Search for Electric Dipole Moments using Storage Rings (srEDM)

erc — European Research Council — Established by the European Commission

JÜLICH FORSCHUNGSZENTRUM

Scientific Background

Matter-Antimatter Asymmetry of the Universe

What we **should see** and what we **actually observe**

equal amount of matter and antimatter

predominantly matter almost no antimatter

Matter

Anti-Matter

Ratio $10^{10}:1$
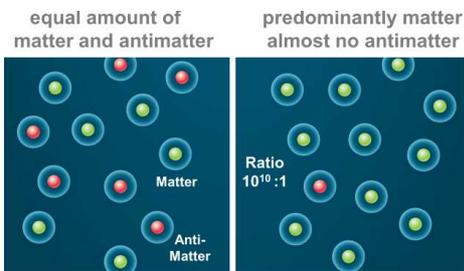
This is one of the big unsolved problems in physics !

Electric Dipole Moments (EDM)

EDMs violate CP – new CP-V provides a possible solution

Electric Dipole Moments violate P- and T-invariance

Spin   EDM   T

Original illustration by: physicsworld.com
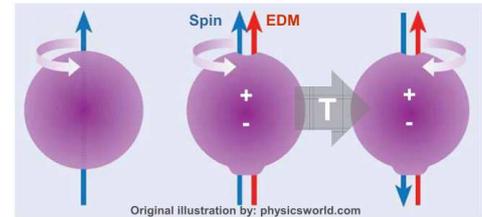
Via CPT theorem, T-violation corresponds to CP-violation

Experimental Approach

Charged Particle EDM Search

EDMs are searched for in electrons, neutrons, atoms and molecules, to date without success – only upper limits were obtained; the **srEDM** (protons, deuterons) will **improve** these limits **significantly** or even **find** an **EDM**

Measurement principle

Particle spin alignment along momentum (*frozen spin*)

V   E
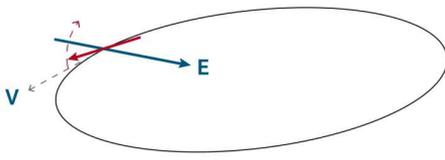
Radial E-field: torque on spin – rotation out of ring plane

Precursor Experiment

In a stepwise approach, starting from R&D for all crucial tools required, proof-of-principle measurements at COSY-Jülich will be conducted, leading to **first** directly determined **upper EDM limits** for the **deuteron** and/or the **proton**

Cooler Synchrotron COSY-Jülich

Outlook: Dedicated EDM Ring

For the EDM search with highest sensitivity, a completely new **high-precision double storage** ring is required aiming at 10^{-29} **e·cm** – a charge separation of **~1 nanometer (if nucleon had the size of the earth!)**

Counter-rotating beams

Purely **electric deflection** (pEDM only)
→ two separated beams simultaneously
Combined **electric/magnetic deflection** (pEDM and dEDM …)
→ two separated beams simultaneously
or one beam at a time and B-field reversal

ERC AdG «srEDM» (Grant 694340): ~2.4 M€ for 5 Years, Start 2016

Principal Investigator

Prof. Dr. Dr. h.c. mult. **Hans Ströher**

(Director IKP-2 of FZ-Jülich, Professor at IKP, Univ. of Cologne)

JARA|Fame and **JEDI**-Collaboration

Collaborating Partners

PI

RWTH   JÜLICH   UNIFE

ZEA's   IKP-2   IKP-4

COSY

JARA-Fame

JEDI Collaboration
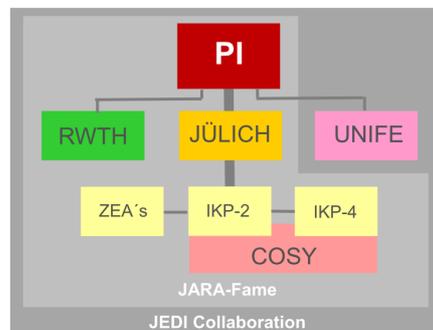
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Work Packages

Key technologies for srEDM

WP-1 Accelerator developments	WP-2 Beam polarimetry	WP-3 Beam simulations	WP-4 Feasibility studies at COSY
Deflectors (electrostatic, E/B)	Data base for proton, deuteron	Beam orbit tracking	Spin coherence time (SCT), spin tune
Instrumentation (BCT, BPM)	Detector characterization	Beam spin tracking	Accelerator feedback system
Accelerator feedback system	Detector, target prototyping		New hardware tests (deflect., polarimtr.)
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Storage ring EDM measurements

WP-5 Proof-of-principle	First EDM measurement
RF-Wien filter: test, installation	COSY upgrade program
Deuteron experiment	Proton, deuteron measurement
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