Synchronization in Collections of Nonlinear Oscillators

The Kuramoto model describes synchronization of coupled oscillators.
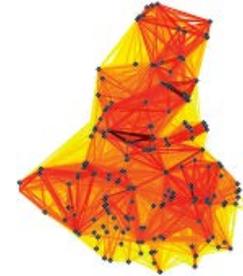Assumes <u>nonlinear coupling</u> between linear oscillators

$$\frac{d\theta_i}{dt} = \omega_i + \frac{K}{N}\sum_{j=1}^{N}\sin(\theta_j - \theta_i), \qquad i = 1\ldots N$$

KuramotoModelPhaseLocking.ogv.360p.webm

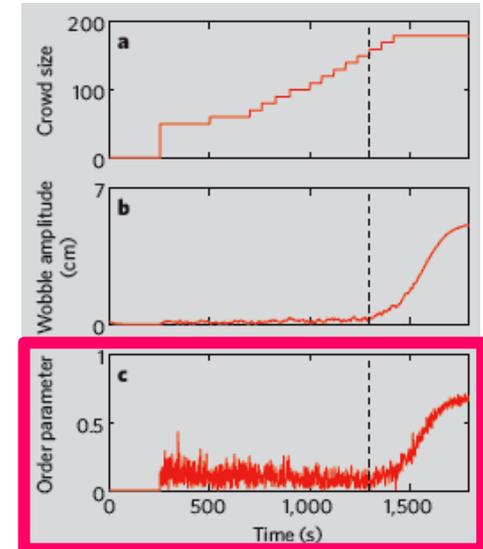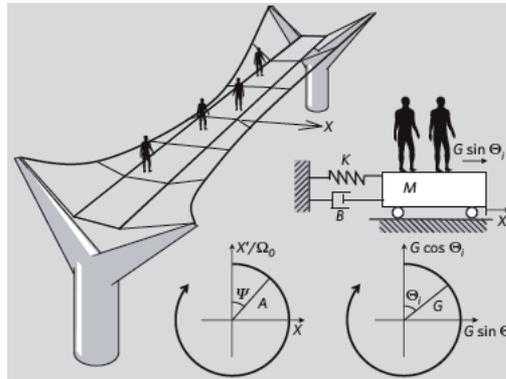## Spontaneous synchrony in power-grid networks

Power-grid of northern Italy

Crowd synchrony on the Millennium Bridge

Footbridges start to sway when packed with pedestrians falling into step with their vibrations.

$$M\frac{d^2X}{dt^2} + B\frac{dX}{dt} + KX = G\sum_{i=1}^{N}\sin\theta_i$$

$$re^{i\psi} = \frac{1}{N}\sum_{j}^{N} e^{i\theta_j}$$

The rf SQUID metamaterial is a coupled collection of <u>nonlinear oscillators</u>