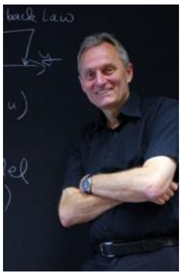

Contribution ID: **9**

Type: **Poster**

A compositional, energy-based software framework for modeling mechanical, electromagnetic and thermodynamic systems

Monday 26 May 2025 17:10 (1h 50m)

This talk introduces a compositional, energy-based modeling language for classical mechanics, electromagnetism, and irreversible thermodynamics. The formal, domain-specific language has a graphical syntax, whose expressions are morphisms in a symmetric monoidal category. This enables the straightforward modular and hierarchical composition of complex systems from simpler subsystems. Primitive subsystems are classified into energy storage, reversible energy exchange, and irreversible processes.

The proposed framework builds on established theories, including port-Hamiltonian systems, bond graph notation, and the metriplectic or GENERIC formalisms. Additionally, some category theory is applied to ensure a well-behaved, compositional structure. Unlike general-purpose modeling languages such as Modelica, which handle unstructured differential-algebraic equations, this framework is specifically designed for physical systems, having a structure that ensures adherence to principles such as the first and second laws of thermodynamics.

After summarizing the theoretical setup, the talk presents a prototype implementation of the modeling language, as a first step toward practical applications. It concludes with reflections on potential directions for future work.

Author: LOHMAYER, Markus (FAU Erlangen-Nürnberg)

Co-authors: LYNCH, Owen (University of Oxford); LEYENDECKER, Sigrid (FAU Erlangen-Nürnberg)

Presenter: LOHMAYER, Markus (FAU Erlangen-Nürnberg)

Session Classification: Poster Blitz & Poster Section