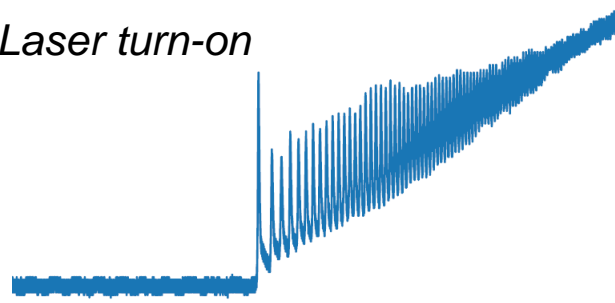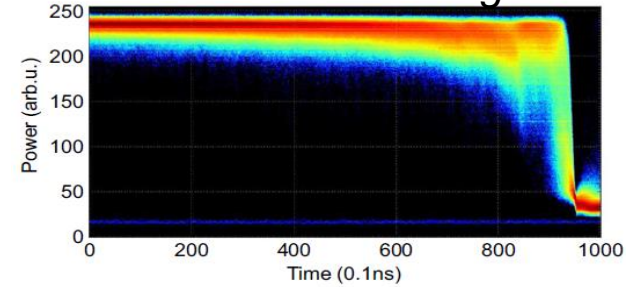*Laser turn-on*

Polarization switching

In temporal networks correlation lags are informative of approaching bifurcations

Giulio Tirabassi and Cristina Masoller
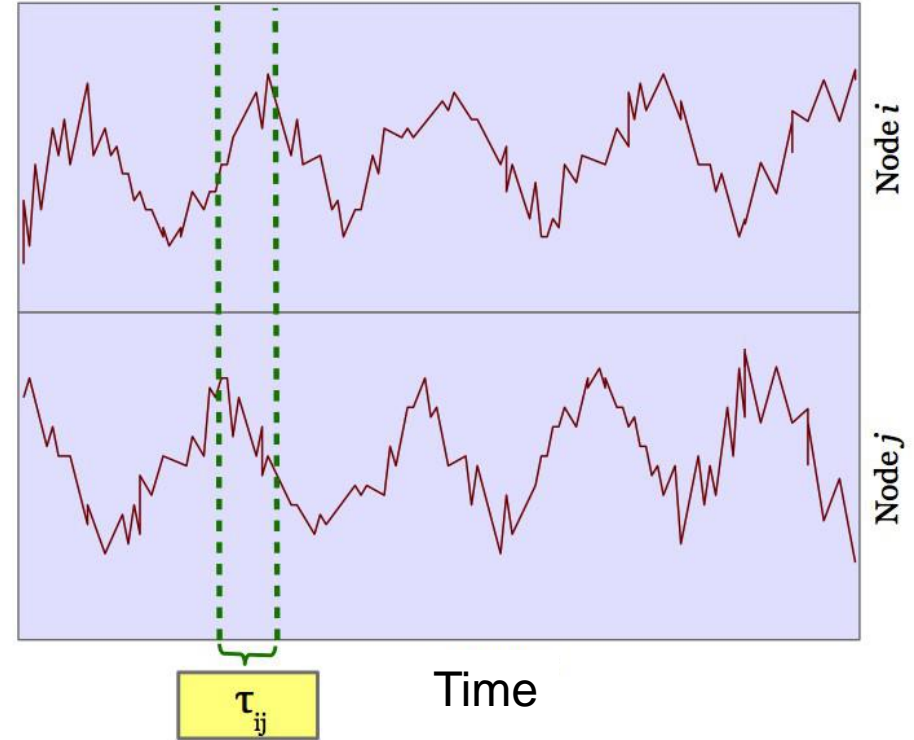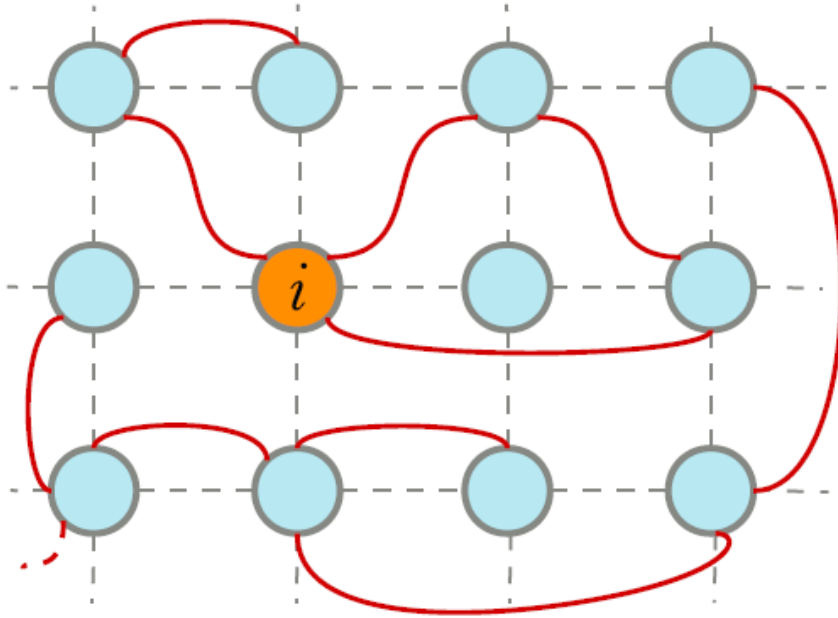
Departament de Fisica
Universitat Politecnica de Catalunya
Terrassa, Barcelona, Spain

COMPLEX NETWORKS 2022, Palermo
November 9, 2022

cristina.masoller@upc.edu   @cristinamasoll1

Spatio-temporal system described by a "correlation network"

C_{ij} = Pearson correlation coefficient $|C_{ij}(\tau_{ij})| > \text{Th} \Rightarrow A_{ij} = 1$, else $A_{ij}=0$

Node i

Node j

τ_{ij}

Time

Indicator of approaching bifurcation: variance of the distribution of lags

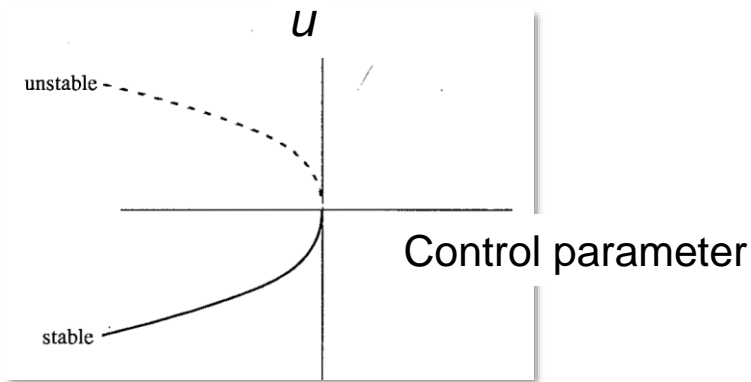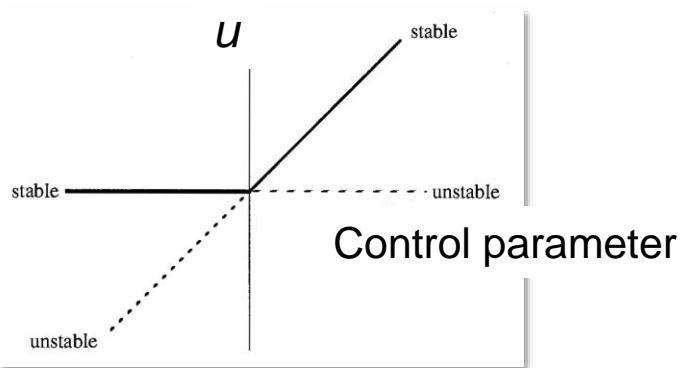$$\sigma_\tau = (1/M) \sum_{i,j} (\tau_{ij} - \langle \tau \rangle)^2$$

2

Models: Bistable reaction-diffusion, Fitzhugh–Nagumo, Vegetation extinction

$$\frac{\partial u}{\partial t} = -u^3 - \alpha u^2 + u(1+\alpha) + D\frac{\partial^2 u}{\partial x^2} + \xi$$

$$\frac{\partial u}{\partial t} = \Lambda u - u^3 - \Sigma v - I + D_u \Delta u + \xi_u,$$
$$\frac{\partial v}{\partial t} = v(u-v) + D_v \Delta v + \xi_v.$$

Bifurcations: Trans-critical, saddle-node, subcritical and supercritical Hopf and a global bifurcation: travelling waves
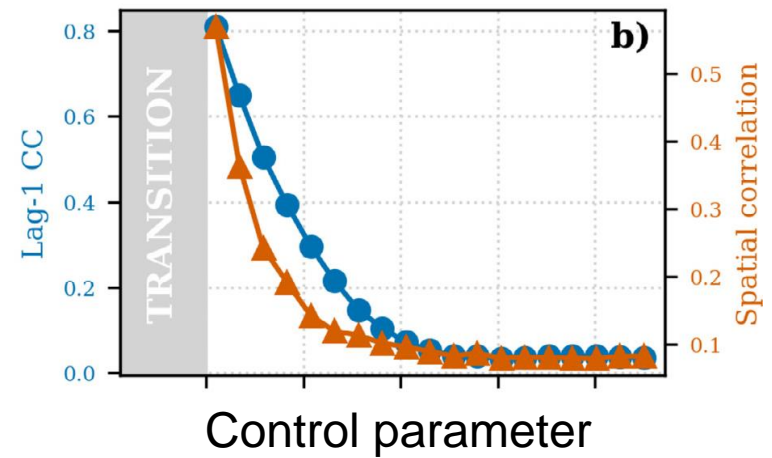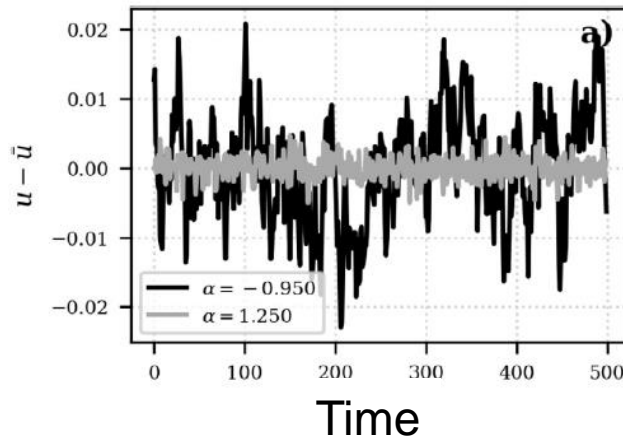

Classical indicators: lag-1 cross-correlation, spatial correlation

$$\text{lag-1 CC} = \left\langle \left| \left\langle u_i(t) u_i(t+1) \right\rangle_t \right| \right\rangle_i \qquad \text{Spatial CC} = \left\langle \left| \left\langle u_i(t) u_j(t) \right\rangle_{i,j} \right| \right\rangle_t$$

Results

a) Time series plot with legend:
$\alpha = -0.950$
$\alpha = 1.250$
x-axis: Time, y-axis: $u - \bar{u}$

b) Lag-1 CC (blue) and Spatial correlation (orange) vs Control parameter, TRANSITION region shaded

c) σ_τ (green) and $\langle \tau \rangle$ (gray dashed) vs Control parameter, TRANSITION region shaded

Indicator of approaching bifurcation: variance of the distribution of lags max or min before the bifurcation
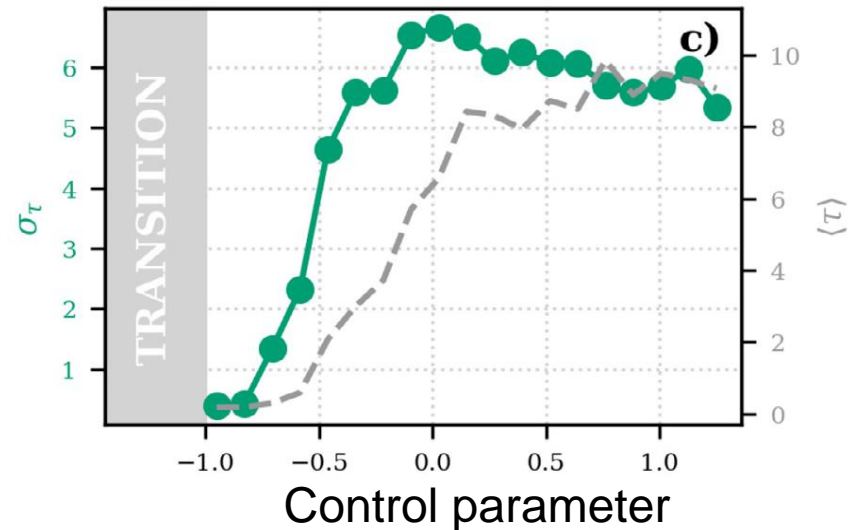
Reference:

G. Tirabassi, C. Masoller, "*Correlation lags give early warning signals of approaching bifurcations*", Chaos, Solitons and Fractals 155, 111720 (2022)

cristina.masoller@upc.edu   @cristinamasoll1