Modelling and characterisation interoperability facilitated by EMMO

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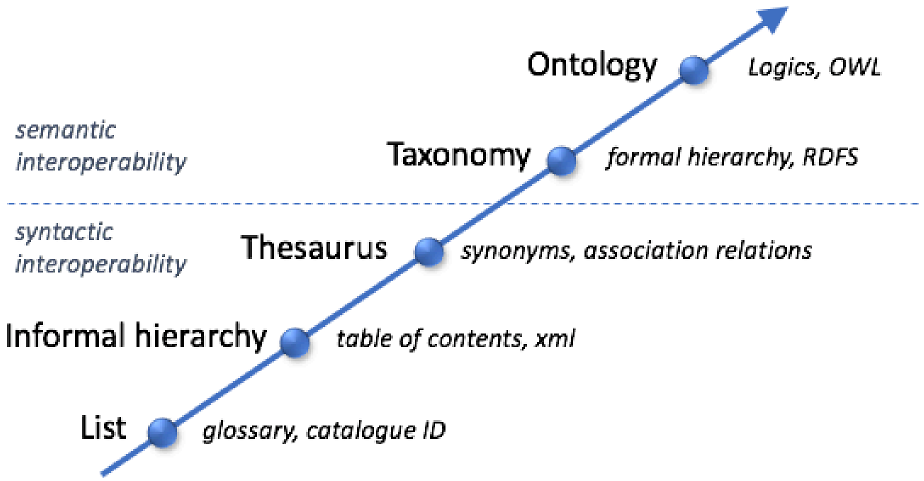
Motivation

- Knowledge graphs are useful to describe complex scientific data
  - can describe unstructured data and how they are interrelated
  - typically realised with RDF (subject, predicate, object) triples
  - may be unstructured (without or with weak schema)
- Ontology – can be seen as a schema for a knowledge graph
  - EMMO fills the role as a **strong schema** for knowledge graphs for applied sciences
  - enable reasoning

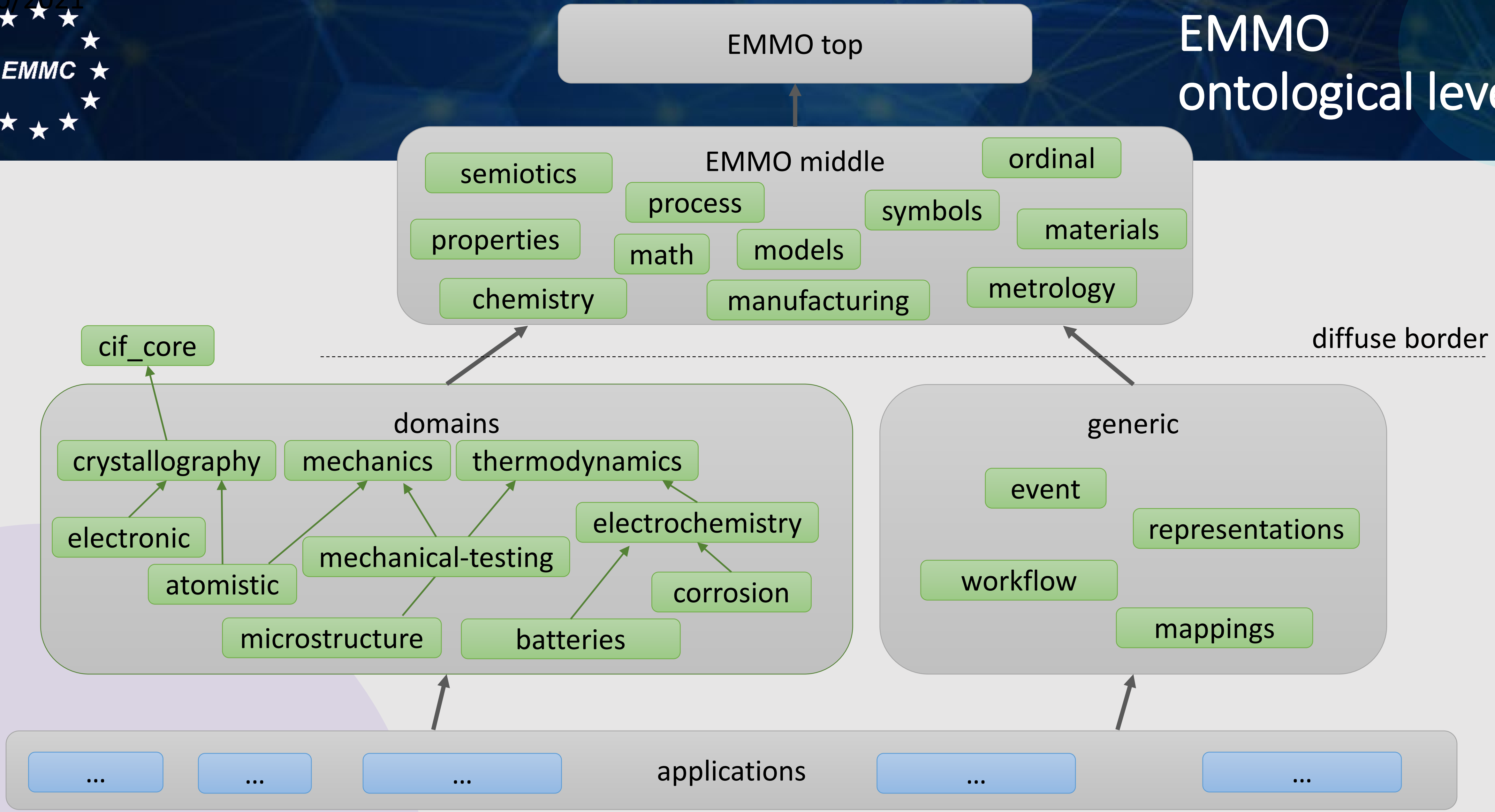


Source: Geoff Gross, Osthus

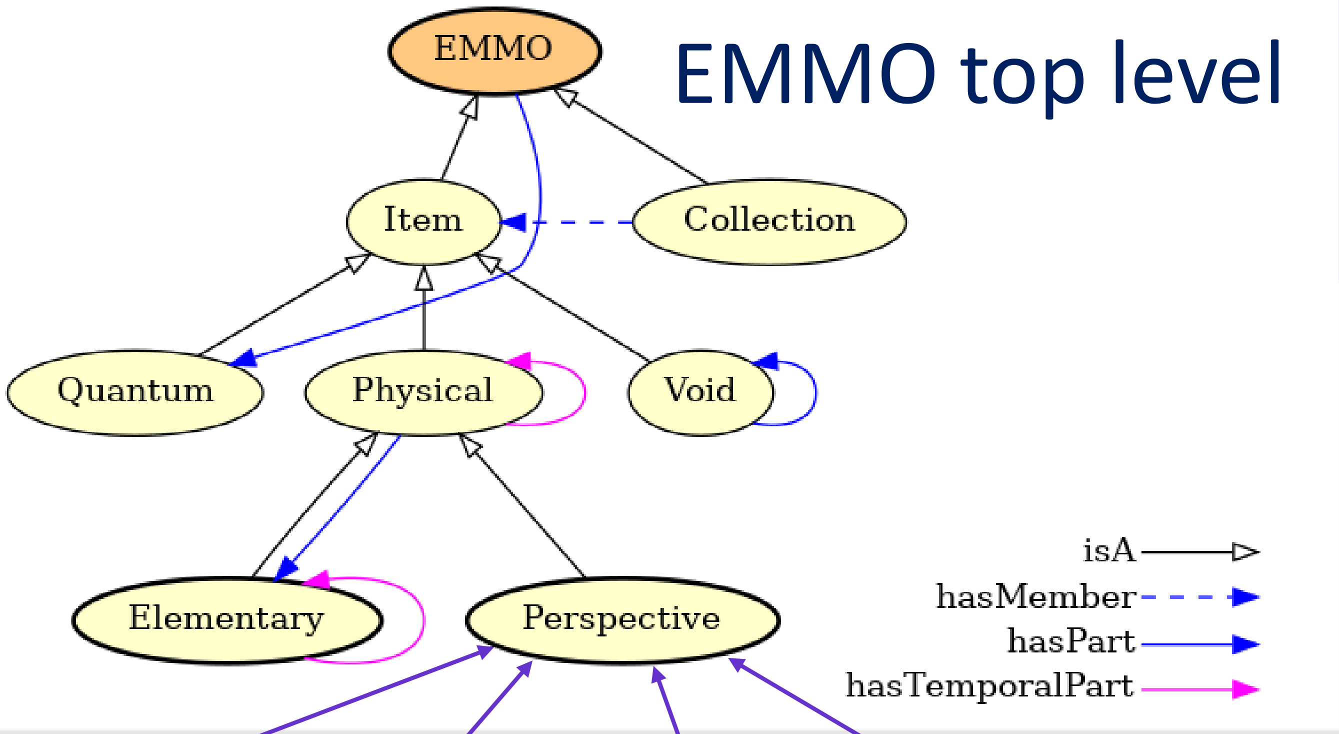
Layout

- Introduction to EMMO
- Example of how to enable interoperability between characterisation and modelling using EMMO
- Questions

EMMO ontological levels



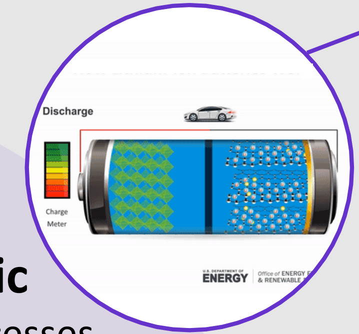
EMMO top level

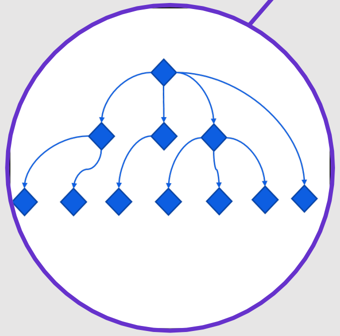


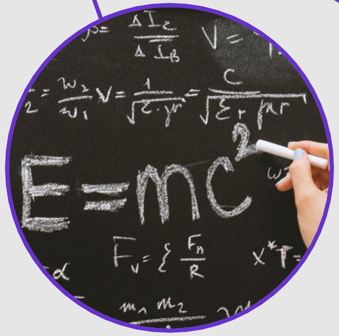
EMMO mid level

Perspectives

Pluralisms







Holistic

- processes
- semiotics
- properties
- models

Reductionistic

- direct parthood
- countability
- ordering

Physicalistic

- matter
- field
- material

Perceptual

- symbols
- languages
- metrology
- mathematics

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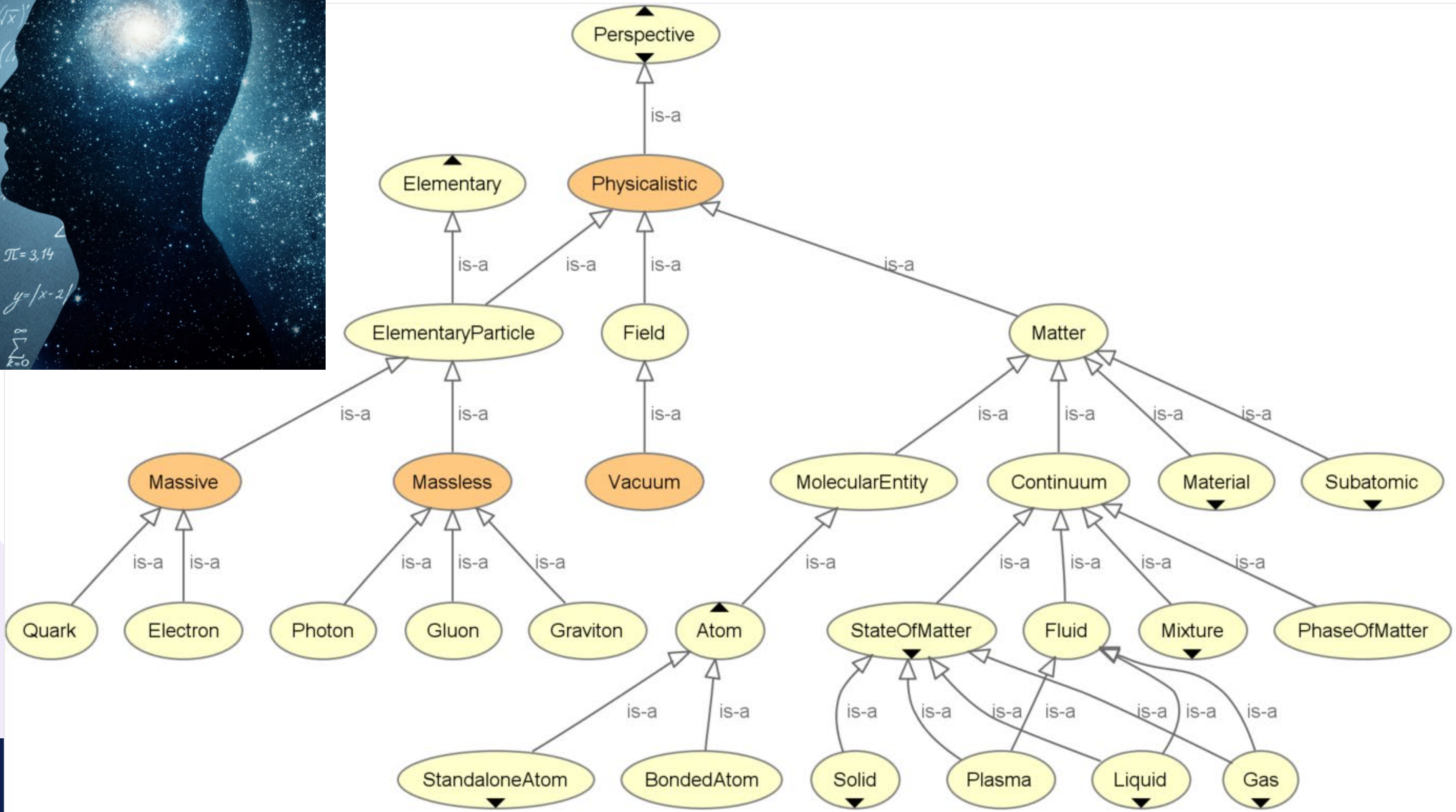
Physicalistic perspective

Image credit: [Furman University]

The world as described by a physicist



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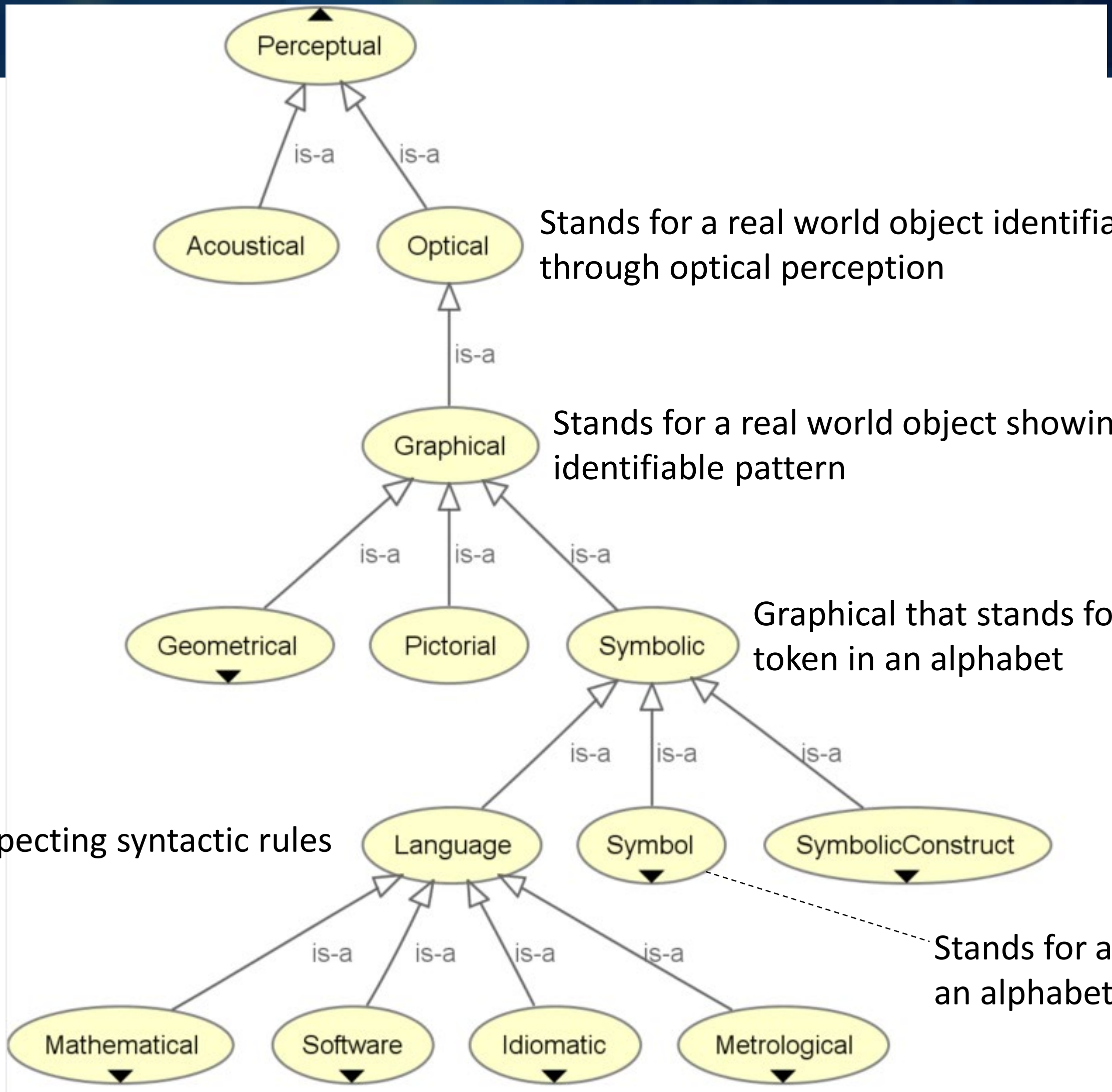
Perceptual perspective

Physicals that stand for a real world objects that can stimulate a perception



Stands for a real world object identifiable through optical perception

Stands for a real world object showing an identifiable pattern

Graphical that stands for a token in an alphabet

Symbolic object respecting syntactic rules

Stands for an elementary mark in an alphabet

physical quantities, units, …

Adapted from E. Ghedini

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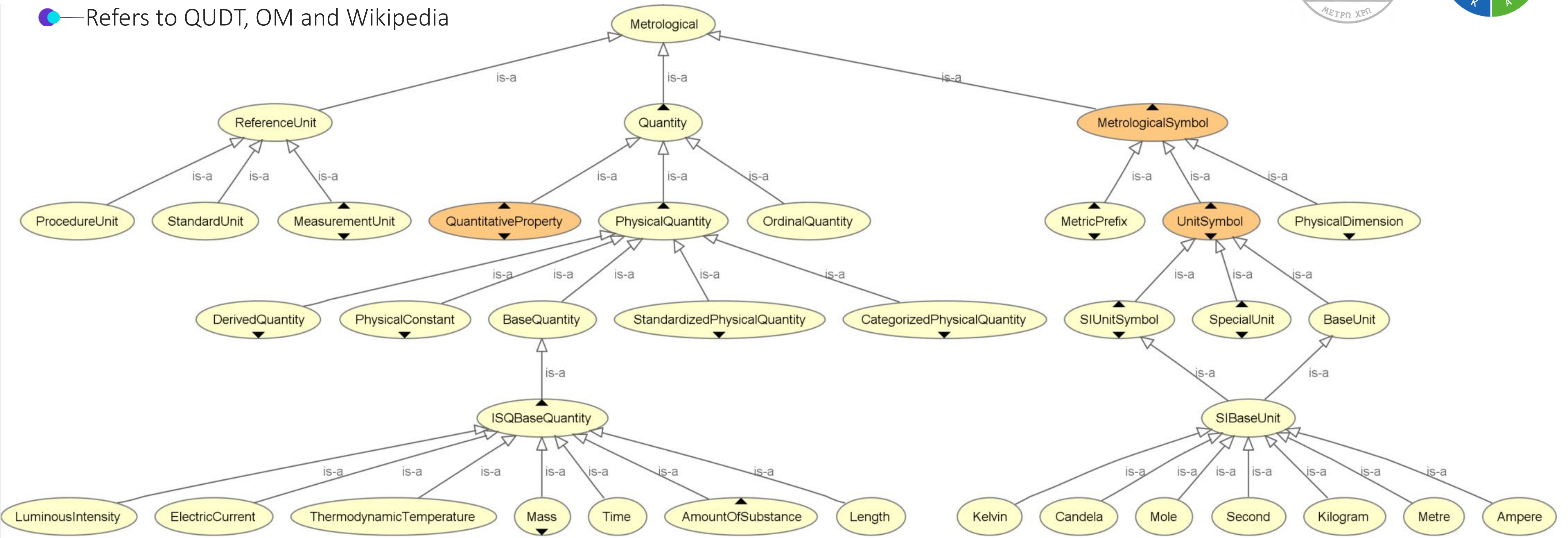
Metrology

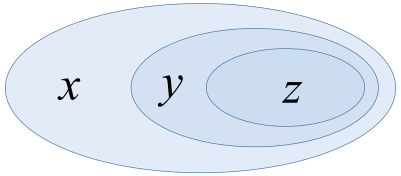
- Based on the International Vocabulary of Metrology (VIM) and ISO 80 000
- Essential part of practical interoperability
- Refers to QUDT, OM and Wikipedia



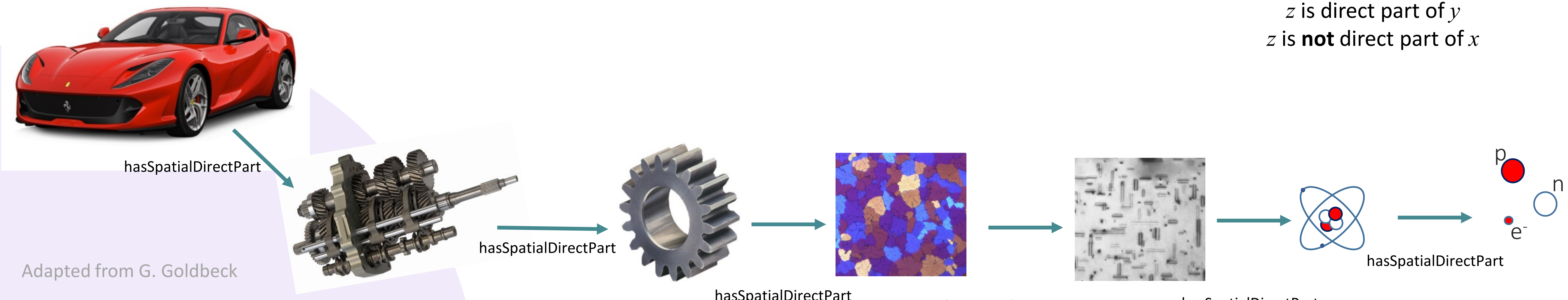
Reductionistic perspective: direct parthood

- Material Entities **can** be represented in EMMO by a Hierarchy of parthood relations.
- One material - different levels of granularity.
- Hierarchy of structure can be univocally defined.

Direct parthood is non-transitive



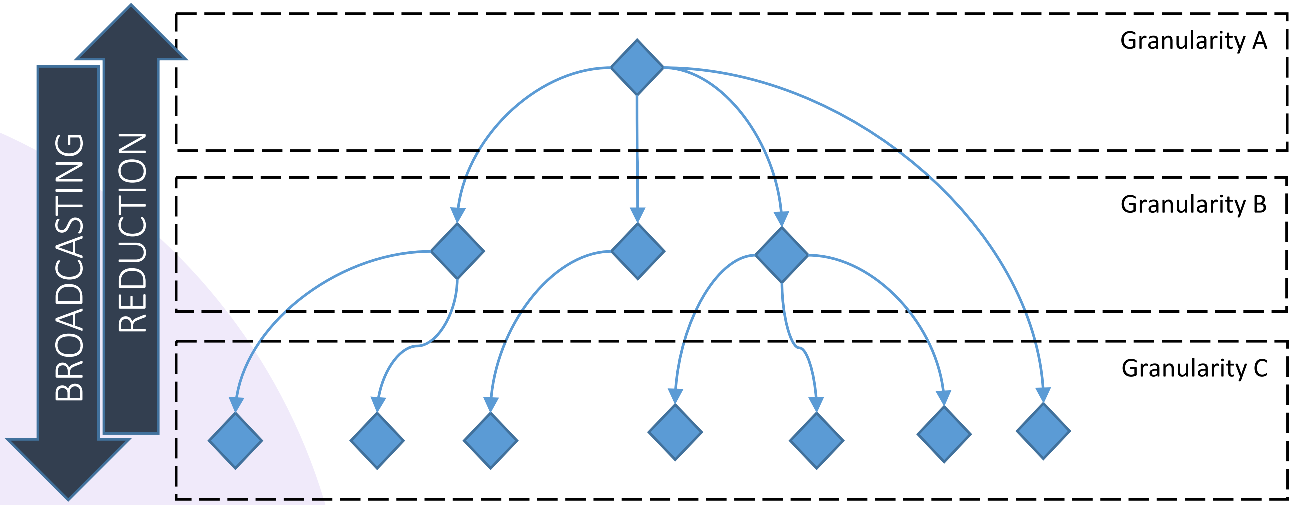
y is direct part of x
z is direct part of y
z is **not** direct part of x



Adapted from G. Goldbeck

Reductionistic: Direct parthood and granularity

- 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
- The individuals at a certain granularity level are countable and can be ordered!



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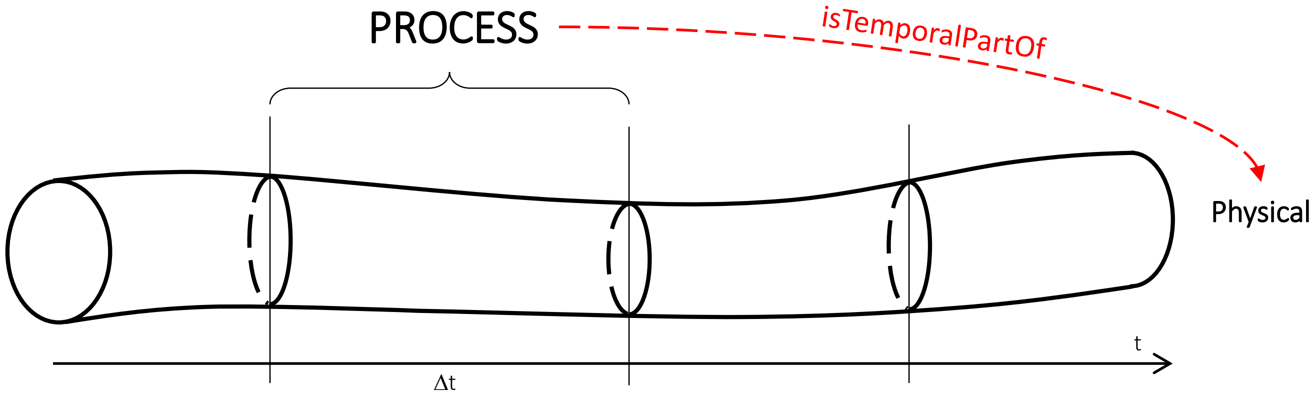
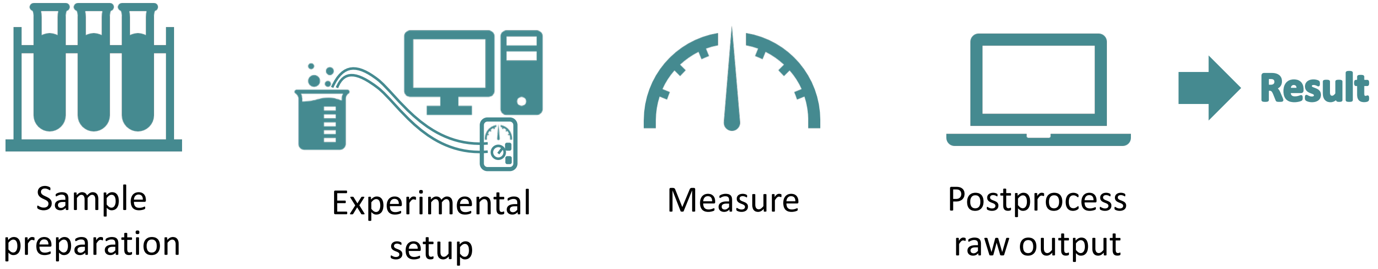
Holistic Perspective

Describes whole 4D object (process) and the **role** of its participants

Assigned by the Ontologist



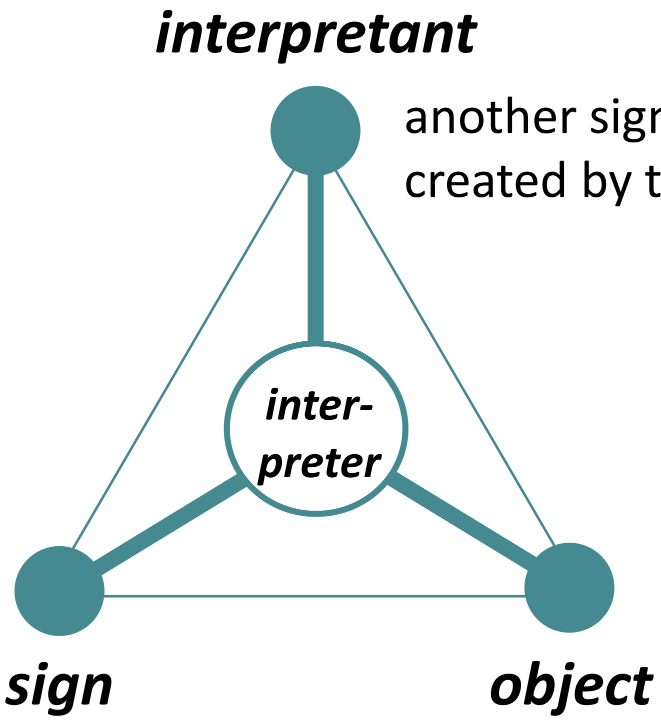


Example: Measurement process
May be divided into sub-processes

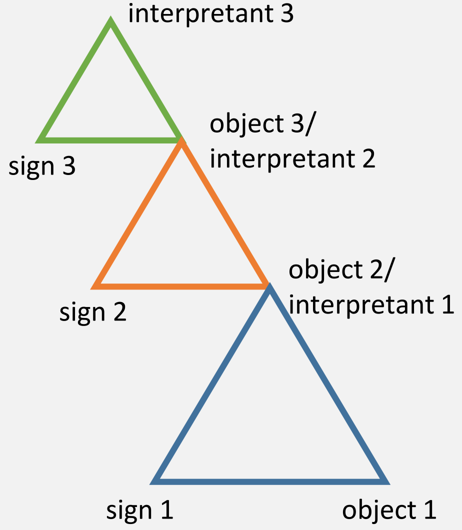
Adapted from G. Goldbeck

Semiotic process

Charles S. Peirce
semiotic theory



The cascade of semiosis



Provides a formal way to describe a process to needed level of granularity

The **interpreter** providing the connections between the three elements

EMMO Properties

TECHNICAL SPECIFICATION

ISO/TS 10303-1002

First edition
2001-09-01

Industrial automation systems and integration — Product data representation and exchange —

Part 1002:
Application module: Colour

Systèmes d'automatisation industrielle et intégration — Représentation et échange de données de produits —

Partie 1002: Module d'application: Couleur

4.2.1 Colour

A Colour is a name for a property of reflecting light at a particular wavelength.

EXPRESS specification:

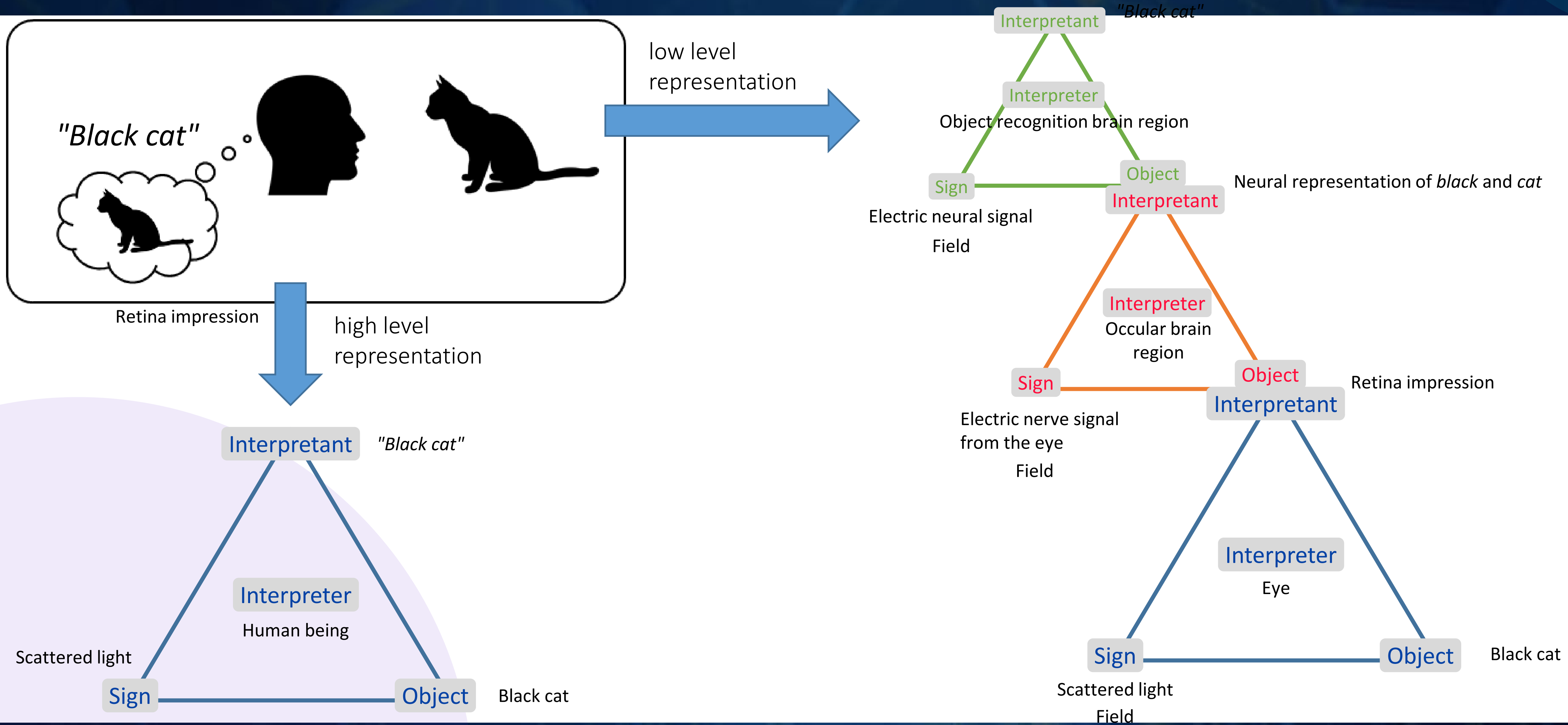
```
*)
ENTITY Colour;
  name : STRING;
END_ENTITY;
(*
```

Attribute definitions:

name: The **name** specifies the word or group of words by which the Colour is known.

Example by Emanuele Ghedini

Semiotic Reductionism

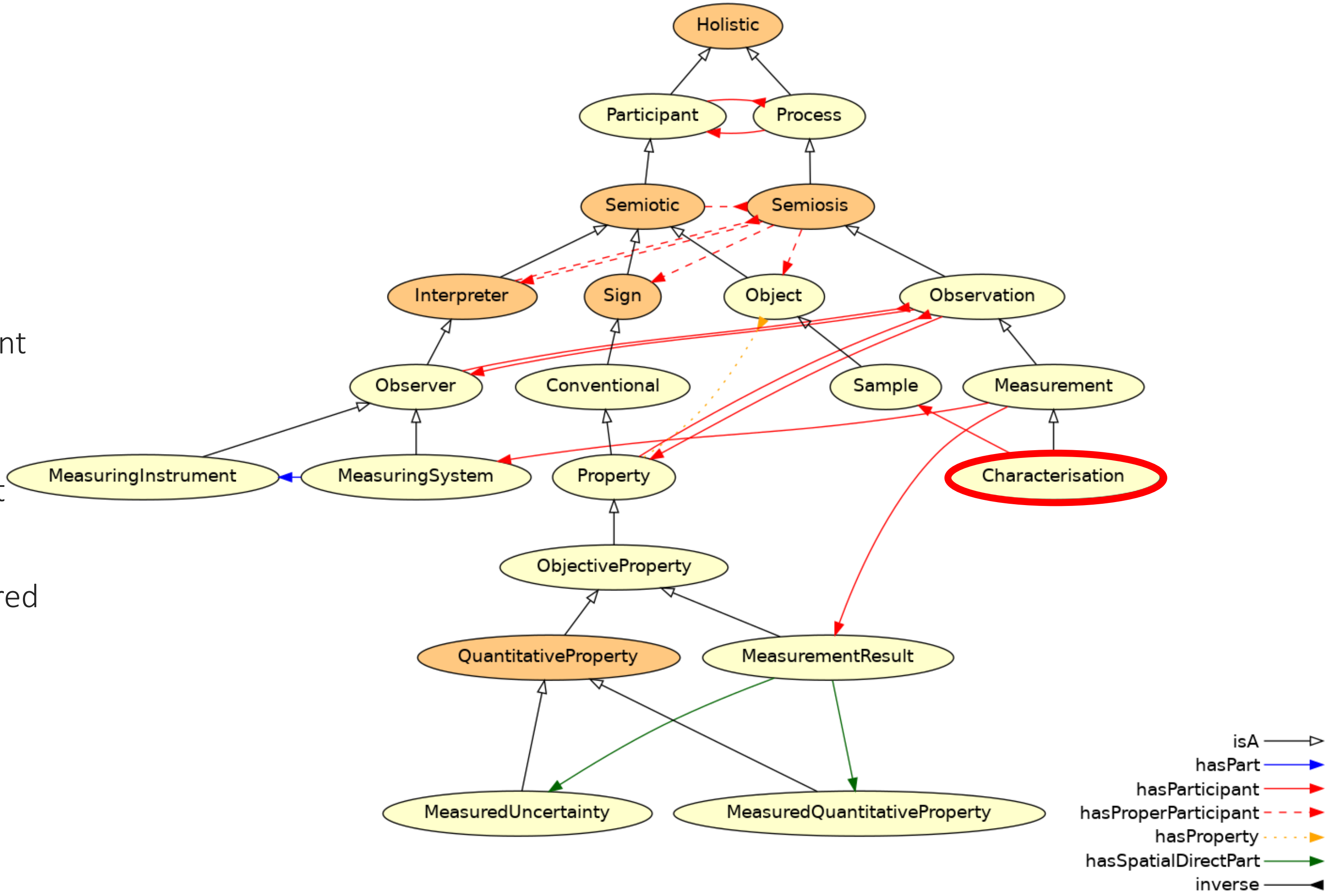


Characterisation

Characterisation is the (semiotic) process of measuring determining a material's structure and properties.

Quantitative properties are determined by a well-defined semiotic process, with participants:

- **Object**: real world object with a property that we want to measure -> *Sample*
- **Sign**: stands for the physical that communicates the measurement (-> signal in the MeasuringSystem that produces the MeasurementResult)
- **Interpretant**: another sigh that stands for the measured quantitative property -> *MeasurementResult*
- **Interpreter**: the measurement instrument used to perform the measurement -> *MeasuringSystem*

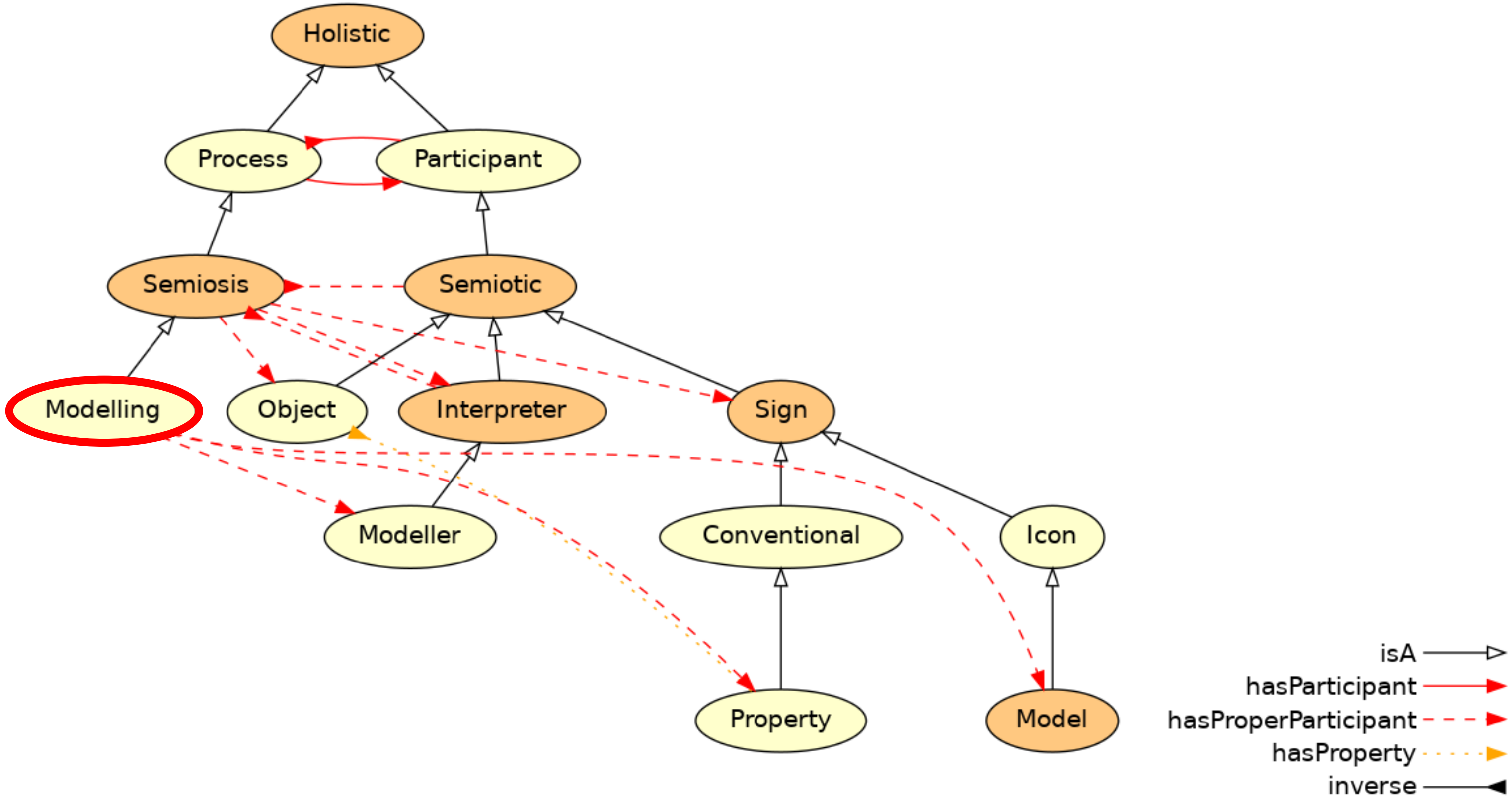


Modelling

Modelling is the (semiotic) process of applying a model to describe or predict a phenomenon.

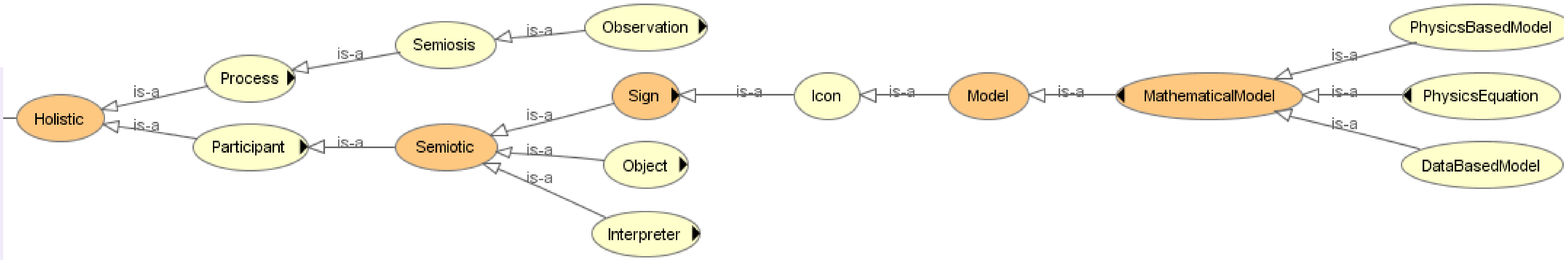
Quantitative properties are determined by a well-defined semiotic process, with participants:

- **Object**: real world object with a property that we want to model -> *Object*
- **Sign**: stands for the model that is used to produce the result -> *Model*
- **Interpretant**: another sigh that stands for the modelled property -> *Property*
- **Interpreter**: the person or system that runs and interprets the results of a model -> *Modeller*

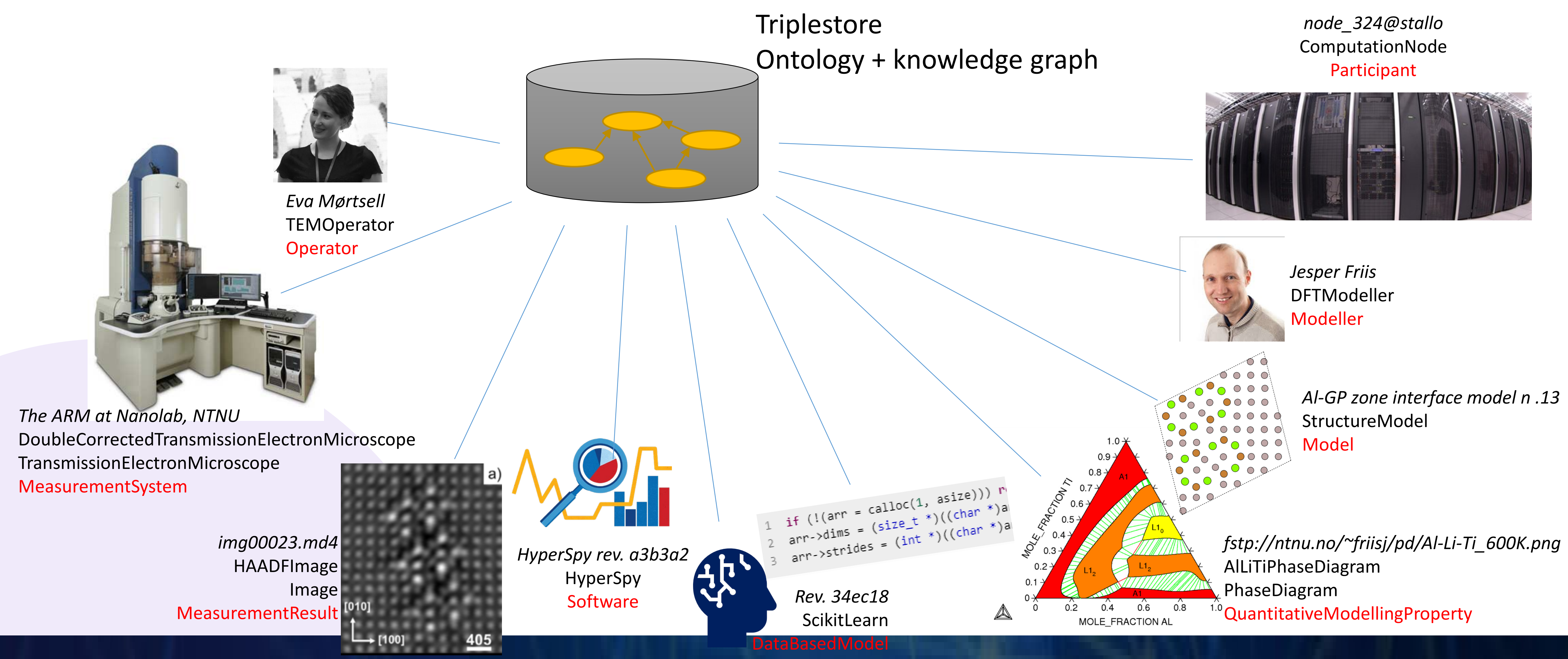


EMMO Models

- A **Model** is also **Sign**
- A simplified representation of a physical or process, aimed to assist calculations for describing or predicting its behaviour.



Enabling interoperability between characterisation and modelling using EMMO



What to include in the triplestore?

- What to include
  - ontologies (top, middle, domain, application)
  - individuals representing the participants and metadata in the characterisation/modelling case
  - mappings (e.g. from data sources to ontological concepts)

- What to not include
  - data sets (images, modelling output files, …)

- Benefits of including data
  - semantic searchable (SPARQL)

Acknowledgements

Development and application of EMMO

European Materials Modelling Council, EMMC-CSA, EMMC ASBL

Digital Ontology-based Modelling Environment for Simulation of materials

Materials Modelling Marketplace for Increased Industrial Innovation

Virtual Materials Market Place

Ontology Driven Open Translation Environment

Ontology-driven data documentation for Industry Commons

Digital Open Marketplace Ecosystem 4.0

Integrated Open Access Materials Modelling Innovation Platform for Europe

Virtual Open Innovation Platform for Active Protective Coatings Guided by Modelling and Optimization

2016

EMMO foundations laid within EU project
EMMO governance managed by EMMC ASBL

EMMO applications cases Team of philosophers, ICT experts and applied scientists.

EMMO applied to larger materials modelling communities and marketplaces infrastructures.

EMMO Domain ontologies and industrial application cases

Ontologies and tools foundation for data documentation in materials and manufacturing industry

EMMO applied to industrial data ecosystem

EMMO applied to open innovation platforms and workflows

2024

Thank you!

Join the EMMC community:

https://emmc.eu/register/

Acknowledgement:

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