow$ $\boxed{\vec{\Omega} := f(\vec{x}, \Delta\gamma_s); \sigma[(\vec{x}, \Delta\gamma_s)] \implies \sigma[\vec{\Omega}].}$ [3]

- Study whether variation in the injection point changes the angle between Ω_x^{MDM} and Ω_y^{MDM}. [4]

Research questions

1. Magnet tilts affect our ability to calibrate Ω_x^{MDM} by observing Ω_y^{MDM}. Quantify calibration *accuracy* (the difference in Ω_x^{MDM} when $\Delta\Omega_y^{\text{MDM}}$ is *strictly* 0) as a function of $\sigma[\text{tilt}]$. (Bonus: quantify precision.)
2. Do the same, but as a function of $\sigma[(\vec{x}, \Delta\gamma_s)]$. (Bonus: modify COSYInf to make TSP produce an appropriate (phase-space-dependent) DA-vector.)

[1] List of categories of imperfections!

[2] We deal with that by the intriduction of the CW/CCW procedure, i.e. by change of estimator to $\hat{\Omega}^{\text{EDM}} = \kappa \cdot (\hat{\Omega}^{CW}_{meas} + \hat{\Omega}^{CCW}_{meas})$.

[3] Unless the deviation of an injection point changes the angle between Ω_y^{MDM} and Ω_x^{MDM}, this is irrelevant, is covered by calibration; if it does, then it affects our ability to calibrate the CW-to-CCW transition, and thus the problem is reduced to that of C1.

[4] In COSYInf, that would be given by n-bar from TSP; however, TSP yields the spin-tune and spin-invariant axis' dependence on parameters *only*, we need that on phase space variables. **Figure out how to do that?**