



European Materials Modelling Council

European Materials & Modelling Ontology

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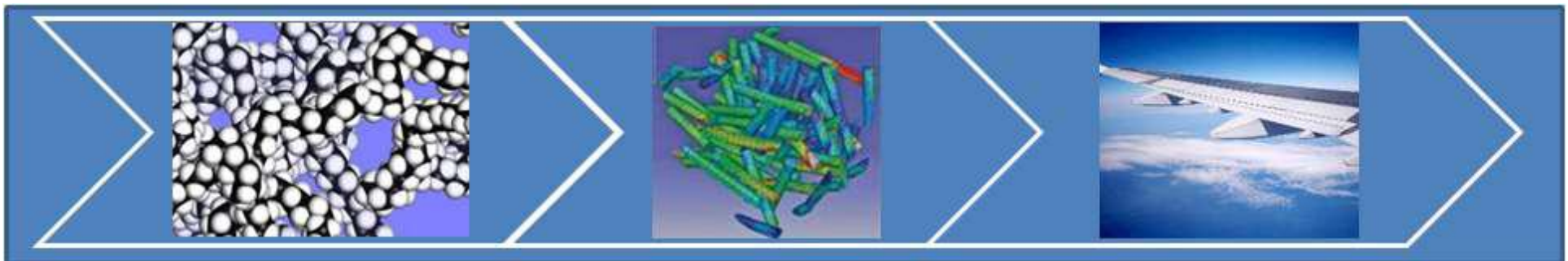
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Application Domain

- Applied Sciences, including applications in
 - Materials science: modelling, characterisation etc
 - Chemistry: modelling, analytical, formulations etc
 - Physics: e.g. representations of a system in terms of different interpretations of quantum mechanics
 - Engineering: components and systems, processes etc



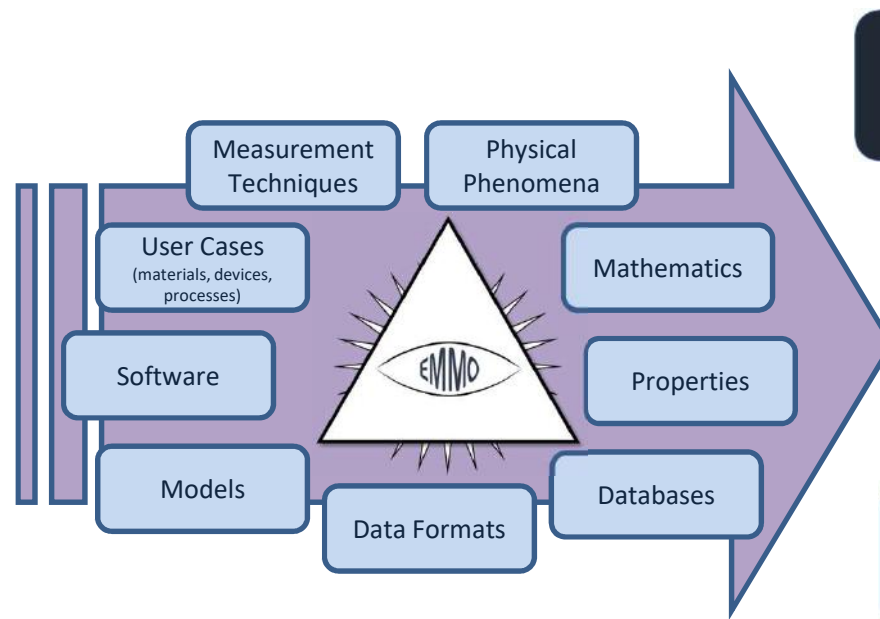
Intended Purpose

- EMMO is a tool connecting Materials User Cases to Models, Characterisation etc, incl. Inference, organising concepts according to scientific and mereotopological principles
- EMMO supports Interoperability, Data organisation, Databases integration, Translation etc.



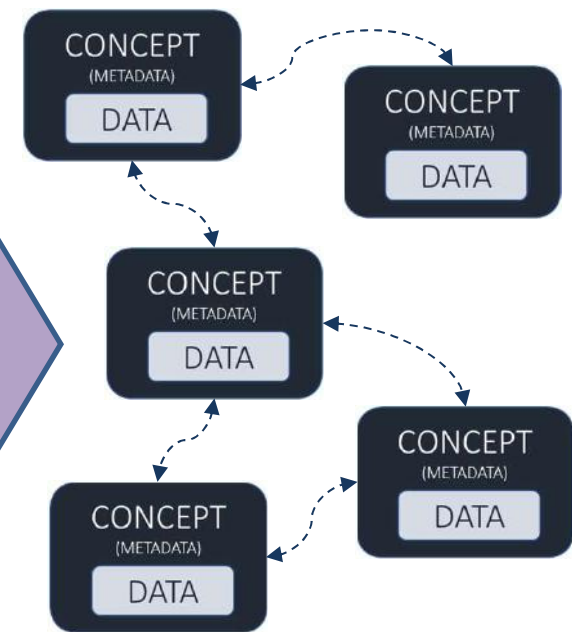
USER CASE

From real world entities
at different scales...



ONTOLOGY

...through a formal knowledge-
based representational system...



INFORMATION

...to a digital representation
and knowledge management.

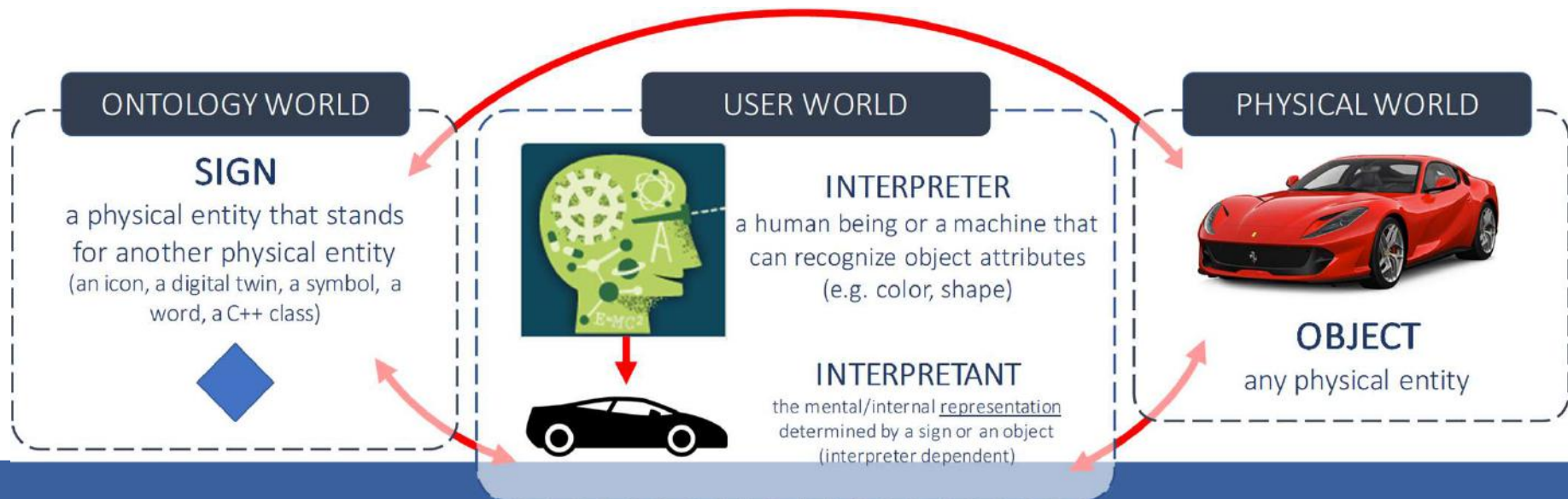


Representation language and Implementation

- EMMO is implemented in OWL-DL (Description Logic)
- It draws on Mereotopology (MT) which is a First Order Logic (FOL) theory,
- FOL MT can be used as a tool at the EMMO 'Interpreter' level, to enable understanding what EMMO OWL entities stand for in the real world.
- Future work may develop a FOL version of EMMO.

Knowledge represented

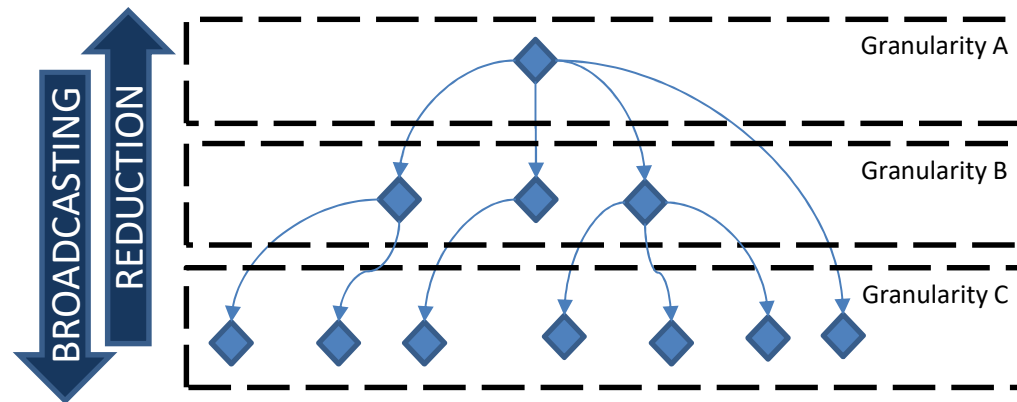
- Semiotics, Nominalism, Mereotopology, Set Theory
- EMMO is rooted in a strict form of nominalism
 - Real-world objects are represented by signs, where the relation between signs and object only exists via the interpreter: non-existence of universals!
 - everything (i.e. signs, interpreters and objects) exists in space and time. There are no abstract objects outside space and time.



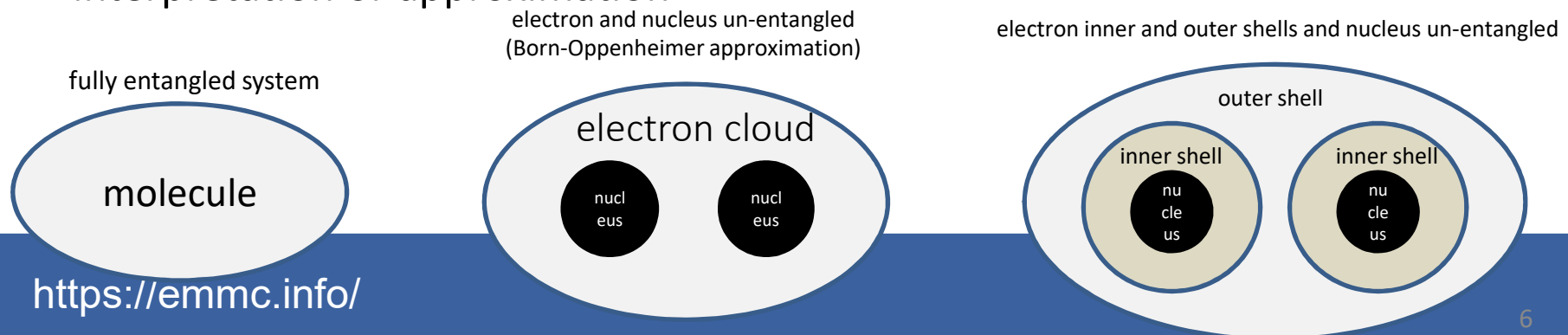
Representing granularity

- EMMO covers continuum and discrete representations

By defining the mereological relation of direct parthood, EMMO is able to describe entities as made of parts at different level of granularity. The individuals form a directed rooted tree



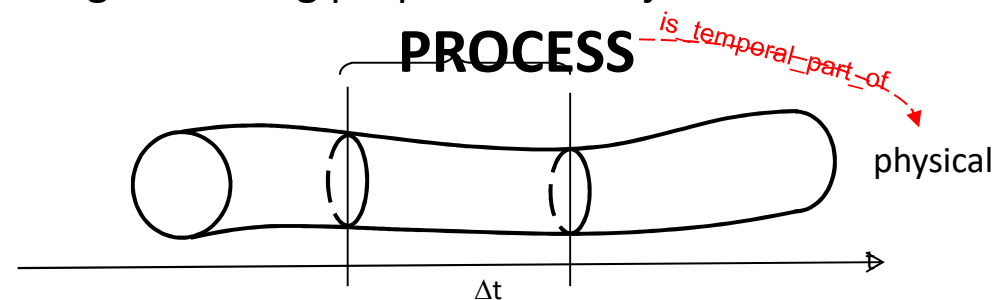
- EMMO covers quantum systems: declaring parts based on the relevant QM interpretation or approximation





Representation of processes

- EMMO is about describing the 'real world', i.e. things that we perceive (we can interact with). The real world is within a 4D spacetime.
- Real world objects can be processes: objects evolving in time.
- Classes of processes can be defined as required/relevant, e.g.
 - OBSERVATION: A process that involves an observer that perceives other physicals by interacting with them and track instants or intervals of their evolutions in time.
 - MEASUREMENT: An observation that results in a quantitative comparison of a physical property with a standard reference.
 - EXPERIMENT: A process that is aimed to replicate a physical phenomena in a controlled environment.
 - MANUFACTURE: A process aiming at altering properties of objects towards a desired property

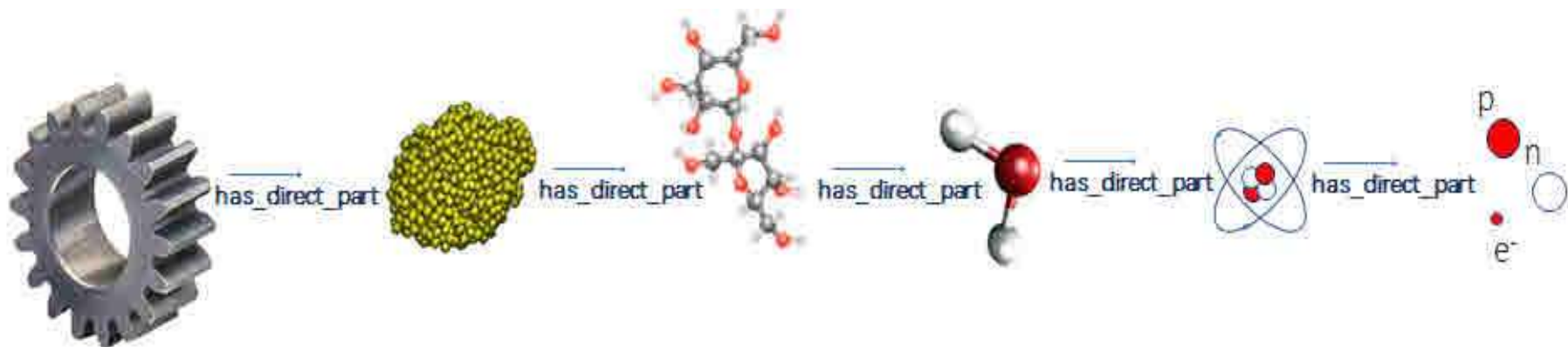




Capturing of materials

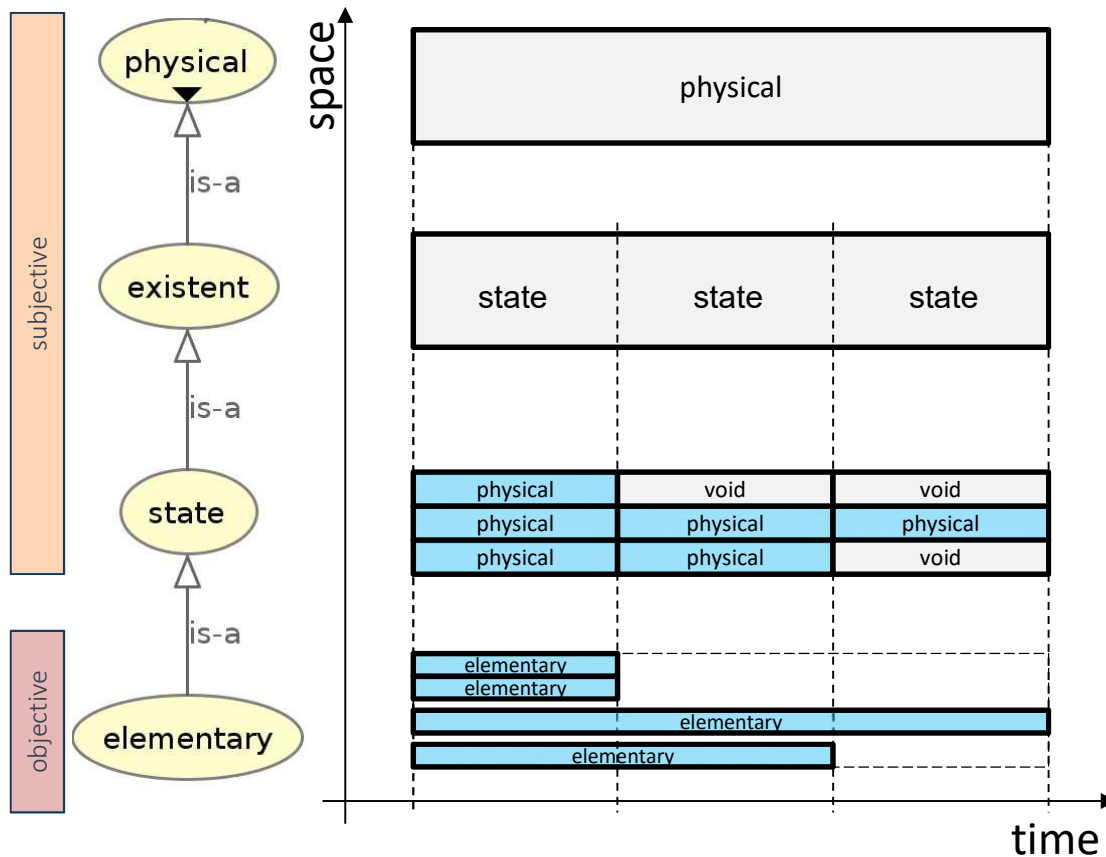
EMMO Material Entities are defined by a Hierarchy of parthood relations, including the NEW concept of **direct parthood**

Material can be represented at different levels of granularity.
Hierarchy of structure can be univocally defined.



- **Elementary:** the fundamental, non-divisible, constituent of entities

Capturing Materials



The **EMMO** identifies a parthood hierarchy in **physicals**, by introducing the concept of:

- **elementary** as the fundamental, non-divisible, constituent of entities (i.e. atomistic mereology)
- **state** as a **physical** whose parts have a constant cardinality during its life time (similar to endurants)
- **existent** as a succession of **states** (similar to perdurants)

so that a **physical** entity can be defined using a multiscale perspective.

An elementary particle, that expresses some fundamental physical properties (e.g. mass, charge, spin) can be represented by an **elementary** in a physics ontology.

However, in another material ontology an **elementary** can be something else, depending on the perspective (e.g. a brick for a LEGO ontology, a furniture component in a IKEA ontology)



Capturing manufacturing

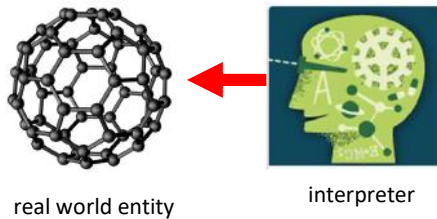
- EMMO Physicals can represent any real world object and process, including manufacturing.
- See also previous slide on Processes.



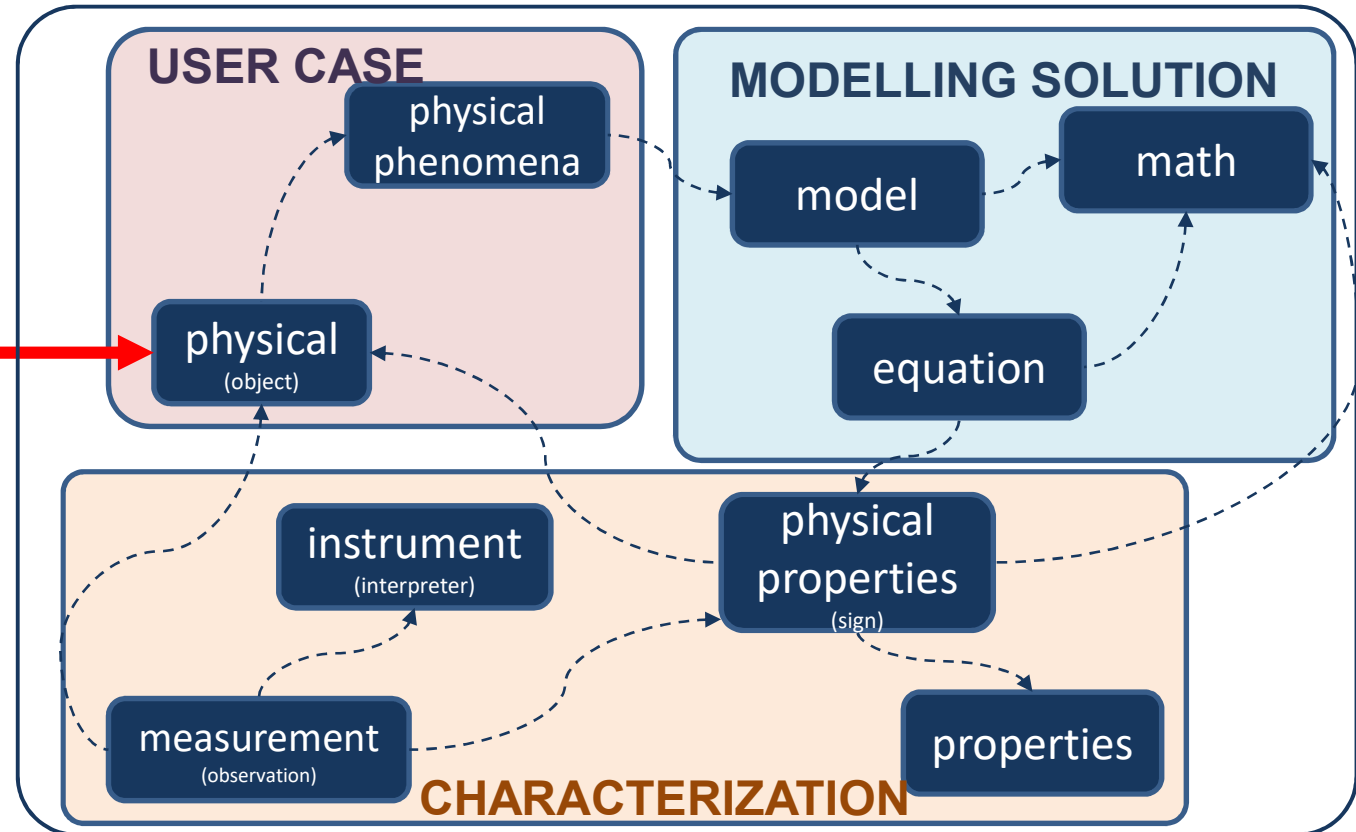
Connection between physical properties, materials models and measurement

Horizontal interoperability:

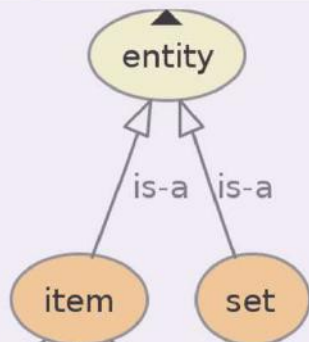
one user case, multiple modelling solutions.



Linking between properties database, models and user cases to facilitate validation and data collection.



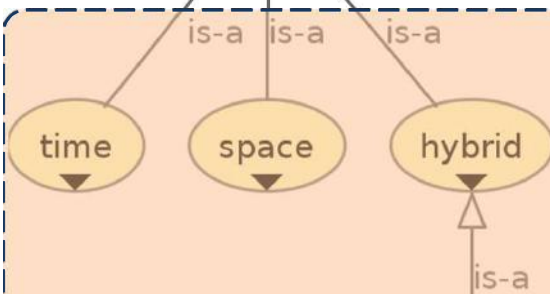
Upper level concepts, with definitions



ABSTRACT CONCEPTUAL LEVEL

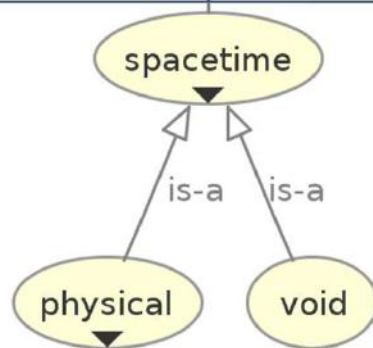
Clear separation between **set** (set theory) and **item** (mereotopology). **set** individuals are collection of **items** according to defined concepts (e.g. red entities). **item** individuals stand for something that is 'real', i.e. a 4D portion of the universe.

Abstract concepts are represented as the **sets** that concretize them (e.g. friendship is the collection of all friendship acts)



GEOMETRIC/TOPOLOGICAL LEVEL

items unfolds in space (3D) and time (1D) and can be sliced in pure **time**, pure **space** or **hybrid** space and time entities.



PHYSICAL LEVEL

Real world entities exists only in full 4D **spacetime** (3D space and 1D time).

A **spacetime** that can be perceived by (interact with) the interpreter is a **physical**.

If the **spacetime** entity is empty in terms of perception, it is a **void**.



Industrial use cases



European Materials Modelling
Council - CSA

2019

EMMO foundations
laid within this CSA
project.



Digital Ontology-based
Modelling Environment for
Simulation of materials

2022

EMMO applications cases
and integration within a
OSP expected within
2020-2021.

Team of philosophers, ICT experts and
applied scientists.



Materials Modelling
Marketplace for Increased
Industrial Innovation
Virtual Materials Market Place

2022

2021

EMMO applied to larger
materials modelling
communities and
marketplaces
infrastructures.



... more **existing projects** to involve and more to come in the **next DT-NMBP calls** (hopefully)!!!



Overlaps with other taxonomy and/or ontologies

- EMMO is a tool.
- There is no application of EMMO (yet) which would overlap with existing semantic assets.
- EMMO allows for semantic connection to existing domain ontologies.