FFG
Promoting Innovation.

PREPARING A COMPETITIVE ERC ADVANCED GRANT PROPOSAL - PHYSICAL SCIENCES AND ENGINEERING

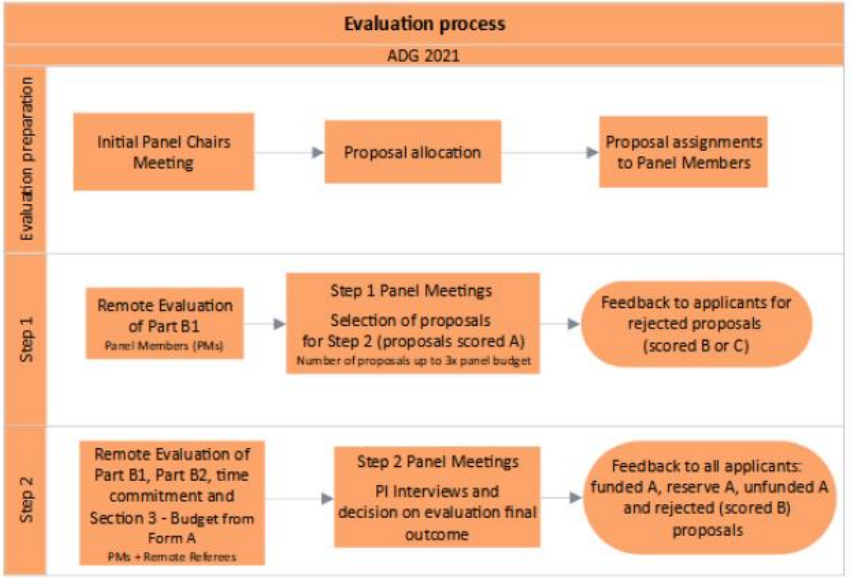
28.06.2021, FFG Academy

OUTLINE

- Sharing Experiences: Q+A Matteo Maffei, ERC Panel Member Computer Science and Informatics (PE6), ERC Consolidator Grantee
- Proposal Writing: Discussing inspirational nuggets

photo credit: TU Wien

Sharing experiences/Q+A



WRITING THE PROPOSAL: INSPIRATIONAL NUGGETS

Ströher srEDM

Part B1

ERC Advanced Grant 2015
Research proposal [Part B1]
(Part B1 is evaluated both in Step 1 and Step 2
Part B2 is evaluated in Step 2 only)

Electric Dipole Moment Search using Storage Rings

srEDM

Cover Page:
- Name of the Principal Investigator (PI) — Prof. Dr. Dr. h.c. mult. Hans Ströher
- Name of the PI's host institution for the project — Forschungszentrum Jülich, Germany
- Proposal duration in months — 60

According to our present understanding, the early Universe contained the same amount of matter and anti-matter and, if the Universe had behaved symmetrically as it developed, every particle would have been annihilated by one of its antiparticles. One of the great mysteries in the natural sciences is therefore why matter dominates over antimatter in the visible Universe. The breaking of the combined charge conjugation and parity symmetries (CP-violation, CPV) in the Standard Model of particle physics (SM) is insufficient to explain this and further sources of CPV must be sought. These could manifest themselves in electric dipole moments (EDMs) of elementary particles, which occur when the centroids of positive and negative charges are mutually and permanently displaced. An EDM observation would also be an indication for physics beyond the SM.

Investigations on different systems are required to pin down CPV sources and this proposal aims to lay the foundations for the study of new CPV mechanisms by searching for EDMs of *charged hadrons* in a new class of precision storage rings. It will develop the key technologies and achieve a first directly measured EDM limit for protons and deuterons and thus provide the basis for a new European flagship research infrastructure.

The EDM measurement principle, the time development of the polarization vector subject to a perpendicular electric field, is simple, but the smallness of the effect makes this an enormously challenging project. A stepwise approach, from R&D for key-technologies towards the holy grail of a double-beam precision storage ring with counter-rotating beams, is needed. The research environment of the Forschungszentrum Jülich (Germany), including COSY, provides the optimum basis for one of the most spectacular possibilities in modern science: finding an EDM as a signal for new physics beyond the SM and perhaps explaining the

FUNDED TOPICS – EXAMPLES ADG, PE

Random matrices beyond Wigner-Dyson-Mehta

Novel Superfluids in Ultracold Fermionic Mixtures

Correlated Molecular Quantum Gases in Optical Lattices

Dynamics of Molecular Interactions with Ions

Deciphering River Flood Change

The design and evaluation of modern fully dynamic data structures

Quantum Criticality - The Puzzle of Multiple Energy Scales

Nanoscopic and Hierachical Materials via Living Crystallization-Driven Self-Assembly

Nova Scientia. Early 4 pi sky: Extreme Astrophysics with Revolutionary Radio Telescopes

Modeling Silicon Spintronics

ABSTRACT

According to our present understanding, the early Universe contained the same amount of matter and anti-matter and, if the Universe had behaved symmetrically as it developed, every particle would have been annihilated by one of its antiparticles. One of the great mysteries in the natural sciences is therefore why matter dominates over antimatter in the visible Universe. The breaking of the combined charge conjugation and parity symmetries (CP-violation, CPV) in the Standard Model of particle physics (SM) is insufficient to explain this and further sources of CPV must be sought. These could manifest themselves in electric dipole moments (EDMs) of elementary particles, which occur when the centroids of positive and negative charges are mutually and permanently displaced. An EDM observation would also be an indication for physics beyond the SM.

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source: Hans Ströher, Advanced Grant srEDM, http://www.sredm-ercgrant.de/SharedDocs/Downloads/SREDM/EN/Documents/erc-application-b1.pdf?__blob=publicationFile

BIG PICTURE

The underlying scientific case, i.e., the quest to fundamentally understand the difference between matter and antimatter that has led to our matter-dominated universe, is one of the grand challenges in contemporary physical sciences. This has been widely acknowledged, e.g., in the recently published strategy reports of the European and the US high-energy physics communities.

In order to determine which systems are the most promising, several calculations have been performed in recent years for EDMs of the nucleon (neutron, proton) and several light nuclei, using modern effective-field-theory techniques. These show that the θ-term could be identified with good accuracy once EDM measurements of the neutron, proton and deuteron have been performed. If this is indeed the source, the EDMs of these systems are all expected to be of the same order of magnitude, but the precise quantitative relations between the individual EDMs are a clear prediction of the θ-term. In this way, the existence of strong CP violation could be convincingly determined, potentially solving a puzzle that has been around for almost fifty years.

fundamental knowledge gap

HIGHLY VISIBLE RESEARCH AIMS

one, is compulsory. The steps towards the holy grail of a charged particle EDM search, using a double-beam precision storage ring with counter-rotating beams, comprise:

1. Research and development of all the key techniques at an existing conventional single-beam storage ring. COSY, the cooler synchrotron and storage ring at the Forschungszentrum Jülich, is the ideal place for these investigations, which involve spin-coherence time optimization, precision polarimetry development, beam tracking measurements, etc.;
2. Precision spin-tracking simulations: an essential requirement for an assessment of the capabilities of the final precision ring is to provide realistic simulations, e.g., for benchmarking EDM test installations in COSY;
3. A proof-of-principle experiment: this measurement will use COSY-Jülich without major transformations except for improvements of the beam position monitor (BPM) system and the assembly of a radiofrequency (rf) Wien-filter which (in an ideal storage ring) would induce spin rotation if an EDM exists;
4. A first direct EDM measurement (for the proton and the deuteron), again exploiting COSY-Jülich, but here upgraded with a short electrostatic deflector inside the ring. The beam chicane could be inserted in one of the straight sections of COSY. This would test one of the key techniques of the final ring and should lead to an EDM upper limit in the order 10^{-24} e·cm. It would also provide a reality check on further key items, e.g., the spin coherence time and polarimetry;
5. Conceptual design report (CDR) and technical design report (TDR) for the final dedicated storage

The current proposal addresses items 1) – 4).

driving research questions
(testable hypotheses?)

research aims: clear and measurable
not too many

WORK OF THE PI LEADING UP TO THE PROPOSAL
PROOF OF PRINCIPLE-RESULTS/PRELIMINARY DATA

The PI´s group at IKP performed hadron physics experiments with polarized beams at COSY for about 15 years, using internal detector systems (ANKE, PAX and WASA). With the phasing out of the COSY hadron-physics programme at the end of 2014, most of IKP-2 scientists are now fully focused on srEDM. The central engineering institutes of FZJ (ZEA-1 (mechanics), ZEA-2 (electronics)) are IKP-2 partners in the new project.

An alternative is to use a combined machine, with both radial electric and vertical magnetic fields. By suitable combinations of the E- and B-fields, a ring with a bending radius between 10 and 30 m could be used for protons, deuterons and ^{3}He nuclei ("all-in-one" ring). Such a ring is suggested by the JEDI-collaboration [http://collaborations.fz-juelich.de/ikp/jedi/] at COSY.

In conclusion it can be stated that all the requirements for a successful planning, implementation, and execution of the proposed studies, including, e.g., the necessary hardware (COSY) and experienced highly motivated personnel, are fulfilled. With a successful application, we will provide the basis for a major avenue to probe new physics beyond the Standard Model of elementary particle physics through a search for charged-particle EDMs with unprecedented sensitivity.

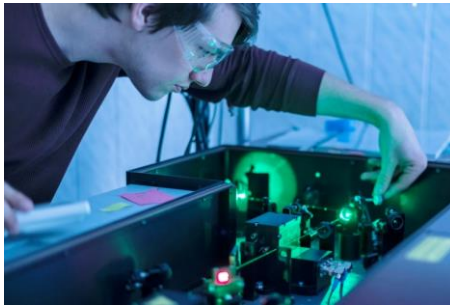
Feasibility; favourable risk-gain-balance:
Plan B/mitigation strategies; access to instruments, beam time,….

PRIORITIES EXPLAINED

In summary, it is necessary to determine electric dipole moments of different systems in order to disentangle the different CPV source(s) by comparing the various model predictions. The deuteron EDM has an especially important discriminating power due to its spin-1 – isospin-0 properties. While lepton- (electron, muon) EDMs are directly related to the underlying fundamental theory, the hadronic results are more complex, but also much more interesting.

ambitious scope ⟷ well-justified focus

convincing justification for your choices/priorities within the project



VALIDATION OF RESULTS

EDMs are very small – the best current upper limit for the *neutron* is 10^{-26} e·cm – and the goal for *charged particles* in the ultimate project is 10^{-29} e·cm or even better. In spite of the simplicity of the measurement principle – following the time development of the polarization vector of particles subject to a perpendicular electric field – the smallness of the effect provides exceptional challenges, e.g., to identify and/or avoid any fake signal.

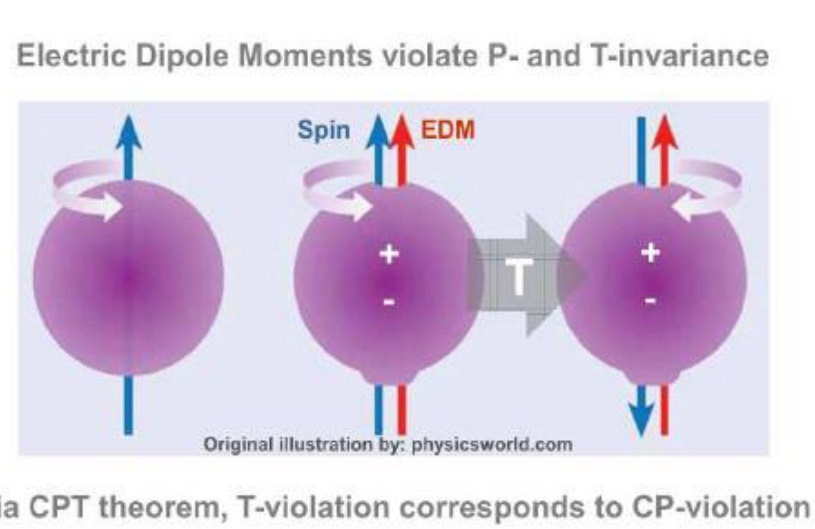
For both options, the use of clockwise (CW) and counter clockwise (CCW) beams is mandatory. This is because the main systematic error will come from an unwanted spin precession due to the MDM in radial magnetic fields which will be indistinguishable from the EDM signal. However, a radial magnetic field causes forces in different directions for the beams in opposite directions and thus it can be controlled to a very high accuracy.

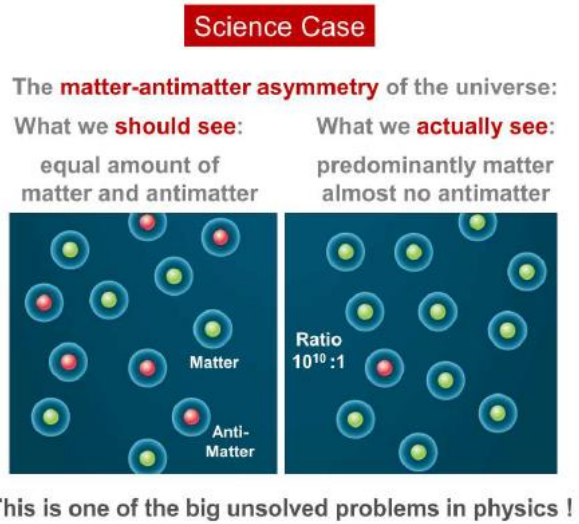
source: Hans Ströher, Advanced Grant srEDM, http://www.sredm-ercgrant.de/SharedDocs/Downloads/SREDM/EN/Documents/erc-application-b1.pdf?__blob=publicationFile

Can the results be generalised?

significance,
explanatory power of results

CHARTS, FIGURES TO ILLUSTRATE OR DOCUMENT





source: Hans Ströher, Advanced Grant srEDM, http://www.sredm-ercgrant.de/SharedDocs/Downloads/SREDM/EN/Documents/erc-application-b1.pdf?__blob=publicationFile

10 YEARS TRACK RECORD:
-OVERVIEW INFORMATION AND HIGHLIGHTS
-EXPLAINING THE SIGNIFICANCE OF THE PI‘S PUBLICATIONS (1)

TOP 10 SCIENTIFIC PUBLICATIONS in the last 10 years

Baudin T., De la Croix D., and P. Gobbi, Endogenous Childlessness and Stages of Development, **Journal of the European Economic Association**, forthcoming.

Measures the importance of opportunity driven and poverty driven childlessness in 36 developing countries with a structural model of fertility and marriage. Shows that the endogenous response of marriage and childlessness matter for determining the impact of social progress.

De la Croix D., M. Doepke, and J. Mokyr, Clans, Guilds, and Markets: Apprenticeship Institutions and Growth in the Pre-Industrial Economy., ***Quarterly Journal of Economics***, **133**, 1-70, 2018.

Compares growth under alternative institutions to deal with the moral hazard problem in master-apprentice relationship. Guilds and market-based systems allow knowledge to cross the family/clan boundaries. Guild adoption is more likely when initially in a nuclear family system.

source: David de la Croix, AdG- 2019, https://perso.uclouvain.be/david.delacroix/erc/UCL_delaCroix_UTHC_AdG_2019_B1.pdf

10 YEARS TRACK RECORD (2): EXPLAINING THE SIGNIFICANCE OF THE PI‘S ACHIEVEMENTS

Most important scientific achievements:

- Leading the scientific exploitation of the ANKE magnetic spectrometer at COSY (Jülich): this experiment has taken data for 15 years until 2014 and was a most successful detector system for unpolarized and polarized internal experiments: among its major achievements were precision data for proton-proton and proton-neutron elastic scattering at forward and backward angles and the mass of the η-meson as well as pion production data to test Chiral Perturbation Theory.
- Initiating the transfer of WASA from CELSIUS (Uppsala) to COSY to install it into COSY: this was a decisive step in order to add photon detection capability to the detector systems operated at COSY: it was operated until 2014; the main research goals were studies of symmetries and symmetry breaking in hadronic reactions and in meson decays; one additional achievement was the observation of a new resonance in double-pionic fusion reactions, which is interpreted as a di-baryon state.
- Initiating the PAX program for polarized antiprotons as a possible upgrade option for the antiproton project at FAIR/HESR (Darmstadt).
- Leading the spin-flip and spin-filtering experiments with protons at COSY – for this project, an ERC-AdG “POLPBAR” was awarded in 2010: as a major result it was shown that only spin-filtering is a viable method to produce an intense beam of polarized antiprotons for use in hadron physics experiments.
- Initiating the JEDI project with the final aim to search for Electric Dipole Moments (EDM) of charged particles in storage rings: this most ambitious project must be divided into a series of steps, ranging from R&D at COSY to the concept, the design and the construction and exploitation of a new high precision storage ring.

source: Hans Ströher, Advanced Grant srEDM, http://www.sredm-ercgrant.de/SharedDocs/Downloads/SREDM/EN/Documents/erc-application-b1.pdf?__blob=publicationFile

What is the key contribution of your project?
What happens if it is not funded now?
What is the biggest weakness of your approach?
….

picture the interview

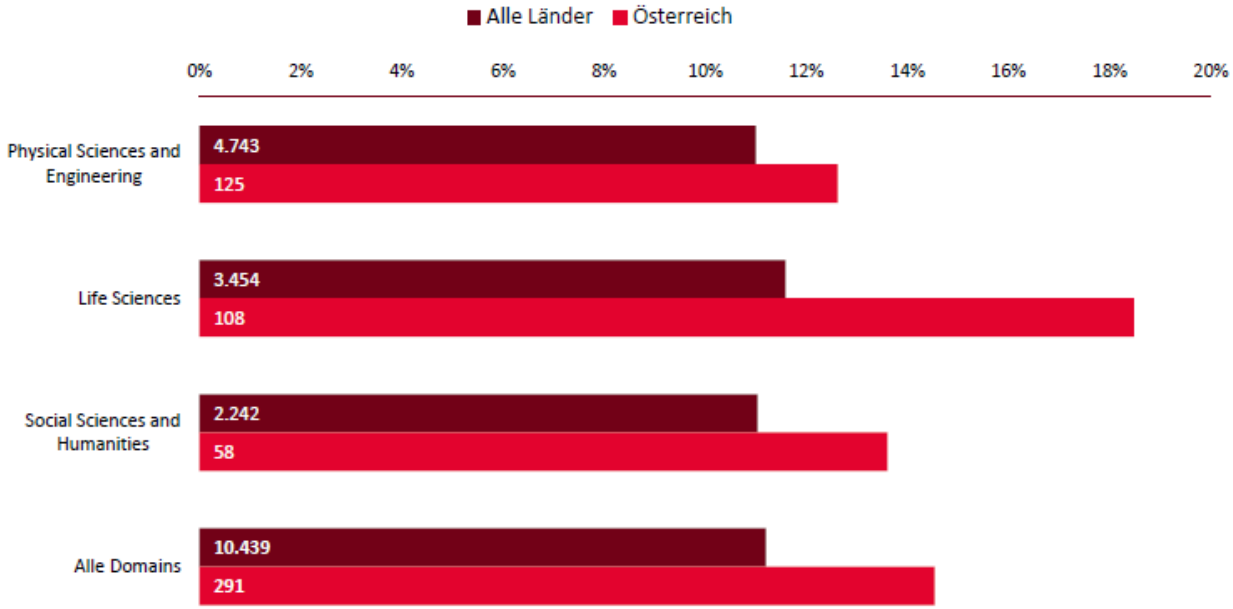
feedback-loops with specialists and generalists
generalists

EXAMPLE: PANEL PE6, 2018 ADVANCED GRANT
COMPUTER SCIENCE AND INFORMATICS

Panel Member	Areas of expertise (examples)
Daphna Weinshall (Chair)	Computer and human vision, machine learning
Susanne Albers	Algorithms and complexity
Lionel Briand	Software engineering
Luc De Raedt	Artificial intelligence
Peter Druschel	Distributed systems
Jeremy Frey	Human-computer-interaction (HCI)
Rosario Gennaro	Algorithms, interactive scientific software
Leonidas Guibas	Computer vision
Manuel Hermenegildo	Program development
Yannis Ioannidis	Database management systems
Jana Koehler	Algorithmic business and production
Matteo Maffei	Formal verification of security properties
John Mylopoulos	information modelling techniques
Philippe Palanque	Interactive critical systems
Stefan Schaal, Alistair Sutcliffe	Statistical and machine learning, HCI

Panel keywords (examples)ss
Computer architecture , ubiquitous computing,…
Computer systems , embedded systems, cyber-physical systems
Software engineering , computer languages,…
Theoretical computer science ,…quantum computing
Cryptology, privacy, security,…
Algorithms , algorithmic game theory,…
Artificial intelligence,….
Machine learning,…
Human-computer-interaction,…
Scientific computing,…

ERC GRANTS AND SUCCESS RATES PER DOMAIN



ERC PI Success Rates according to scientific domain, as of April 2021, FP7 + H2020; all frontier research grants

source: European Commision; EU-Performance Monitoring, FFG

USEFUL LINKS & FURTHER INFORMATION

- ERC homepage: https://erc.europa.eu/
- ERC evaluation panels: https://erc.europa.eu/document-category/evaluation-panels
- ERC funded projects database: https://erc.europa.eu/projects-figures/erc-funded-projects
- Funded ERC Proposals published online: FFG collection at https://www.ffg.at/europa/heu/erc/published-proposals
- For a **proposal check** by FFG (focusing on structural features): Please send your proposal to erc@ffg.at and ylva.huber@ffg.at by **August 6**, 2021 (e.g. **individual scheduling** of proposal arrival between July 15th and Aug. 6th)

FEEDBACK

menti.com

Voting code 9700 6820

Direct link will also be posted in the chat:

https://www.menti.com/eyinzwsptr

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