Intelligence & Field Theory

What is Intelligence?

A physical system that

- has an internal representation of external reality
- percepts, learns, reasons, plans, acts, & communicates

How to represent knowledge? data, states, sets, probabilities

How to update it? logic, probabilistic deduction

How to plan an action? decision theory

How to communicate? decision using theory of mind (ToM)

How to decode a communication? deduction using ToM

Elements of **Intelligence**:

- Probability as logic extended to uncertainty
- Decision theory
- Information measures for optimal information handling
- Perception via data filtering / transformation

→ Information **Field Theory** (IFT):

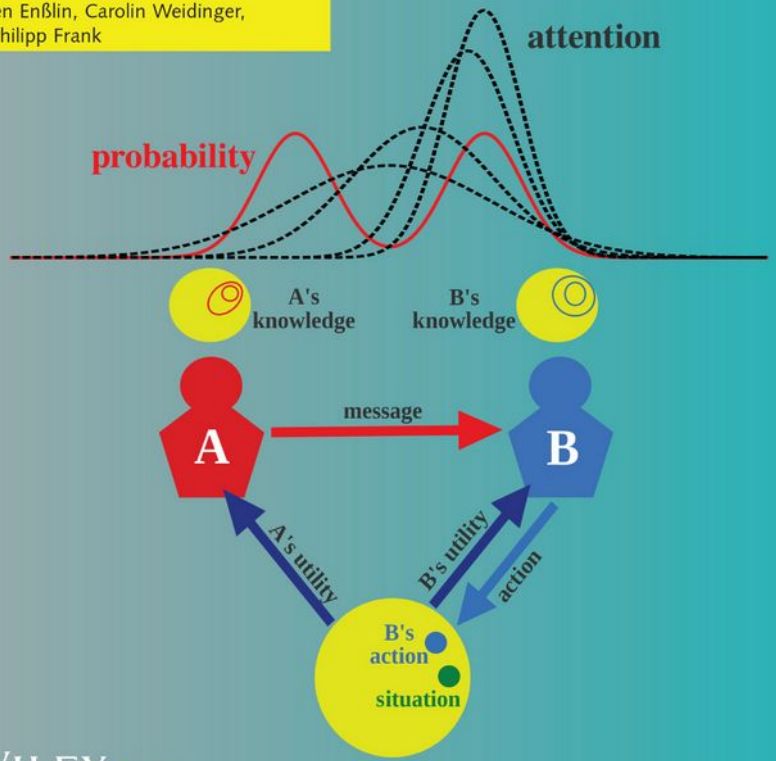
- Filters: optimal linear, Wiener, critical, Feynman diagrams, ...
- IFT with generative models, IFT for dynamical systems → SuSy, ...
- IFT ↔ AI: IFT models ↔ generative neural networks (GNNs),
  inference in IFT ↔ NN training,
  function spaces in IFT ↔ NN as universal function approximation

www.ann-phys.org JULY | 2024

adp annalen der physik

Attention to Entropic Communication

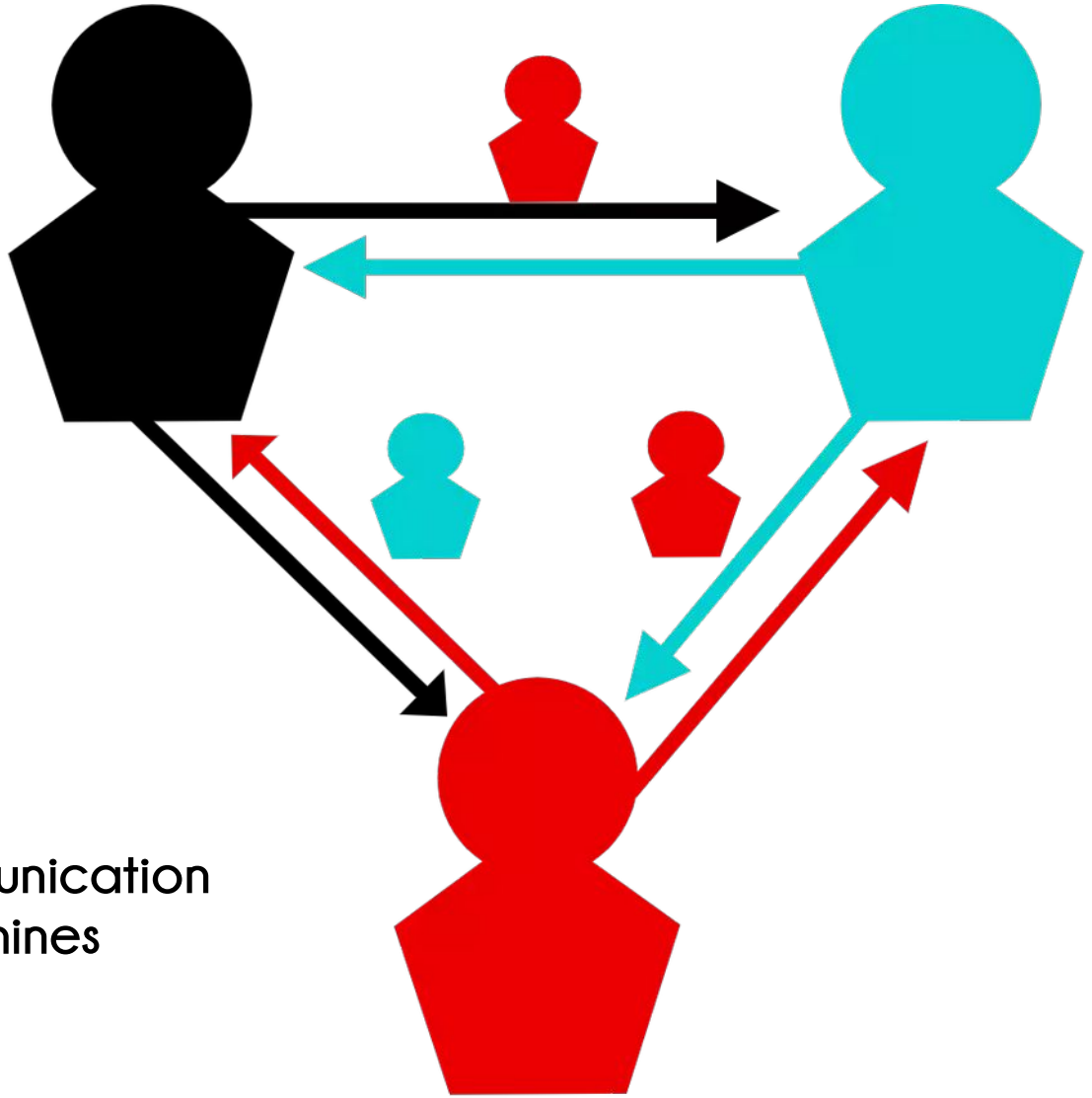
Torsten Enßlin, Carolin Weidinger, and Philipp Frank

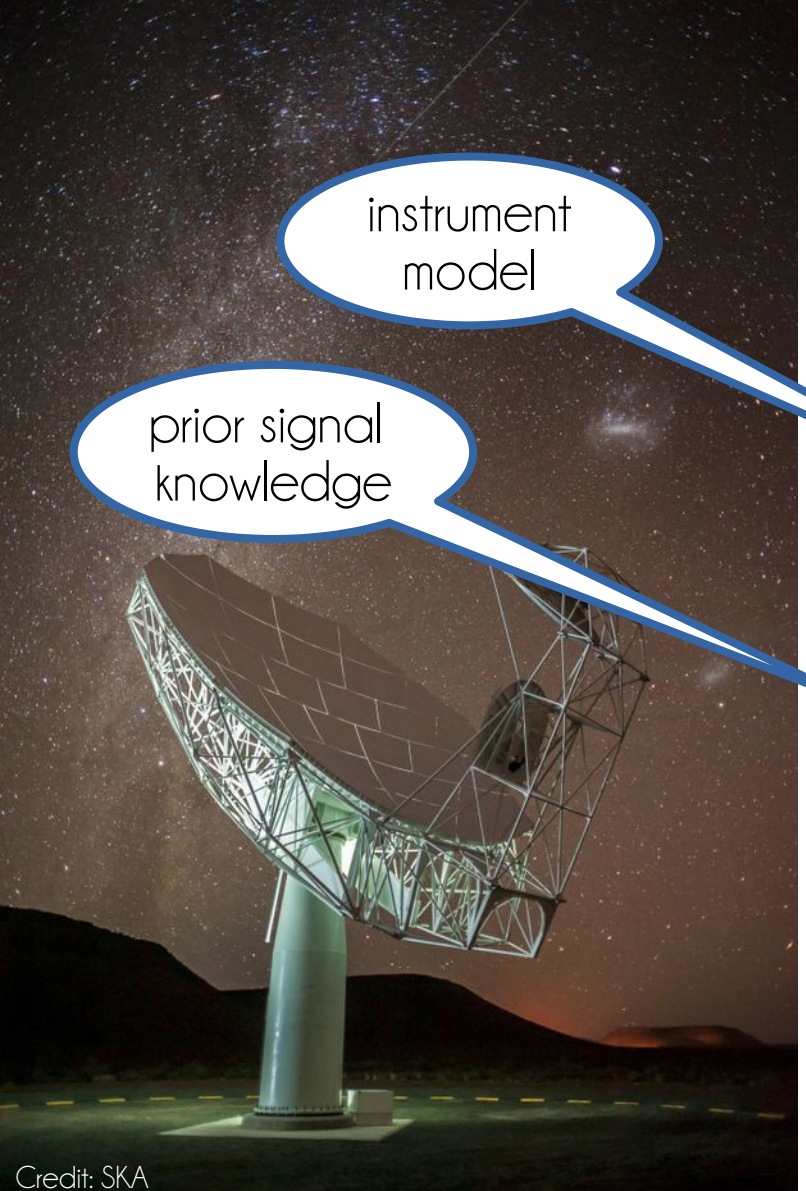


WILEY VCH

ISSN 0003-3804 . Ann. Phys. (Berlin), 536, No 7 (July 2024)

Manipulative communication
in humans and machines





Bayes' theorem **Information theory**

signal

$\mathcal{P}(s|d)$

$\mathcal{P}(d|s)$

$\mathcal{P}(s)$

$\mathcal{P}(d,s)$

data

logic uncertainty probability

Information theory

$$\mathcal{P}(s|d) = \frac{\mathcal{P}(d,s)}{\mathcal{P}(d)} = \frac{e^{-\mathcal{H}(d,s)}}{\mathcal{Z}(d)}$$

$$\mathcal{H}(d,s) = -\log \mathcal{P}(d,s)$$

Information

$$\mathcal{Z}(d) = \mathcal{P}(d) = \int \mathcal{D}s\, \mathcal{P}(d,s)$$

$$\mathcal{P}(d,s) = \mathcal{P}(d|s)\, \mathcal{P}(s)$$

$$\mathcal{H}(d,s) = \mathcal{H}(d|s) + \mathcal{H}(s)$$

is additive

Intelligence & Field Theory

Elements of a theory of intelligence:

probabilistic logic → information measures
generative models & networks
inference in ultra-high dimensions
IFT for artificial perception systems
IFT as mathematical framework to understand AI

Perspective:

data scientist / analyst, AI theoretician, galactic cartographer, radio astronomer, gravitational wave hunter, computational psychologist, ...