

Javni razpis za (so)financiranje raziskovalnih projektov za leto 2025

Naziv projekta:

Topološka stanja in dinamika polarizacije v feroelektričnih nanomaterialih (J1-70018)

Akronim projekta: **TOPOFER**

NAČRT ZA RAVNANJE Z RAZISKOVALNIMI PODATKI

Vodja projekta:

dr. Anna Razumnaya

Raziskovalna organizacija:

Institut »Jožef Stefan«

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0 Splošne informacije		
0.1	Šifra projekta	J1-70018
0.2	Naziv projekta	Topological states and polarization dynamics in ferroelectric nanomaterials (TOPOFER)
0.3	Datum začetka in konca projekta	01.03.2026 – 28.02.2029
0.4	Opis projekta z vidika ravnanja z raziskovalnimi podatki	The project investigates topological polarization states and their dynamics in ferroelectric nanomaterials. The research is based on the theoretical description of confined ferroelectric systems, in which long-range electrostatic interactions and material geometry can lead to complex polarization textures such as vortices, skyrmions, and Hopfions. The main objectives are to experimentally identify such states, develop methods for their three-dimensional reconstruction, and investigate their chirality. The project combines experimental characterization with numerical modelling and data analysis. Experimental data will be generated using structural, microscopic, spectroscopic, electrical, and optical techniques, including X-ray diffraction, scanning electron microscopy, atomic and piezoresponse force microscopy, Raman spectroscopy, and advanced STEM techniques. These measurements will provide information on material composition, morphology, crystal structure, polarization distributions and local physical properties. Computational data will be generated through phase-field modelling, numerical calculations and reconstruction procedures. Experimental and simulated datasets will be processed and combined to reconstruct three-dimensional polarization fields and to identify characteristic topological structures. Derived data will include processed microscopy datasets, reconstructed polarization and atomic-displacement maps, topological descriptors, statistical analyses and visualisations.
0.5	Šifra vodje projekta	59112
0.6	Ime in priimek vodje projekta	Anna Razumnaya
0.7	Ime in priimek osebe, ki je v RO zadolžena za podporo pri ravnanju z raziskovalnimi podatki	Zala Dvornik
0.8	Ime in priimek odgovorne osebe za ravnanje z raziskovalnimi podatki pri projektu	Anna Razumnaya
0.9	Elektronski naslov odgovorne osebe za ravnanje z raziskovalnimi podatki pri projektu	anna.razumnaya@ijs.si
0.10	Version and date of NRRP	1.0 (17.08.2026) 2.0

1	Povzetek in opis raziskovalnih podatkov	
1.1	Ali boste pri projektu ponovno uporabili že obstoječe podatke (lastne ali tuje)?	☒ Da ☐ Ne
1.2	Katere vrste podatkov boste ustvarili oz. ponovno uporabili in v katerih formatih bodo shranjeni?	The project will generate new experimental, computational and derived research data and will also reuse selected existing data from previous research. Most research data will originate from new experiments, simulations and data-processing procedures carried out within the project. Existing experimental datasets, previously developed phase-field models, topology-analysis methods, reconstruction algorithms and software tools will also be reused where relevant. Existing and publicly available experimental data may be used as reference data for comparison with newly generated results and for the development and validation of three-dimensional reconstruction methods. Reused datasets will be appropriately referenced and handled in accordance with the applicable licensing and intellectual-property conditions. Experimental data will be generated by structural, microscopic, and spectroscopic characterization of ferroelectric nanomaterials. These data will include X-ray diffraction patterns, scanning electron microscopy data, atomic and piezoresponse force microscopy measurements, Raman spectra, and advanced STEM datasets. Computational data will be generated mainly by phase-field modelling, numerical calculations and three-dimensional reconstruction procedures. They will include simulation input and output files, simulation parameters, reconstructed polarization distributions, image-processing workflows and results of topological analysis. Derived data will include processed data, reconstructed three-dimensional polarization maps, atomic-displacement and polarization maps, extracted topological descriptors, statistical analyses, data visualisations and publication-quality figures. Research software may include Python scripts, MATLAB codes, phase-field and reconstruction algorithms, image-processing workflows. The following file formats are expected to be used, depending on the experimental instrument or software: – <i>text documents</i>: LaTeX (.tex), PDF (.pdf), MS Office (.doc, .docx, .ppt, .pptx); – <i>spreadsheets and tabular data</i>: XLS/XLSX and CSV; – <i>microscopy and image data</i>: TIFF, JPEG, PNG, EPS, SVG, PDF and instrument-specific microscopy formats such as DM3/DM4 where applicable; – <i>spectroscopy and diffraction data</i>: ASCII/TXT, CSV and instrument-specific raw formats;

		– <i>three-dimensional and numerical data</i>: HDF5 (.h5), MATLAB (.mat), NumPy (.npy), VTK (.vtk), CIF (.cif), XYZ (.xyz), and XML; – <i>programming and analysis</i>: Python (.py), MATLAB (.m); – <i>metadata and configuration files</i>: XML, INI and other machine-readable formats. Open, non-proprietary and community-recognised formats will be preferred whenever possible to support long-term preservation, interoperability and reuse.
1.3	Kakšna je pričakovana velikost podatkov, ki jih nameravate ustvariti oz. ponovno uporabiti?	☐ 0–10 GB ☐ 10–100 GB ☐ × 100–1000 GB ☐ >1000 GB
2	Shranjevanje in varnostno kopiranje podatkov	
2.1	Kje bodo podatki med izvajanjem projekta shranjeni in varnostno kopirani?	During the project, primary and processed data will be stored on research computers with controlled access. Institutional storage and backup systems will be used for research data wherever available. Regular backups will be maintained to reduce the risk of data loss due to hardware failure or other unforeseen events. Data used for calculations may also be stored on the JSI computing infrastructure during analysis. Access to non-public working data will be restricted to authorised members of the project team.
2.2	V katerem zaupanju vrednem repozitoriju bodo objavljeni podatki v skladu z načelom »odprti, kolikor je mogoče, zaprti, kolikor je nujno«?	Research data supporting scientific publications will, where appropriate, be deposited in trusted research repositories in accordance with the principle “as open as possible, as closed as necessary”. The project proposal specifically foresees open publication of research data and analysis scripts through Zenodo (https://zenodo.org/). The JSI institutional/national repository DIRROS (https://dirros.openscience.si/) may also be used where appropriate. Datasets selected for deposition will primarily include data necessary for the verification, reproducibility, and interpretation of published scientific results, such as relevant experimental datasets, processed data supporting publications, selected simulation input and output files, reconstructed three-dimensional datasets, analysis scripts, and accompanying metadata. The selected repositories provide long-term preservation and digital curation and assign persistent identifiers, typically Digital Object Identifiers (DOIs), which enable stable access, citation, and reuse of deposited datasets.
3.	Zagotovitev podatkov na način FAIR prek repozitorijev	
3.1	Ali bodo vsi podatki odprto dostopni, upoštevajoč načelo „odprti, kolikor je mogoče, in zaprti, kolikor je nujno“? Če ne bodo,	☐ Da ☒ Ne Open access to research data will be partial, following the principle “as open as possible, as closed as necessary”. Research data supporting scientific publications will be

	pojasnite posebnosti glede dostopa.	made openly accessible whenever this is compatible with intellectual-property protection, publication requirements, third-party rights and technical feasibility. Raw data that are very large, redundant, or not required to reproduce the published results may not always be deposited in full. Data may also be temporarily restricted before publication or where disclosure could interfere with the protection of potentially exploitable intellectual property. Datasets supporting scientific publications will normally be made openly available at the latest at the time of publication of the associated scientific article, unless a justified embargo or restriction is required for intellectual-property or publication-related reasons. During the project, working and non-public datasets will be accessible only to authorised JSI project members. For datasets that cannot be made openly available after publication, access may be provided by the responsible researcher upon reasonable request, subject to intellectual-property, technical and legal considerations. Some datasets, especially numerical simulation outputs and reconstructed three-dimensional polarization fields, may require additional documentation, processing information or specific software for correct interpretation. Where relevant, README files, metadata, workflow descriptions and information about required software will therefore accompany the deposited data.
3.2	Kako boste omogočili uporabljivost vaših raziskovalnih podatkov (metapodatki, ključne besede, programska oprema, licence, drugo)?	Datasets deposited in trusted repositories such as Zenodo or DiRROS will be assigned persistent identifiers, typically Digital Object Identifiers (DOIs), according to the repository service. Deposited datasets will be accompanied by descriptive metadata. Depending on the dataset, metadata may include: – dataset title and short description; – creator(s) and institutional affiliation; – project identifier J1-70018; – scientific keywords; – material composition and sample identifier; – synthesis or fabrication method; – experimental or simulation conditions; – instrument and measurement method; – software used for data acquisition, processing or simulation; – processing status and version; – file formats; – date of creation; – licensing and access conditions. Where applicable, repository-specific metadata schemes or widely used generic schemes such as Dublin Core will be followed. For experimental datasets, additional discipline-specific information necessary for interpretation of the measurements will be included.

		Metadata will include descriptive scientific keywords reflecting the content of the datasets, such as ferroelectrics, nanomaterials, polarization, topological polarization textures, vortices, Hopfions, chirality, phase-field modelling, advanced electron microscopy, piezoresponse force microscopy and three-dimensional reconstruction. Standard terminology used in condensed matter physics, materials science, ferroelectrics, crystallography, spectroscopy, microscopy and computational materials science will be used. Material compositions will be identified using conventional chemical formulas and crystallographic conventions, and physical quantities and units will follow standard SI terminology wherever applicable. No dedicated project-specific controlled vocabulary is expected to be required. Datasets selected for public release will be accompanied by sufficient documentation to enable interpretation and reuse. This may include README files containing information on creators, sample or material identification, experimental or computational methodology, acquisition and processing conditions, relevant physical quantities and units, file structure and formats, software and software versions, processing workflow, licensing and access conditions, and the relation to the corresponding publication. Publicly released research data will preferably be licensed under the Creative Commons Attribution 4.0 International (CC BY 4.0) licence. This licence allows third parties to copy, distribute, adapt and reuse the data, including after the end of the project, provided that appropriate credit is given to the data creators and the source is cited. Where repository or intellectual-property conditions require a different licence, the applicable licence will be clearly indicated in the dataset metadata.
3.3	Kakšne postopke zagotavljanja kakovosti raziskovalnih podatkov boste uporabili?	Data quality will be maintained through established experimental, computational, and data-processing procedures designed to provide accurate, reliable, and reproducible results. Experimental measurements will be performed using calibrated and maintained research equipment and, where appropriate, repeated measurements or reference samples. Data from complementary techniques will be compared to verify consistency. For instance, structural and microscopic characterisation will be cross-checked using different complementary experimental methods. For numerical simulations, input parameters, boundary conditions and numerical convergence will be checked and documented. Simulation results will be compared with experimental observations, analytical calculations and, where relevant, with previously validated calculations or available atomistic-simulation data.

		Intermediate and final datasets used for scientific publications will be reviewed for consistency before publication.
4.	Etični in pravni vidiki	
4.1	Ali boste med izvajanjem projekta obdelovali, hranili, ustvarili ali ponovno uporabili občutljive osebne podatke oziroma posebne vrste osebnih podatkov?	☐ Da ☒ Ne The project does not involve the collection, processing, storage, creation or reuse of personal data, sensitive personal data, or special categories of personal data. The research concerns physical materials, experimental measurements, numerical simulations and derived research data.
4.2	Kako bo med raziskavo poskrbljeno za varnost podatkov in zaščito občutljivih podatkov?	Research data will be stored on JSI-managed storage systems and research computers with controlled access. Access to non-public working data will be limited to authorised members of the project team. Regular backups will be maintained wherever available, reducing the risk of data loss due to hardware failure or other unforeseen events. Data integrity will be supported by preserving original raw data, maintaining separate processed copies where appropriate, and documenting the main processing steps. Where data are transferred electronically, secure institutional or encrypted transfer methods will be used when necessary. The project does not involve sensitive personal data or special categories of personal data. Therefore, no additional protection measures specific to personal data are required.
5.	Drugi raziskovalni rezultati	
5.1	Ali boste poleg podatkov ustvarili ali ponovno uporabili tudi druge raziskovalne rezultate?	☒ Da ☐ Ne In addition to research data, the project will generate other research outputs, including: – analysis and reconstruction Python scripts; – phase-field simulation tools and numerical workflows; – data-processing and three-dimensional reconstruction procedures; – experimental and synthesis protocols; – physical ferroelectric nanomaterial samples; – scientific publications and accompanying supplementary materials. Digital research outputs that are relevant for the interpretation or reproduction of published results will, where appropriate, be documented and shared together with the corresponding datasets or through suitable repositories, in accordance with FAIR principles and subject to applicable intellectual-property conditions. Research scripts will be accompanied by appropriate documentation where needed for their reuse. Physical samples will be stored and handled according to standard JSI laboratory practice and their further scientific usefulness.

6.	Finančna sredstva	
6.1	Kakšni bodo stroški ravnanja s podatki in drugimi rezultati projekta po načelih FAIR in kako bodo kriti?	No dedicated additional budget is foreseen specifically for research data management or for the management of other research outputs. Data generation, processing, documentation, storage, backup, archiving, and preparation for reuse form part of the normal scientific work and existing institutional infrastructure of JSI. The project will primarily use existing JSI computing, storage, and backup infrastructure and trusted repositories that do not require specific deposition fees. Costs associated with preparation of data and other research outputs for publication, archiving or reuse will be covered from the project budget where eligible. No substantial additional costs for long-term data preservation are currently expected.