Contribution ID: **126** Type: **Contributed Oral**

μ+SR for a Sustainable Society

Monday, 21 July 2025 13:10 (20 minutes)

Establishing a sustainable society is one of the 21st century's grand challenges. A key barrier is the efficient harvesting, storage, and use of clean energy. Addressing this requires developing new generations of functional materials and devices with advanced energy and quantum properties, which in turn demands control over matter at the nanometer, atomic, and subatomic scales.

In this talk, I will show how μ^+SR is a unique and powerful technique for probing energy-relevant materials [1,2]. μ^+SR provides microscopic insight into ion mobility, electronic properties, and phase behavior, often inaccessible by other methods.

I will illustrate this with our recent studies of ion dynamics in both anode [3] and cathode [4] materials for rechargeable batteries, as well as in hybrid perovskites used in photovoltaics [5]. These findings shed light on key mechanisms affecting device performance and stability.

Finally, I will highlight the muon's broader role as a quantum probe [6], vital for the future design of sustainable quantum materials and technologies. Through μ^+SR, we aim to support the transition from today's inefficient electronics to next-generation, energy-efficient quantum devices.

[1] Sugiyama, Phys. Rev. Lett. **103**, 147601 (2009)
[2] Månsson, Phys. Scr. **88** 068509 (2013)
[3] Forslund, Carbon Energy, *Accep.* (2025)
[4] Nocerino, Sust. Ener. Fuels, **8**, 1424 (2024)
[5] Papadopoulos, Adv. Phys. Res. **3**, 2300120 (2024)
[6] Sassa, *Subm.* (2025)

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Funding Agency

Swedish Research Council (VR), Knut & Alice Wallenberg Foundation, Swedish Foundation for Strategic Research (SSF)

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Session Classification: Oral Contributions

Track Classification: Energy storage materials