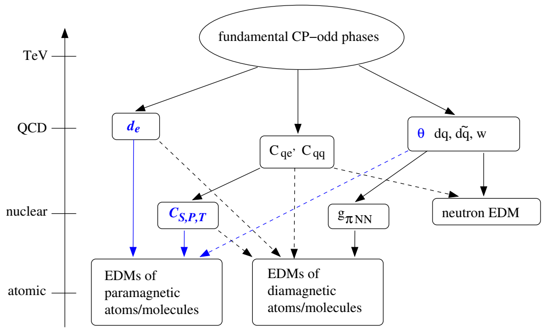
Proposition de Stage M2 - année 2018-2019

Searching for SUSY Beyond the Large Hadron Collider

The Standard Model (SM) of elementary particles is not the ultimate theory of the universe. Among the important unsolved problems in physics is the Baryon Asymmetry of the Universe (BAU), an explanation for which requires the violation of time-reversal ($\mathcal{T}$) invariance at a fundamental level [9]. The search for $\mathcal{T}$-odd lepton moments in nature which are predicted by many models based on SuperSymmetry (SUSY) is, therefore, also the search for physics beyond the standard model.



Electric Dipole Moments (EDMs) of atoms and molecules are $\mathcal{T}$-odd moments that may have sources in both the hadronic and leptonic sector of matter. Recently, a new upper bound to the electron EDM has been determined from experimental [1] and theoretical [2] studies on the thorium monoxide molecule (ThO). Other sources are $\mathcal{T}$-violating weak interactions between the fermions of the atomic system [3–5].

The resulting low-energy bounds on fundamental $\mathcal{CP}$-violating (Charge-Parity-violating) parameters strongly constrain those parameter spaces in Beyond-Standard-Model (BSM) theories.

The intership concerns the theoretical study of $\mathcal{T}$-violating physics in promising candidate atomic and molecular systems. In addition, the studies will include investigations of magnetic hyperfine interaction and the overall relativistic electronic structure. The methods used for the study include general excitation rank Dirac-theory based electron correlation methods [6] and the evaluation of property expectation values in first-order perturbation theory using correlated electronic wavefunctions [7, 8]. The resulting interaction constants in atomic matter combined with high-precision experimental results directly yield bounds on BSM parameters.

RESPONSABLE DE STAGE: Prof. Dr. **Timo Fleig**

Site web: `www.dirac.ups-tlse.fr/fleig`

Tel.: (0)561 55 65 59, e-mail: timo.fleig@irsamc.ups-tlse.fr

Laboratoire de Chimie et Physique Quantiques IRSAMC, Dir. T. Leininger

Site web: `www.lcpq.irsamc.ups-tlse.fr`

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[9] This means that if a laboratory were to move backwards in time, the measured observable would change sign.