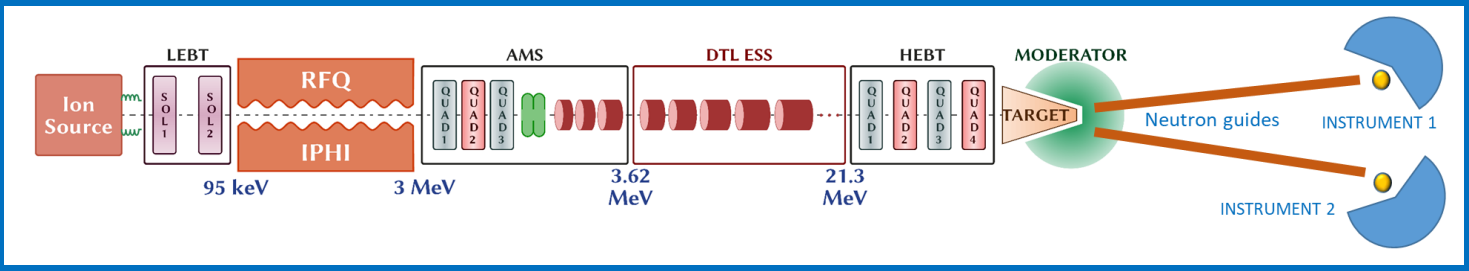
NEUTRONS FOR MATERIALS SCIENCE

In 10 questions

What is SONATE?

The SONATE project is a high brilliance neutron source whose objective is to become a materials science platform characterization using neutron scattering. The platform would eventually propose 10 neutron scattering spectrometers allowing experiments in various fields of solid state physics and chemistry. The performances of the spectrometers would be equivalent to these of the reactor Orphée.

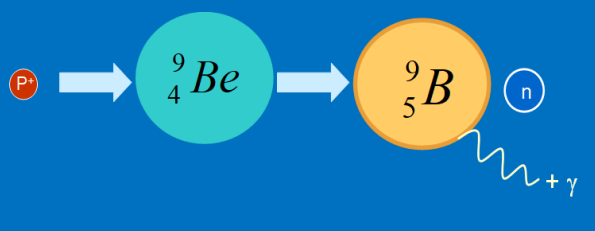


A high intensity (I_{peak} = 100mA) pulsed proton beam is sent on a beryllium target. Via stripping reactions, fast neutrons are produced. Neutrons are thermalized at temperatures of 20 to 300K to have wavelengths from 1 to 20 Å adapted to studies in chemistry and physics of condensed matter.

Why a compact source ?

A compact source uses a low energy accelerator (20-30 MeV) compared to spallation sources (1-2 GeV). The advantages are the following: (i) the cost of the facility is reduced, (ii) the facility can easily be adapted to the users needs, (iii) there is no production of high energy secondary particles (very fast neutrons and gammas rays) and hence the background is reduced, (iv) the facility is not a nuclear facility so that the regulations are relaxed. The production and moderation of the neutrons is performed in a reduced volume so that the source is more « brilliant ».

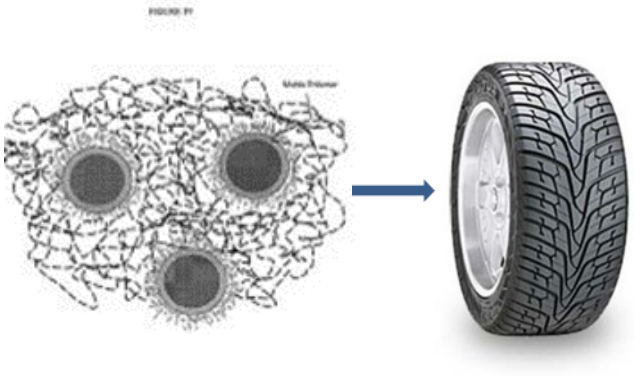
Neutron production via stripping reactions

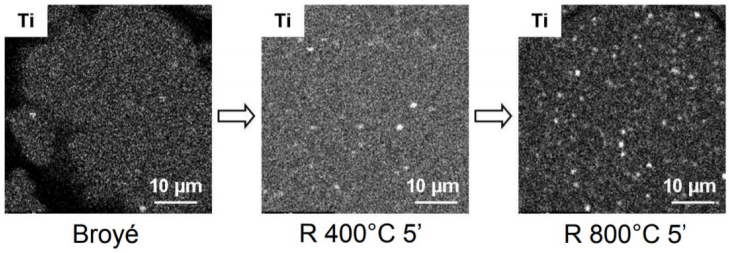


What are the applications in the field of composites materials ?

What mechanisms are at play to reinforce polymer composites using nanoparticle inclusions ?

How do oxide or nitride nanoparticles reinforce steels of the future?



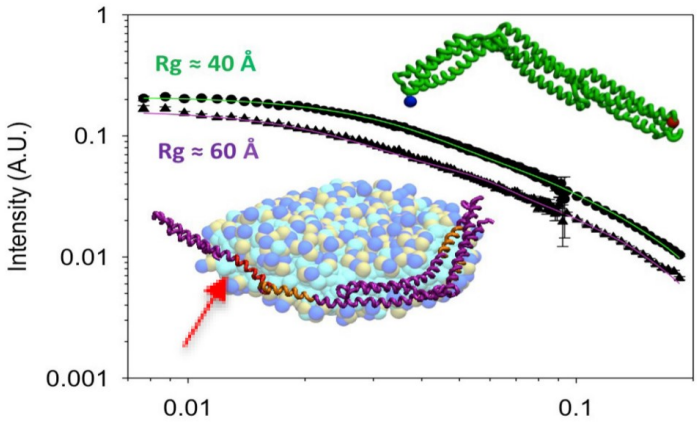


What will be the techniques available on SONATE?

- **SANS / Small Angle Neutron Scattering**
- **Reflectivity**
- **Radio-tomography**

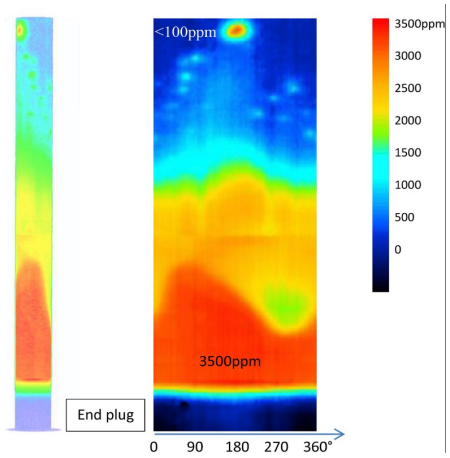
What are the applications in the field of health ?

SANS and reflectivity allow following the interaction of proteins with cell membranes related to diseases such as myopathy or the Alzheimer disease.

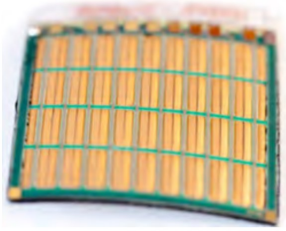


What are the applications in the field of energy ?

Neutron radiography allows the dosage of the hydruration and the fragilization of zircalloy fuel cladding in the case of a criticity accident in a nuclear reactor.

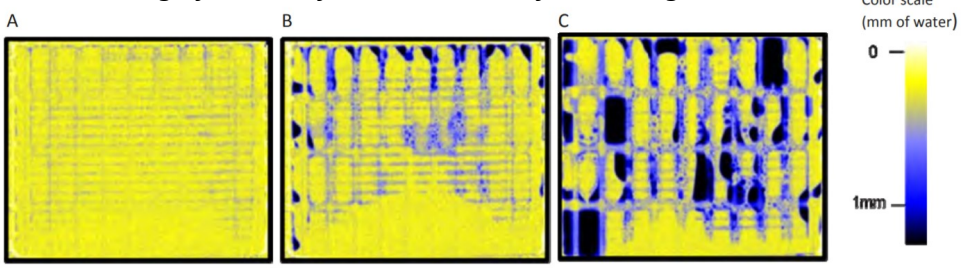


Neutron radiography allows following in-situ the operation of fuel cells or batteries.



Planar micro-PAC

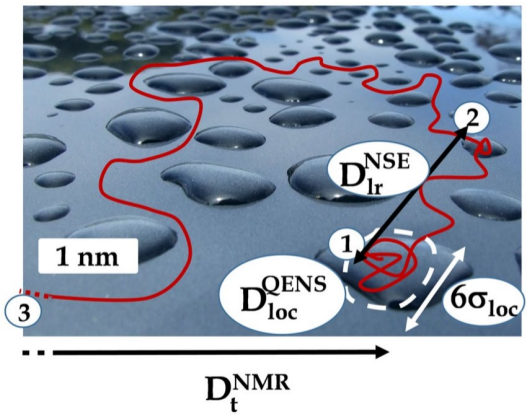
Drowning of a micro fuel cell in case of thermal gradients



Observe diffusion dynamics in electrolytes for batteries

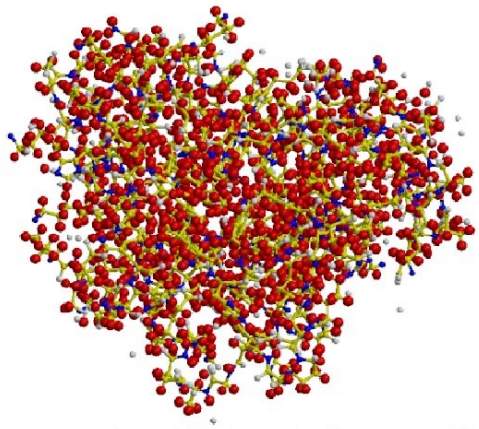
QENS and spin-echo spectroscopies allow the study of diffusion dynamics at various length scales.

Illustration of the nano-structuration of a ionic liquid and the consequences on the transport properties.



See proteins hydration

Neutron diffraction allows localizing water molecules around biological proteins to better understand their operation.

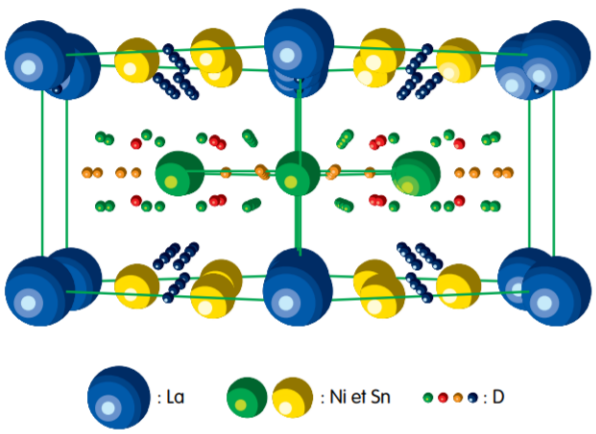


Tertiary structure of myoglobin determined by neutron diffraction

nitrogen, carbon, oxygen, hydrogen

Localize hydrogen atoms

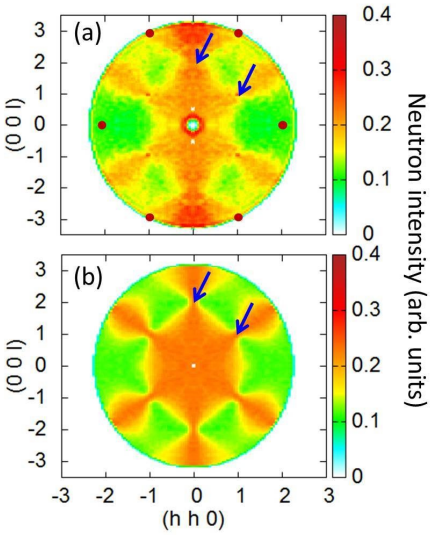
Neutron diffraction allow localizing hydrogen atoms in materials for hydrogen storage.



Unravel new complex magnetic structures

Diffraction, small angle scattering and neutron spectroscopy allow the study of new magnetic structures (skyrmions, vortices, frustrated skyrmions, spin glasses, magnetic fragmentation)

Magnetic diffraction related to the magnetic fragmentation of a spin ice.

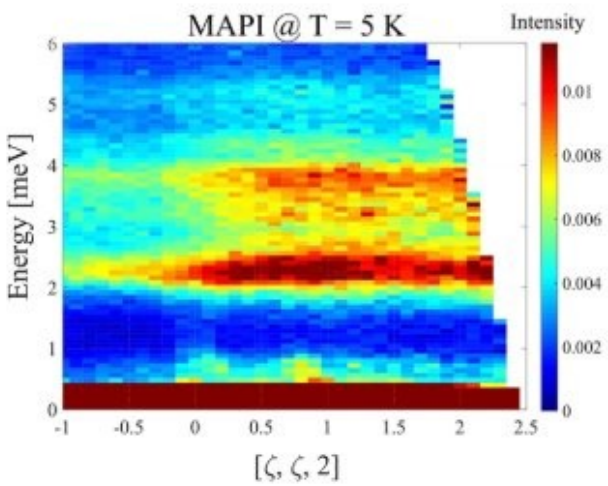


What will be the techniques available on SONATE?

- **Neutron diffraction**
- **Spectroscopy**

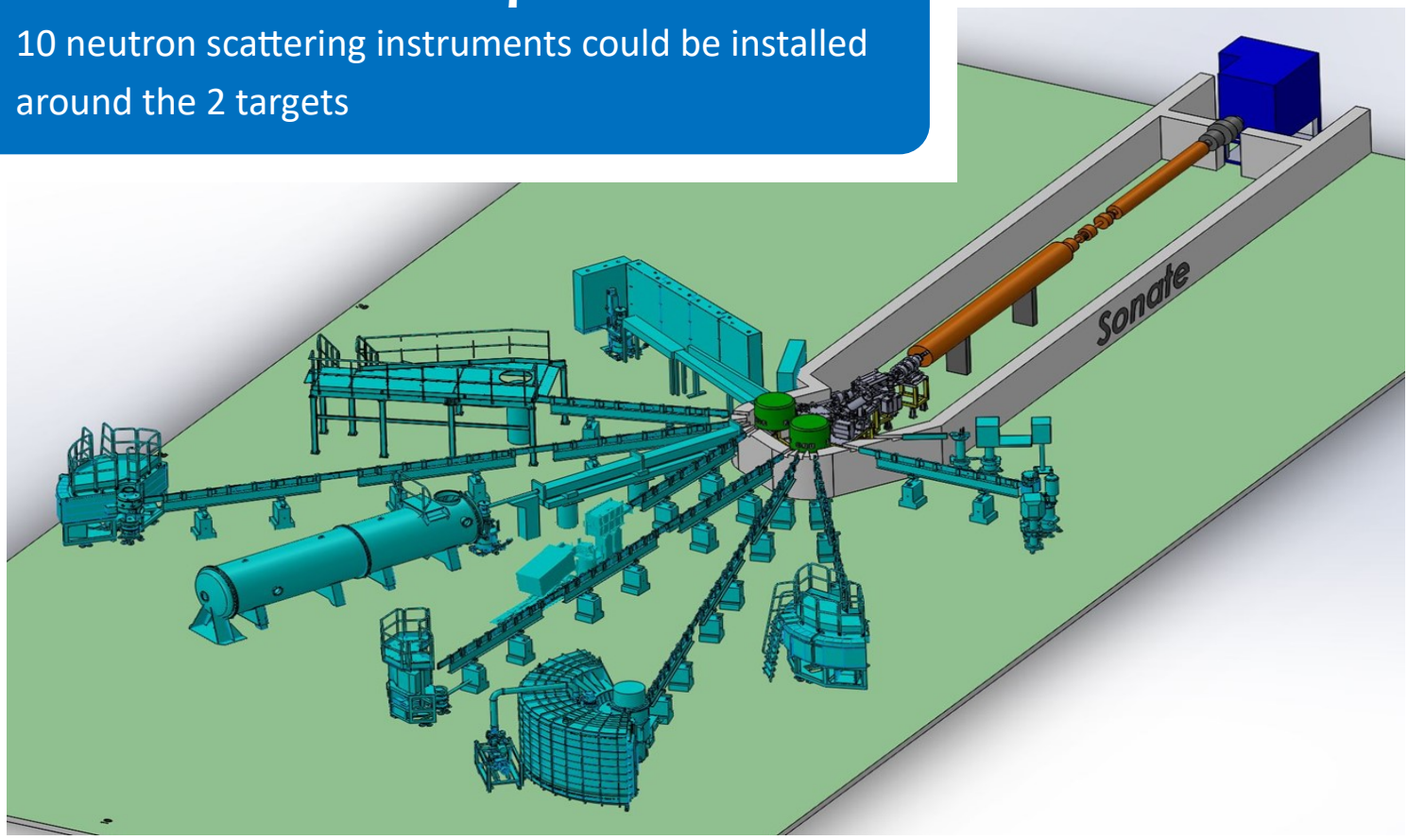
Measure lattice excitations in photovoltaic or thermoelectric materials.

Neutron spectroscopy allow measuring phonon dispersion curves in crystals.



How could the SONATE platform look like ?

10 neutron scattering instruments could be installed around the 2 targets



Who are the potential users of SONATE ?

France hosts about 1500 regular users of neutron scattering techniques and is the second publishing country behind the United States of studies using neutron scattering.

What the milestones of SONATE ?

- IPHI—NEUTRONS demonstrator
- Conceptual Design Report
- SONATE Phase 1 Construction (5 instruments)
- SONATE Phase 2 Upgrade (10 instruments)
- Technology dissemination

Whom to contact for more information ?

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What are the financial supports of the SONATE project ?

The IPHI-Neutron demonstrator is supported by the region via a SESAME project. îledeFrance

Compact Neutron Sources are a priority program of the CEA.