

# Solid State Ion-dynamics in Materials for Future Energy Devices

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One of the most important scientific problems to solve for our modern society is how to convert and store clean energy. In order to accomplish a paradigm shift in this field we need to understand the fundamental dynamical processes that govern the transfer of energy on an atomic scale. For future energy devices like solid-state batteries (SSB) as well as solid-oxide fuel cells (SOFC) this means understanding and controlling the complex mechanisms of ion diffusion in solid matter. Only recently, developments of state-of-the-art large scale experimental facilities e.g. neutron/muon spallation sources as well as free electron lasers, have opened new possibilities for studying such intrinsic material properties in a straightforward manner.

Layered transition metal oxides (TMOs) have been extensively studied both for their correlated electronic properties (frustrated magnetism and superconductivity) as well as for energy applications e.g. Li-ion batteries or thermoelectrics. Recently these two fields have been unified under the framework of the layered  $\text{Na}_x\text{CoO}_2$  family where Na-ion vacancy order as well as dynamics has been shown to tailor low-temperature magnetic and thermoelectric properties. In addition, room-temperature sodium batteries are currently receiving considerable attention since the available lithium reserves of our planet are very limited. In many ways the  $\text{Na}_x\text{CoO}_2$  compound is the Na-analog of the most common Li-ion battery electrode  $\text{Li}_x\text{CoO}_2$ . Hence, understanding Na-ion diffusion mechanisms of  $\text{Na}_x\text{CoO}_2$  would seem a logical first step. Consequently, we have conducted systematic studies of this compound using neutron powder diffraction (NPD) [1], quasi-elastic neutron scattering (QENS) [2] and muon spin relaxation/rotation ( $\mu\text{SR}$ ) [3-4] as a function of temperature as well as Na-content ( $x$ ) and pressure [5].

In this talk I will show how our use of neutron scattering and  $\mu\text{SR}$  has established a novel and detailed insight into the ion diffusion mechanisms in this group of compounds. Further, such knowledge now allows us to contemplate and actively consider future possibilities for tuning fundamental physical properties as well as solid state engineering of energy related materials with improved functional properties.

## REFERENCES

- [1] M. Medarde, M. Månsson et al., Physical Review Letters, 110, 266401 (2013)
- [2] F. Juranyi et al., publication in progress
- [3] J. Sugiyama, M. Månsson et al., Physical Review Letters, 103, 147601 (2009)
- [4] M. Månsson et al., Submitted for publication
- [5] Y. Sassa, M. Medarde, M. Månsson et al., publication in progress

**Primary author:** Dr MANSSON, Martin (Laboratory for Quantum Magnetism (LQM), EPF Lausanne)

**Co-authors:** Prof. BATLOGG, Bertram (ETH Zürich); CHEPTIAKOV, Denis (Paul Scherrer Institut); Dr POMJAKUSHINA, Ekaterina (LDM, PSI, Switzerland); Dr JURANYI, Fanni (LNS, PSI, Switzerland); Prof. OTT, Hans Rudolf (ETH Zurich, Switzerland); Dr LORD, James S. (ISIS, UK); Dr GAVILANO, Jorge (LNS, PSI, Switzerland); Dr SUGIYAMA, Jun (Toyota Central Research and Development Labs., Japan); Dr KAMAZAWA, Kazuya (CROSS, Tokai, Japan); Dr MEDARDE, Marisa (Paul Scherrer Institut); Mr MENA, Mattia (LNS, PSI, Switzerland); Dr GIBLIN, Sean (Cardiff University, UK); Prof. TAKEUCHI, Tsunerhiro (Nagoya University, Japan); Dr POMJAKUSHIN, Vladimir (LNS, PSI, Switzerland); Dr SASSA, Yasmine (ETH Zurich, Switzerland)

**Presenter:** Dr MANSSON, Martin (Laboratory for Quantum Magnetism (LQM), EPF Lausanne)

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