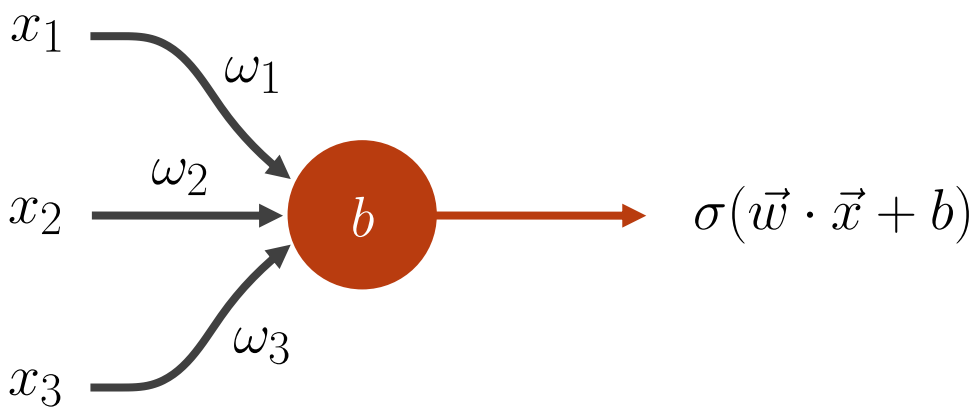
Machine learning physics

Phase transitions

Neural Networks in a nutshell

Typically, the building blocks of a neural network are **sigmoid neurons**

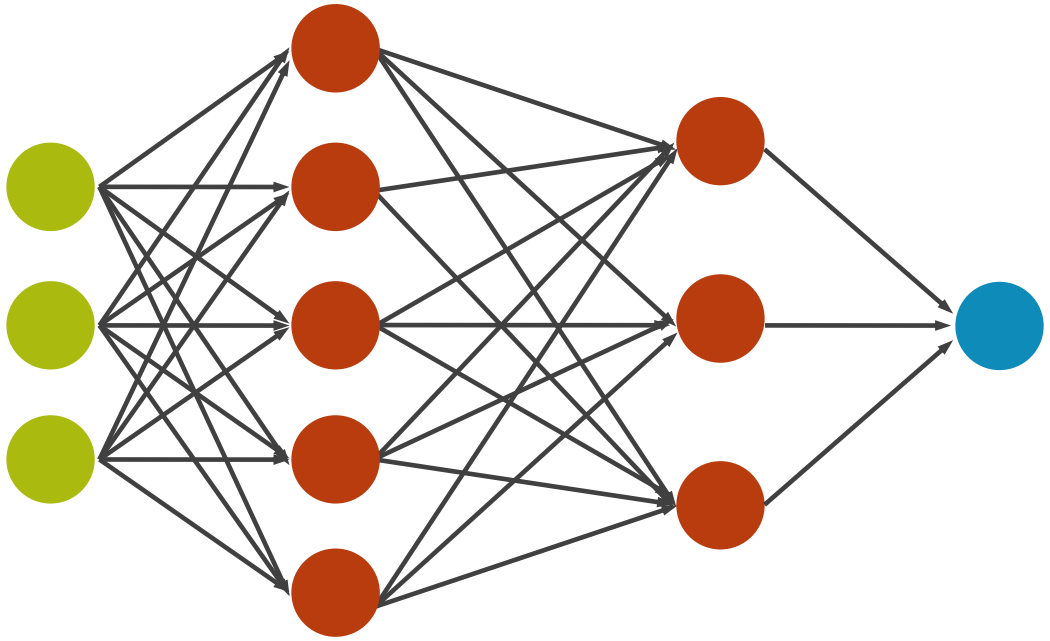


Logistic activation function

$$\sigma(z) = \frac{1}{1 + e^{-z}}$$

Neural Networks in a nutshell

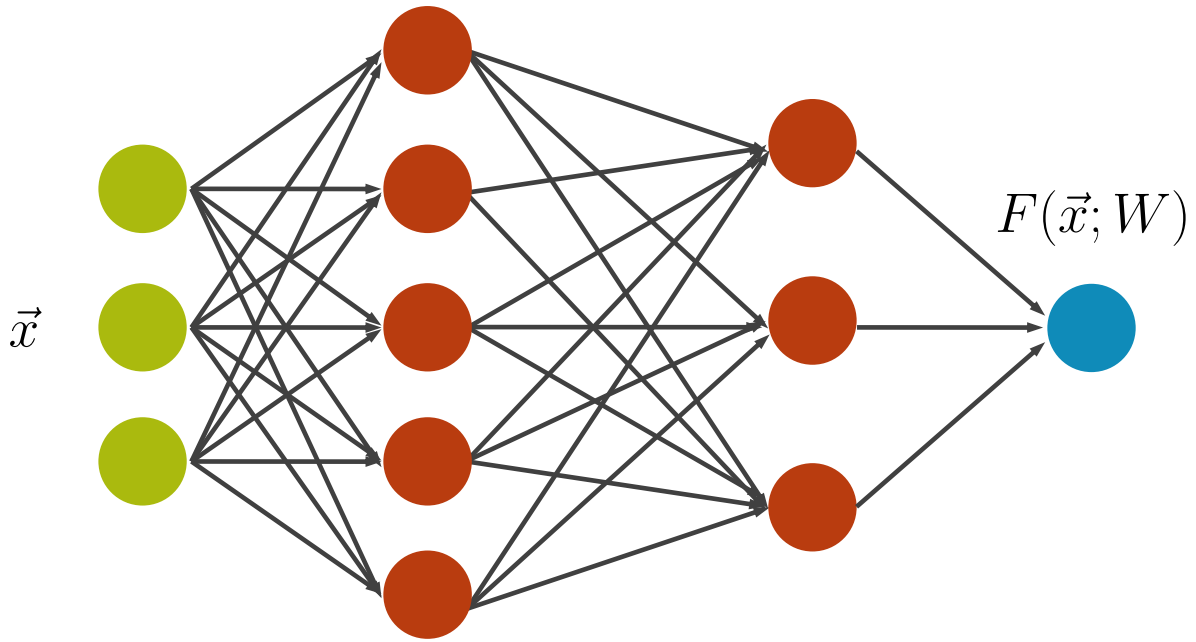
The network graph defines a concatenation of sigmoid neurons



Input layer Hidden layer(s) Output layer

Neural Networks in a nutshell

The network graph defines a concatenation of sigmoid neurons



Neural network is a **highly non-linear mapping** $\vec{x} \rightarrow F(\vec{x}; W)$

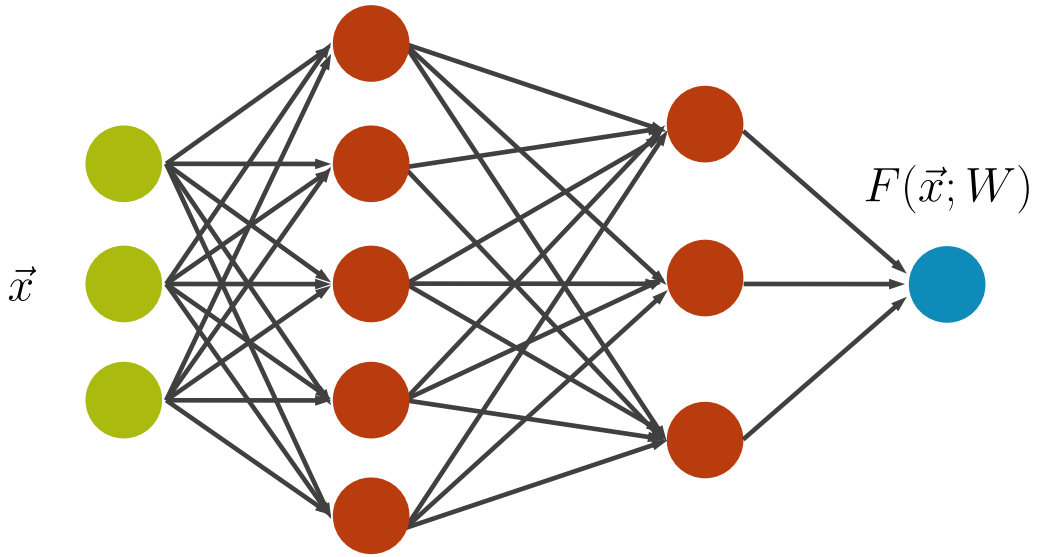
Neural Networks in a nutshell

Labeled training dataset

$$\{(x_1, y_1), (x_2, y_2), \ldots, (x_N, y_N)\}$$

Cost function measure

$$C(W) \sim |F(\vec{x}; W) - y(\vec{x})|^2$$



Use **backpropagation** and **stochastic gradient descent** to adjust weights and biases (check out this great video)

Learning phase transitions

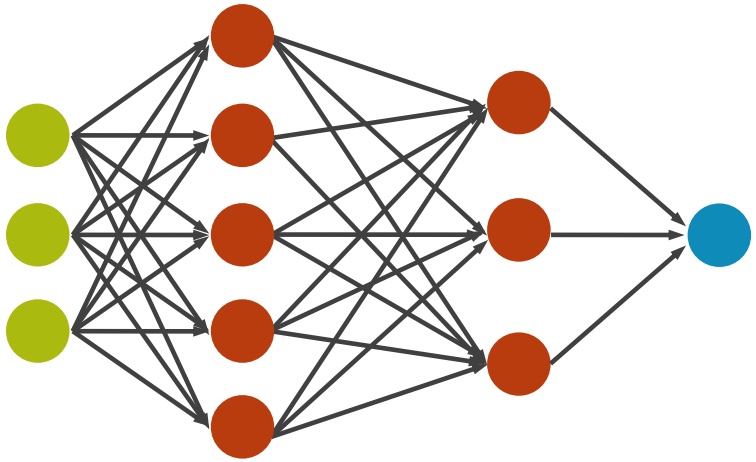
Apply **image/pattern recognition** techniques to physical systems

Carrasquilla, Melko, NPHYS 13 (2017)

Van Nieuwenburg, Liu, Huber, NPHYS 13 (2017)

Broecker, Carrasquilla, Melko, Trebst, arXiv:1608.07848 (2016)

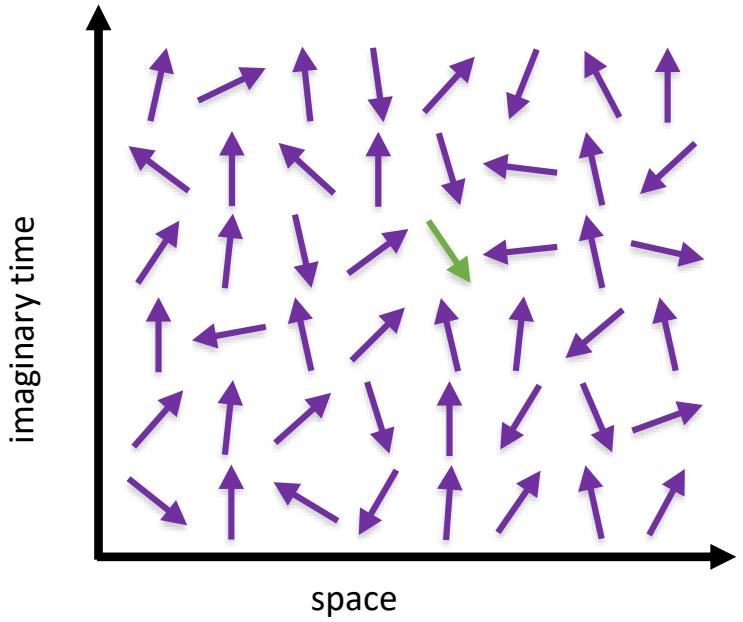
Artificial neural networks have proven to be an extremely powerful tool for feature extraction



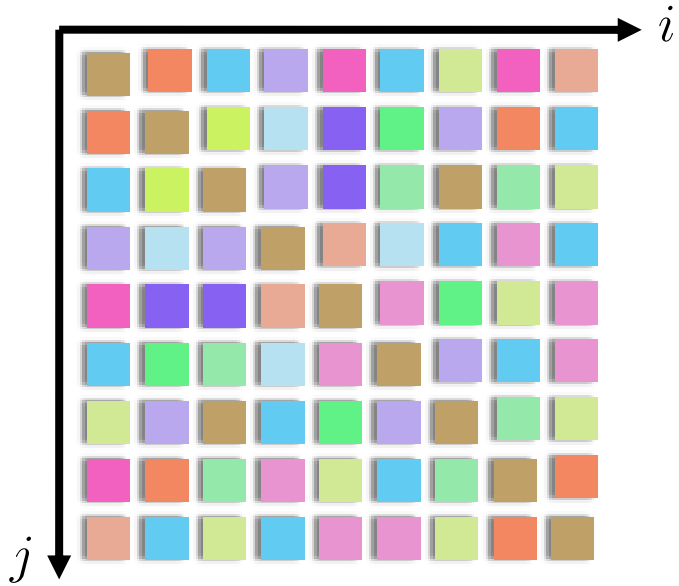
Learning phase transitions

Two natural choices for what to take as “image” of the system

Order parameter



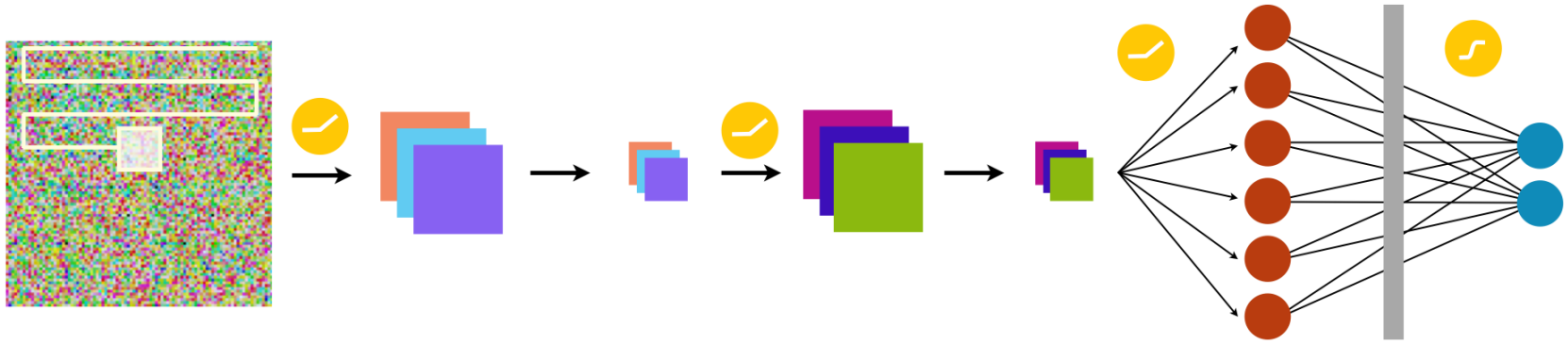
Green’s function



Learning phase transitions

Convolutional neural network (CNN) architecture with preprocessing of input image

Learning smaller **recurring features**

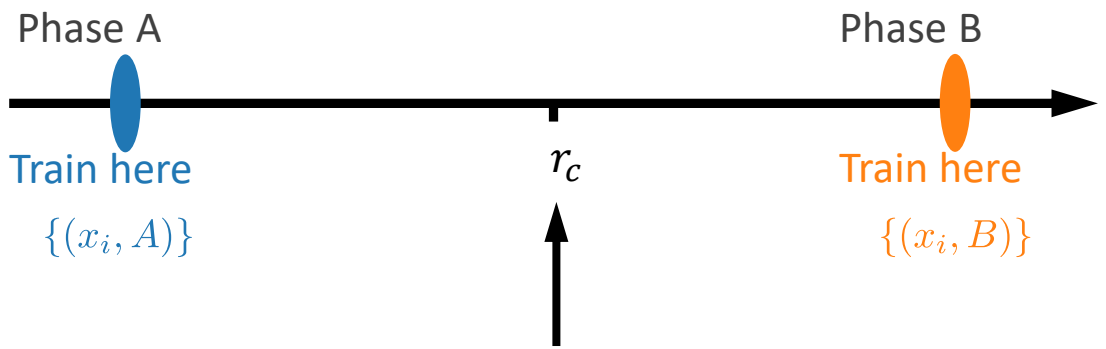


matrix reductions

conventional

Learning phase transitions

Train network **deep in both phases,** predict phase in between.



Learning phase transitions