

# QUICK FACTS

**Name:** Tiago de Paula Peixoto

**Background:** Theoretical physics, statistical mechanics.

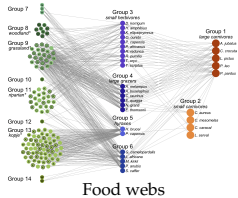
**Areas of activity:** Networks, complex systems, statistical inference.

**Scientific trajectory:**

- ▶ 2008 → PhD in theoretical physics, USP, Brazil.
- ▶ 2008 – 2011 → Post-doc, TU Darmstadt, Germany.  
(Alexander von Humboldt Fellowship)
- ▶ 2011 – 2016 → Post-doc, University of Bremen, Germany.
- ▶ 2015 – present → Ext. researcher, ISI Foundation, Turin, Italy
- ▶ August 2016 – present → Mathematical Sciences, University of Bath

# NETWORKS

Networks form the substrate of a wide variety of systems.



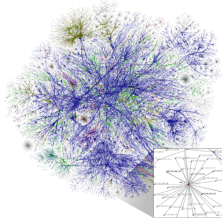
Food webs



Power grid



Air transportation



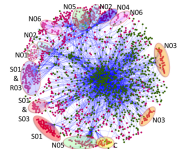
Internet



Ground transportation



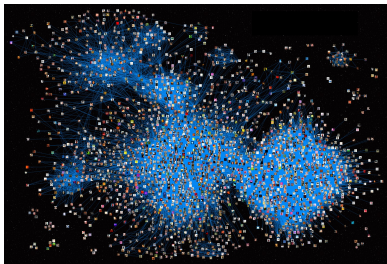
Social networks



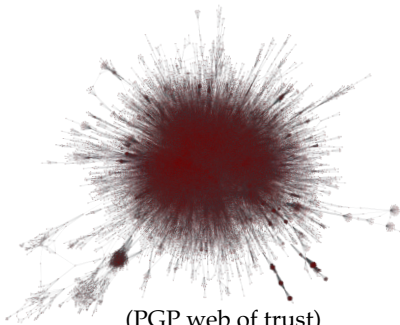
Gene regulation

Structure  $\leftrightarrow$  Dynamics  $\leftrightarrow$  Evolution

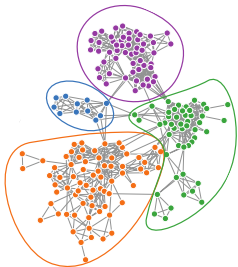
# HOW TO CHARACTERIZE LARGE-SCALE STRUCTURE?



(Flickr social network)



(PGP web of trust)



Find a meaningful network partition that provides:

- ▶ A division of nodes into groups that share similar properties.
- ▶ An understandable summary of the large-scale structure.
- ▶ An insight on function and evolution.

# INFERRING MODULAR STRUCTURE

## Generative models

Model likelihood:  $P(\mathbf{A}|\theta, \mathbf{b})$

$\mathbf{A}$   $\rightarrow$  network

$\mathbf{b}$   $\rightarrow$  partition of the nodes into groups

$\theta$   $\rightarrow$  more model parameters

## Bayesian inference

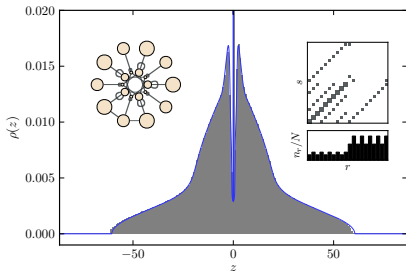
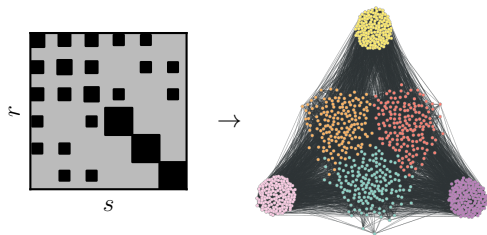
$$P(\mathbf{b}|\mathbf{A}) = \frac{P(\mathbf{A}|\mathbf{b})P(\mathbf{b})}{P(\mathbf{A})}$$

$$P(\mathbf{A}|\mathbf{b}) = \int P(\mathbf{A}|\theta, \mathbf{b})P(\theta)d\theta$$



# STRUCTURE $\rightarrow$ FUNCTION AND DYNAMICS

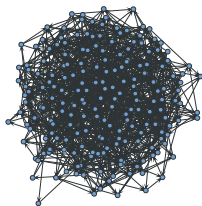
Arbitrary modular structures.



Distribution of eigenvalues.

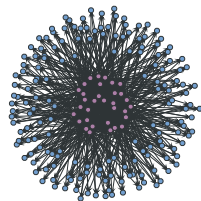
# EVOLUTION OF ROBUSTNESS

Structural phase transitions

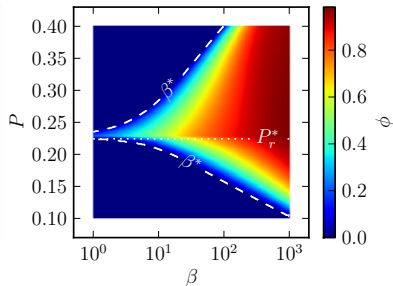
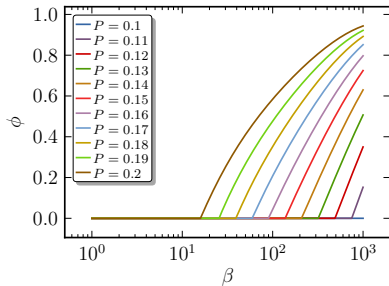


Random structure

increasing selective pressure  $\beta$   $\rightarrow$



Core-periphery



# CENTRE FOR NETWORKS AND COLLECTIVE BEHAVIOUR (CNCB)



- ▶ Alastair Spence
- ▶ Jonathan Dawes
- ▶ Dick James
- ▶ Tim Rogers
- ▶ Kit Yates