



QUASIMODO

QUAntum SIMulations with MulticOmponent ultracold atOms

QuantERA III · Call 2025 — Quantum Phenomena and Resources · 36 months, Aug 2026 — Jul 2029 · now in month 2



www.zilberberg.uni-konstanz.de/
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DE U Konstanz · DE MPQ · LT Vilnius U · ES ICFO & UAB · PL IF PAN · FR LKB / CNRS — full names and PIs below

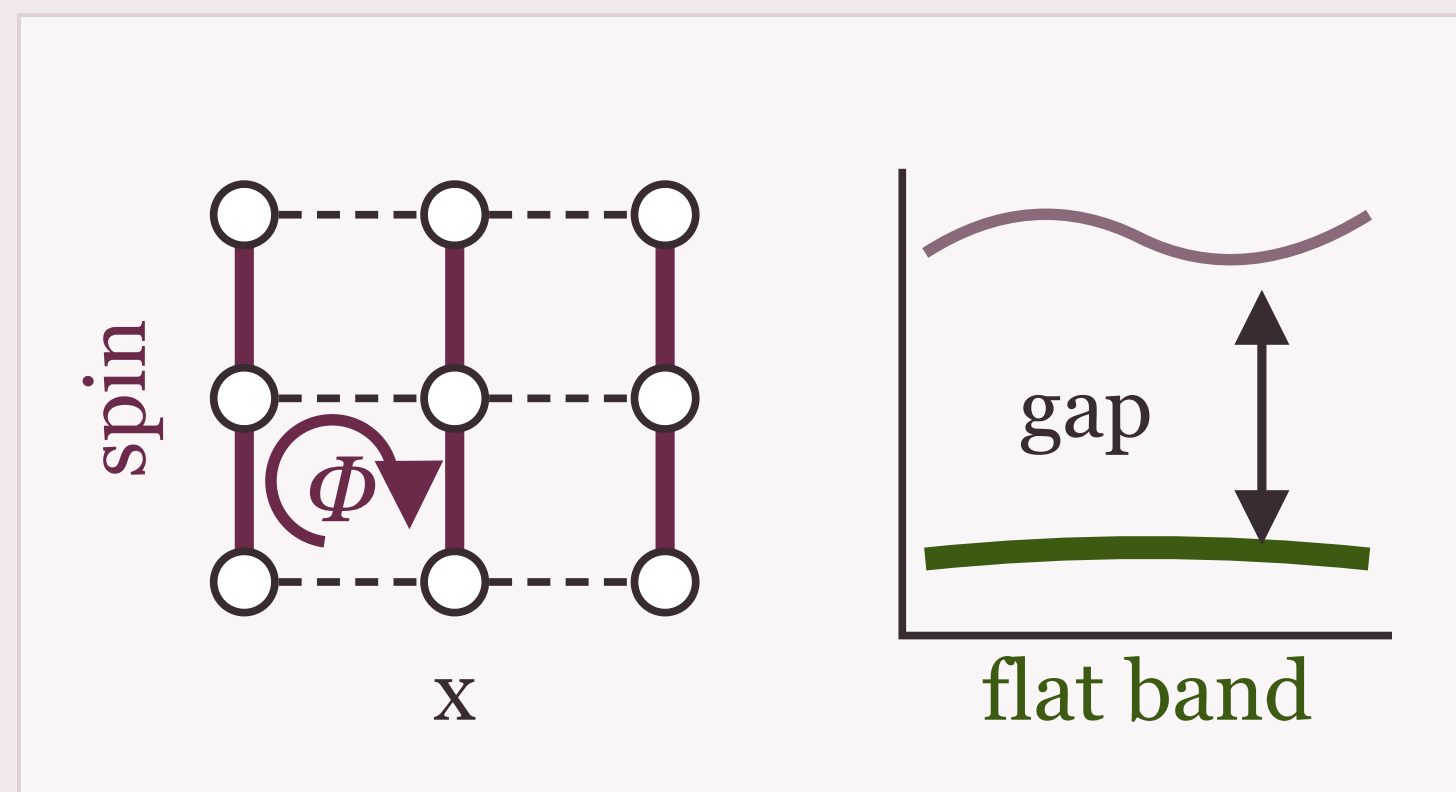
The question

Ultracold Dy, K and Yb atoms carry many internal states. Laser coupling between those states acts as an artificial magnetic field and turns the internal structure into an extra lattice dimension.

Strongly correlated and topological phases follow, with every term of the Hamiltonian under control.

Three barriers stand in the way: **heating** from the light that makes the artificial fields, the **diffraction limit** on lattice design, and no **direct probe of correlations**. QUASIMODO tackles all three.

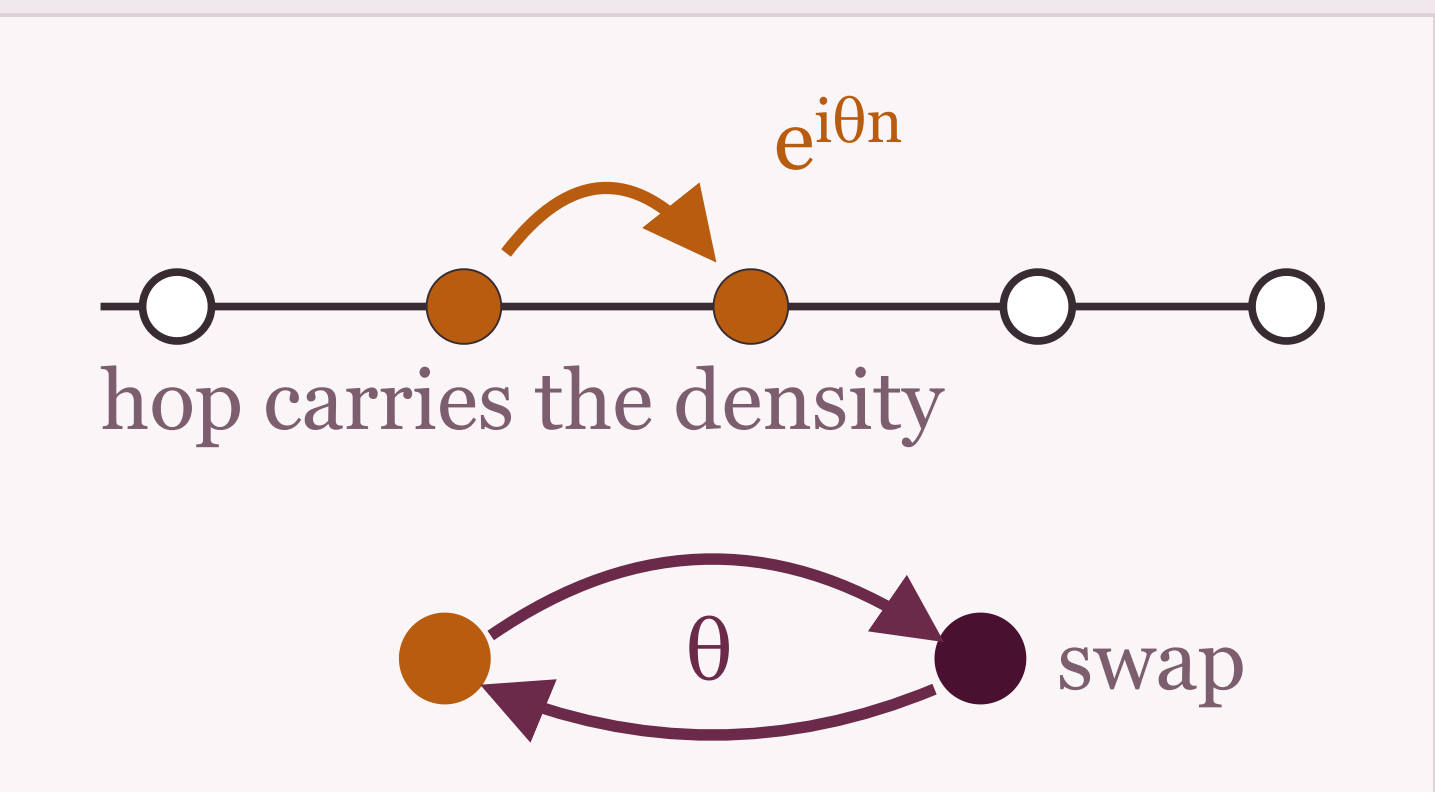
What we will build — four advances beyond the state of the art



WP1

Bigger gaps, flatter bands

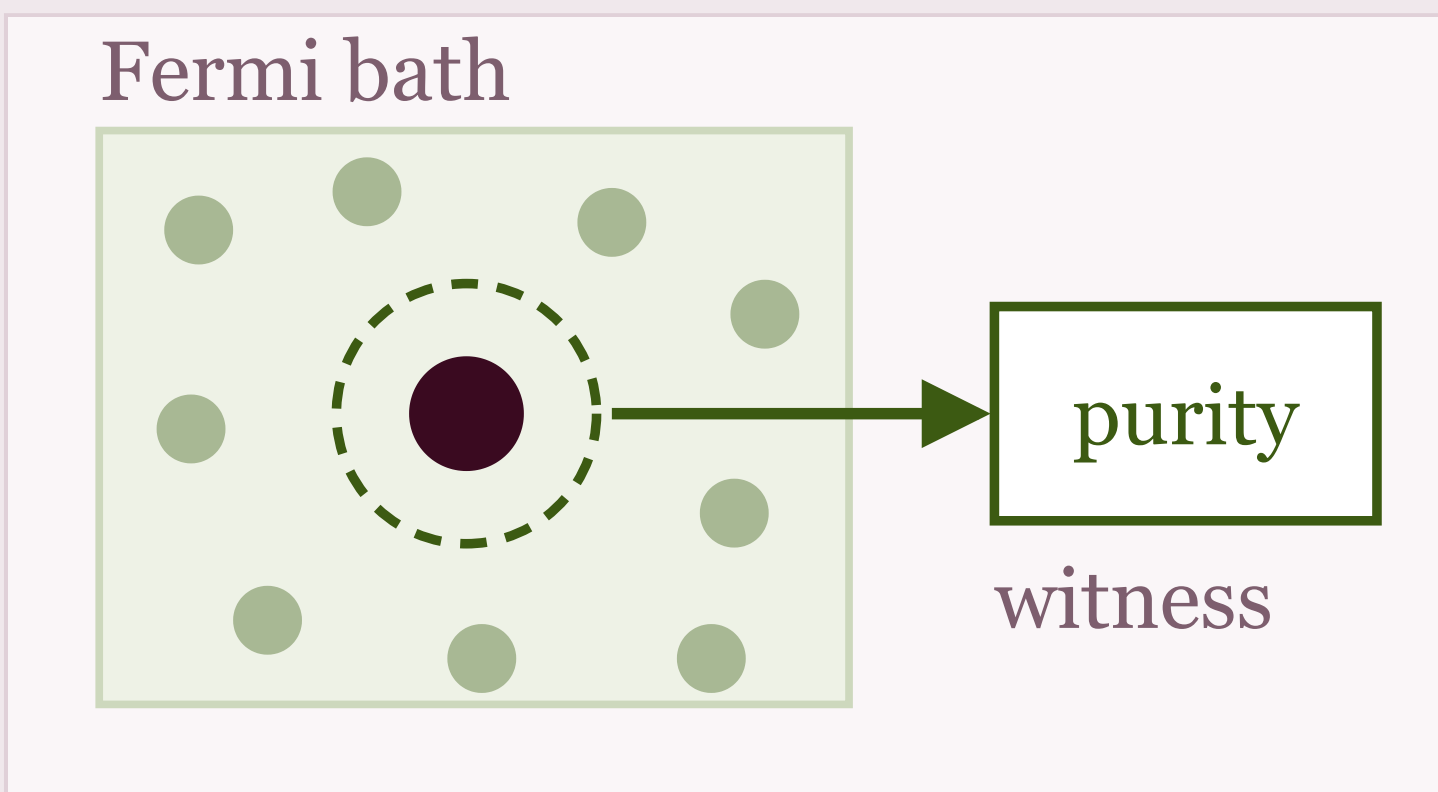
Spin states rescale the lattice: gaps become far larger than an optical lattice gives. Dark-state dressing flattens the band and stops the heating.



WP2

Interactions that carry a phase

Raman coupling between states of different scattering length makes the hopping phase depend on density: 1D anyons, ladders under a self-made flux.

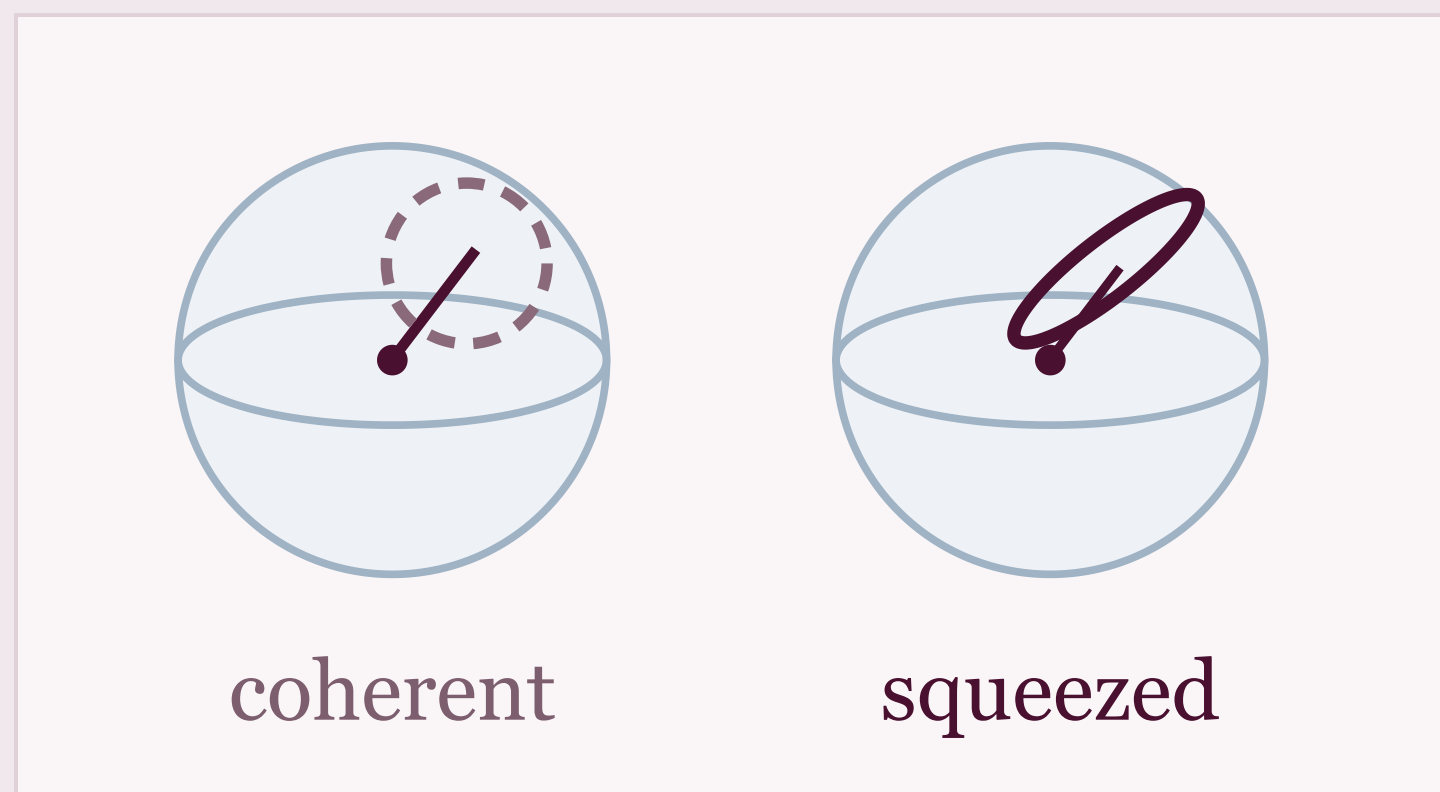


WP2

WP3

Impurities that witness entanglement

An Yb clock-state impurity screened by a Fermi bath. Its purity directly witnesses non-local entanglement, which can be soon measured in the lab.



WP1

WP3

Topology-protected squeezing

Entanglement between Dy atoms, plus non-classical spin states inside each one. The aim: squeezing that noise cannot undo, because topology holds it.

Approach — three work packages, each pairing experiment with theory

All 15 scientific tasks pair a theory node with an experiment node. **E** experiment **T** theory

● WP1 · M1–M36 · 73 PM

Novel spinor topological models

Dy at LKB · Yb clock states at MPQ

OBJECTIVE 1

Spinor topological models with large gaps, flat bands and protected, strongly squeezed spin states.

Led by LKB**E** and IF PAN**T**, with UKON**T**, MPQ**E**, VU**T** and ICFO**E****T**.

▲ WP2 · M1–M36 · 64 PM

Quantum correlations in minimal setups

Yb tweezers at MPQ · K Bose gases at ICFO

OBJECTIVE 2

Strong correlations in the smallest settings that host them: dressed impurities, anyons, frustrated magnets.

Led by ICFO**E****T**, MPQ**E** and VU**T**, with UKON**T**, IF PAN**T** and LKB**E**.

◆ WP3 · M1–M36 · 69 PM

Precision probes and correlations in 2D

Dy at LKB · Yb at MPQ · K lattices at ICFO

OBJECTIVE 3

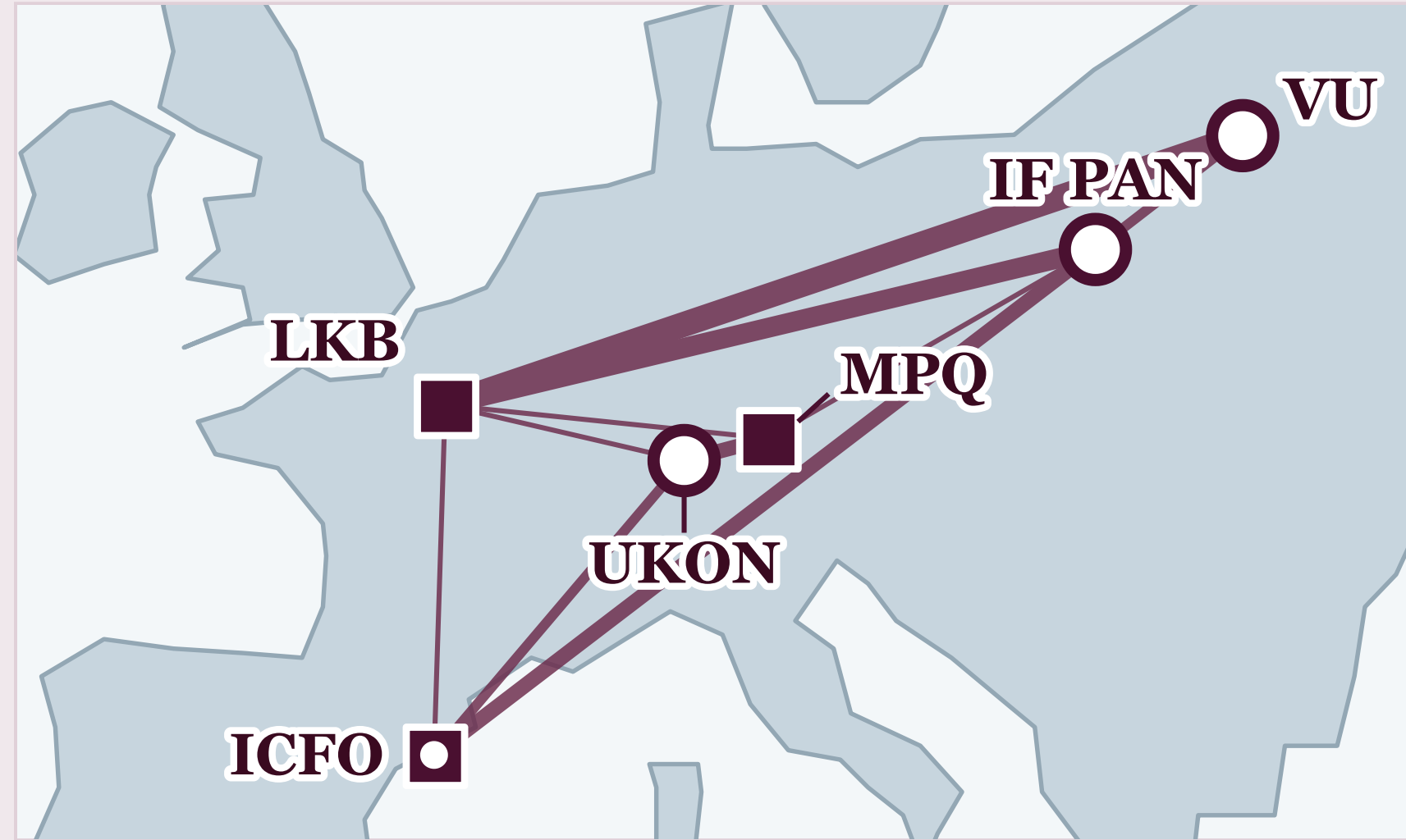
2D Hamiltonians with synthetic magnetic fields and π fluxes, plus probes that read out their correlations.

Led by VU**T**, IF PAN**T**, UKON**T** and ICFO**E****T**, with LKB**E** and MPQ**E**.

WP4 Coordination, communication and dissemination · 17 PM · led by UKON, all partners involved. Knowledge transfer between theory and experiment and, above all, between the three experimental platforms; project website at M3; two public events; intermediate and final reporting.

Consortium — three experiments, three theory groups, one feedback loop

■ experiment ● theory · map links drawn task by task from the responsible / involved columns, width = shared tasks (1–5), 11 of 15 pairs linked.



P1 · GERMANY **COORDINATOR**

University of Konstanz (UKON)

Oded Zilberberg · theory: tensor networks, field theory

P2 · GERMANY

Max Planck Institute of Quantum Optics (MPQ)

Monika Aidelsburger · experiment: Yb clock states

P3 · LITHUANIA

Vilnius University (VU)

Gediminas Juzeliūnas · theory: gauge fields, dark lattices

P4 · SPAIN

ICFO & U. Autònoma de Barcelona (ICFO)

Leticia Tarruell & Alessio Celi · exp + theory: K gases

P5 · POLAND

Polish Academy of Sciences (IF PAN)

Emilia Witkowska · theory: spin squeezing, entanglement

P6 · FRANCE

Laboratoire Kastler Brossel / CNRS (LKB)

Sylvain Nascimbène · experiment: Dy condensates

Timeline — three milestones, two public events



QuantERA III Call 2025: 39 projects funded from 287 proposals, by 34 agencies in 29 countries

dashed line: today, month 2 — no results yet



This project is funded by the QuantERA ERA-NET Cofund in Quantum Technologies implemented within the European Union's Horizon Programme.

Nationally funded by the Deutsche Forschungsgemeinschaft (UKON, MPQ), the Research Council of Lithuania (VU), the Agencia Estatal de Investigación (ICFO, UAB), the Narodowe Centrum Nauki (IF PAN) and the Agence Nationale de la Recherche (LKB / CNRS).

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6 partners · 5 countries · 223 PM · €1,377,011