Low Mg^{++} Waves:

An Elliptic Burster?

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- What terminates activity?

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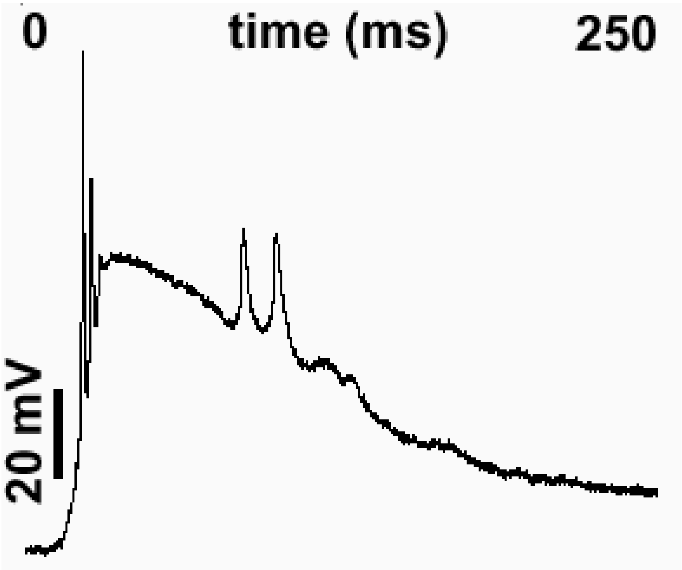
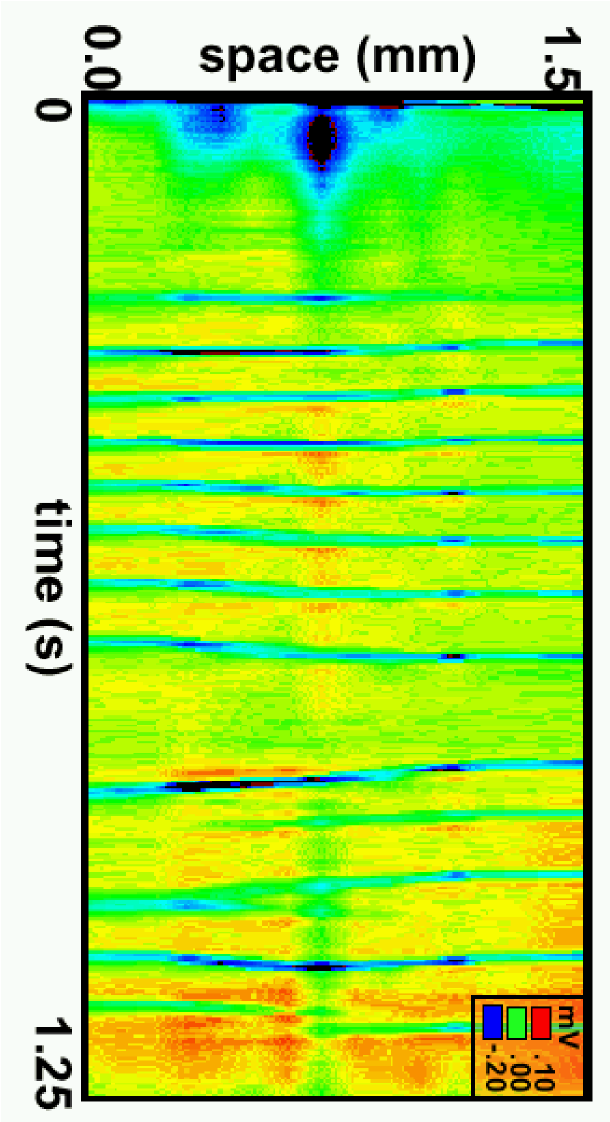
  - Depolarization block may be one mechanism
- In low Mg^{++} wave is sometimes followed by slow oscillations
- We suggest interaction between NMDAr & sodium inactivation

Expt'l depolarization block

- Intracellular recordings during wave
- Large synaptic current
- APs appear to be blocked

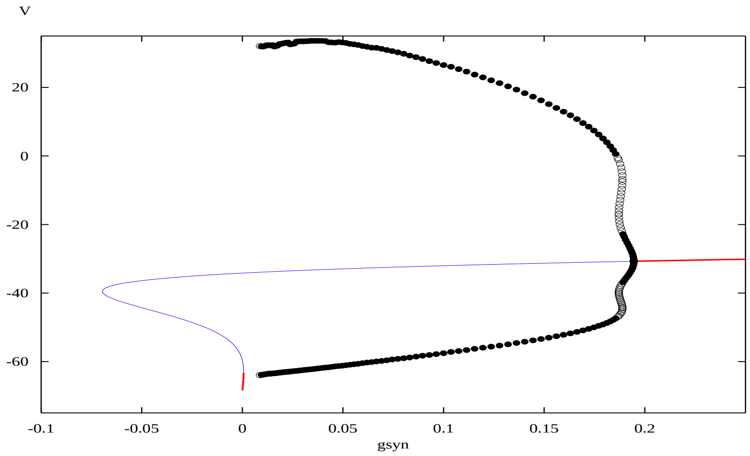


Expt'l oscillations



Model

- Golomb-Amitai single cell
  - Type 1 spiking dynamics
  - Has low threshold for depolarization block
  - Used in past for waves in disinhibited slice
- Excitatory synapses only



The burster

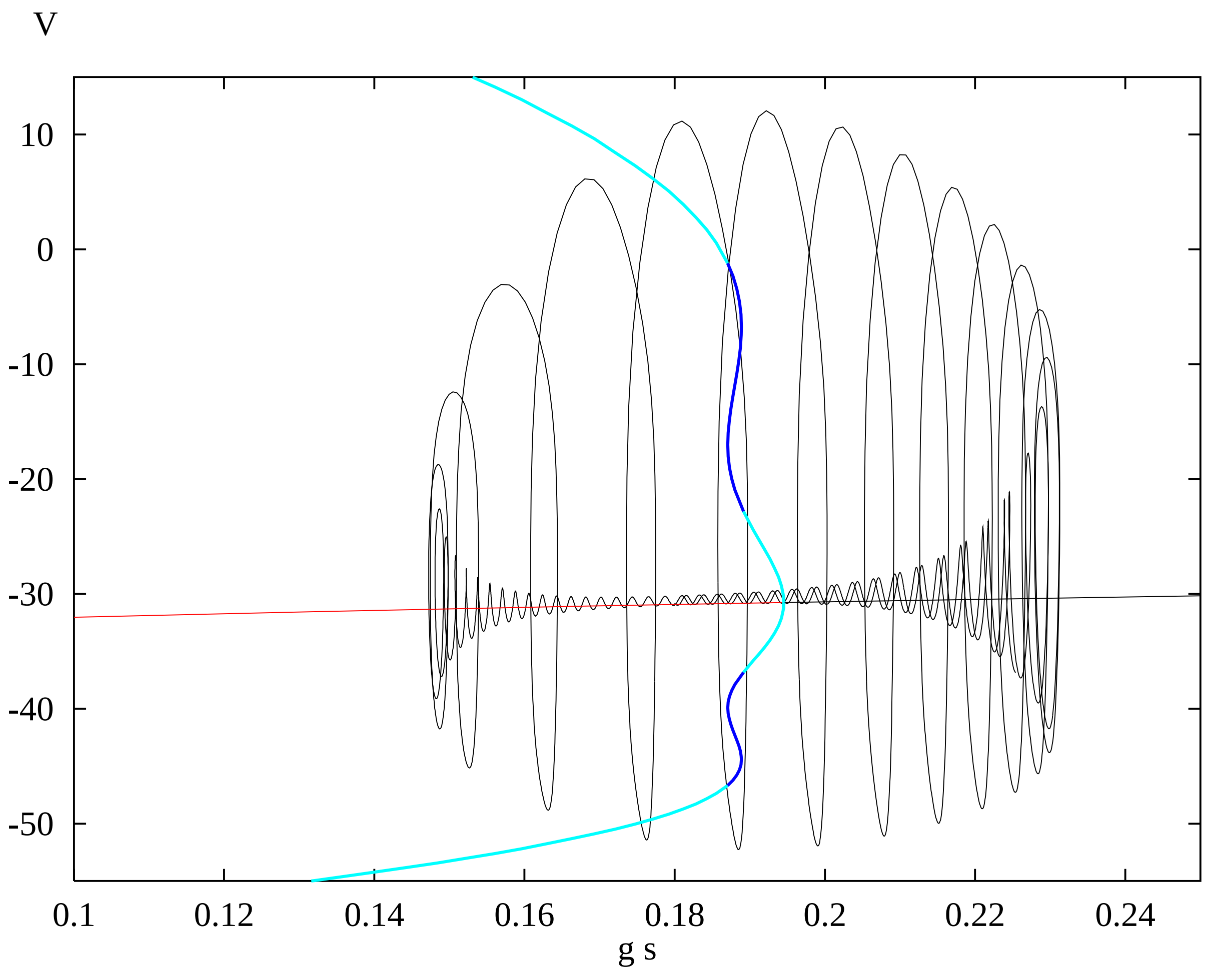
$$
\begin{aligned}
C\frac{dV}{dt} &= -I_{ion} - gs(V - E_{syn}) \\
\frac{ds}{dt} &= [\alpha(V)(1-s) - s]/\tau
\end{aligned}
$$

The burster

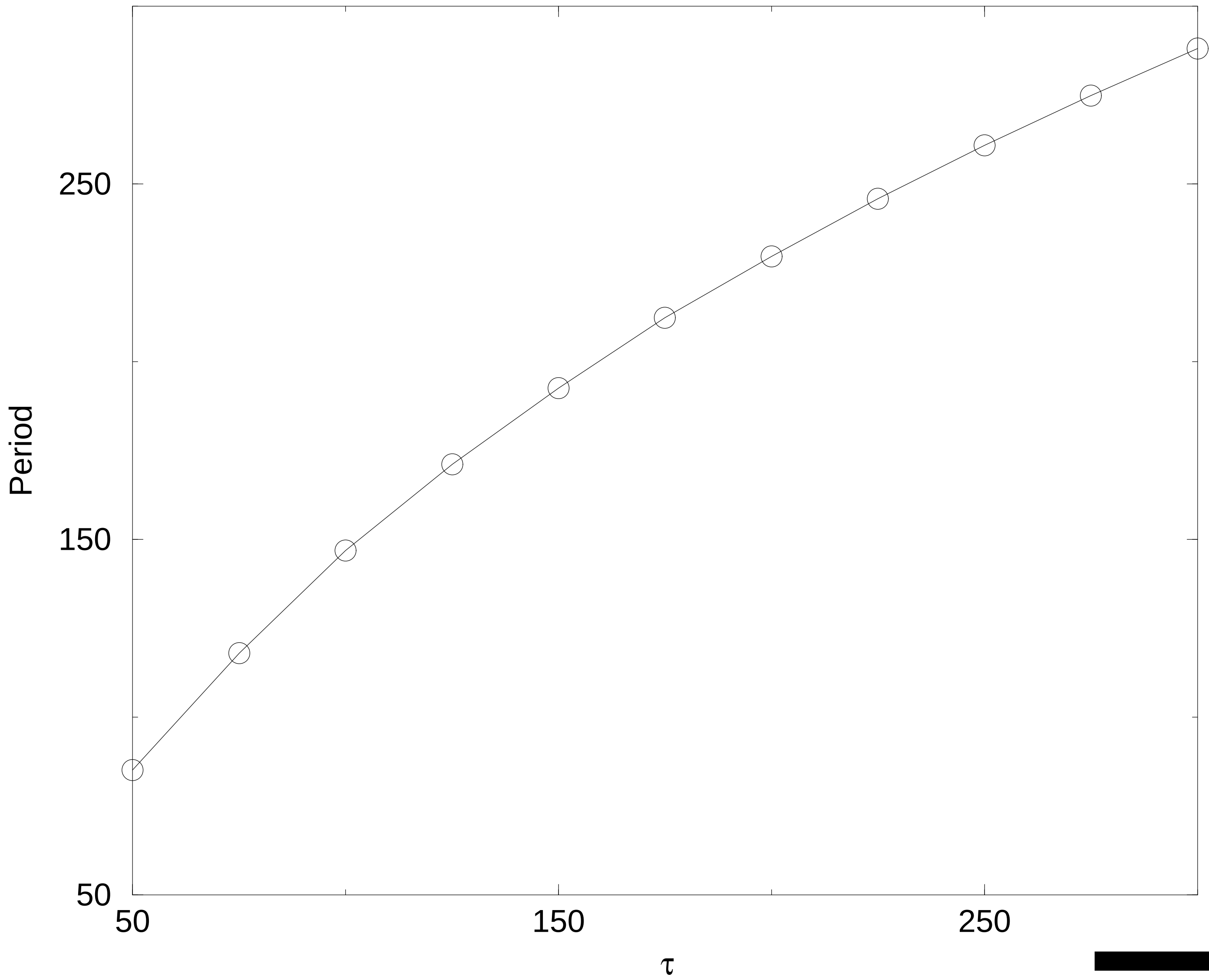
$$C\frac{dV}{dt} = -I_{ion} - gs(V - E_{syn})$$
$$\frac{ds}{dt} = [\alpha(V)(1 - s) - s]/\tau$$

- Treat s as a slow variable
- Traverse upper branch
- Synaptic time course governs period
- Exists for small range of g_{syn} but period is fixed

Slow-fast picture



Burst period vs τ

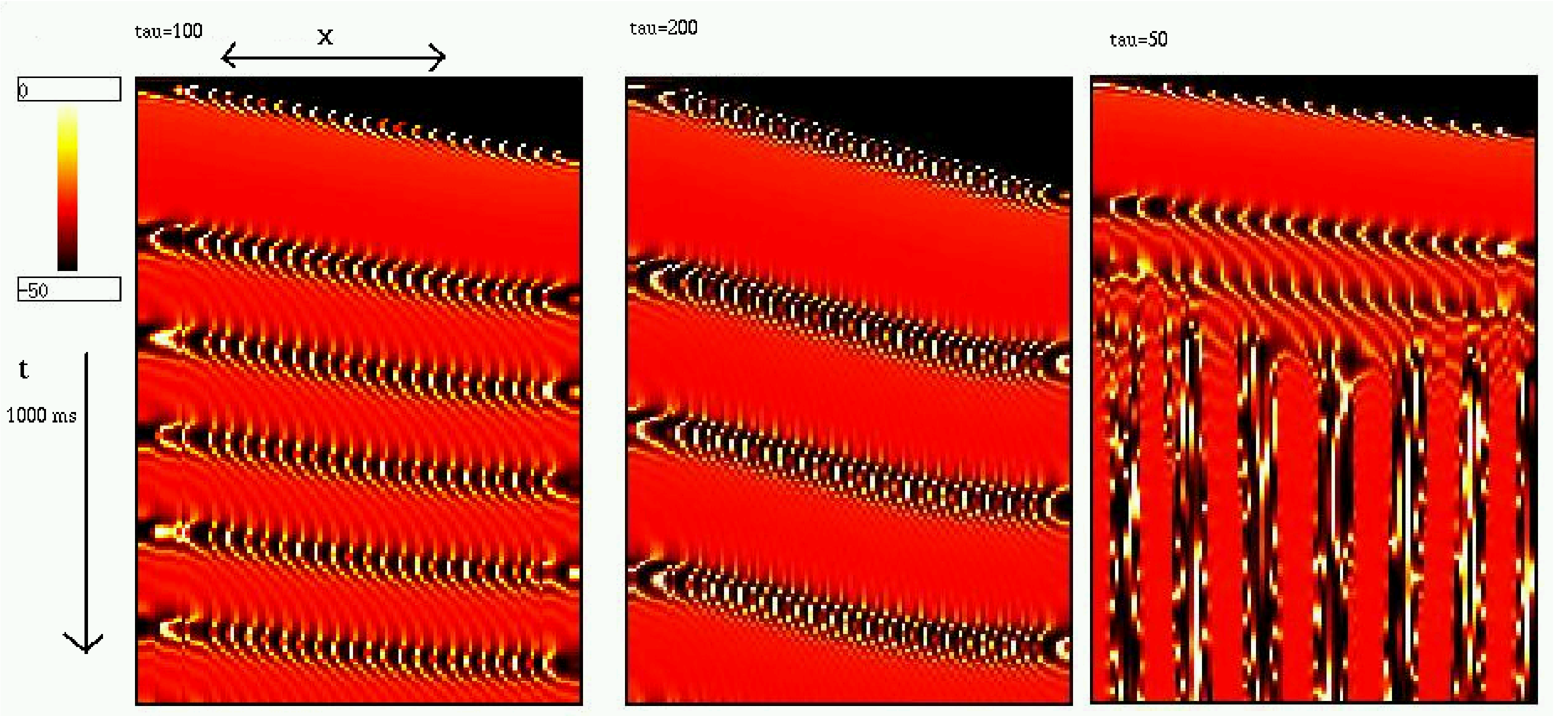


Slice model

$$C\frac{dV_j}{dt} = -I_{ion}(V_j) - g_{syn}\left(\sum_k w_{j-k}s_k\right)[V - E_{syn}]$$

$$\frac{ds_j}{dt} = [\alpha(V_j)(1 - s_j) - s_j]/\tau$$

Simulation



Waves Splinters

Splinters

- As time constant decreases, get a splintering of the wave
- Spatial patterns of localized activity
- “Negative coupling”

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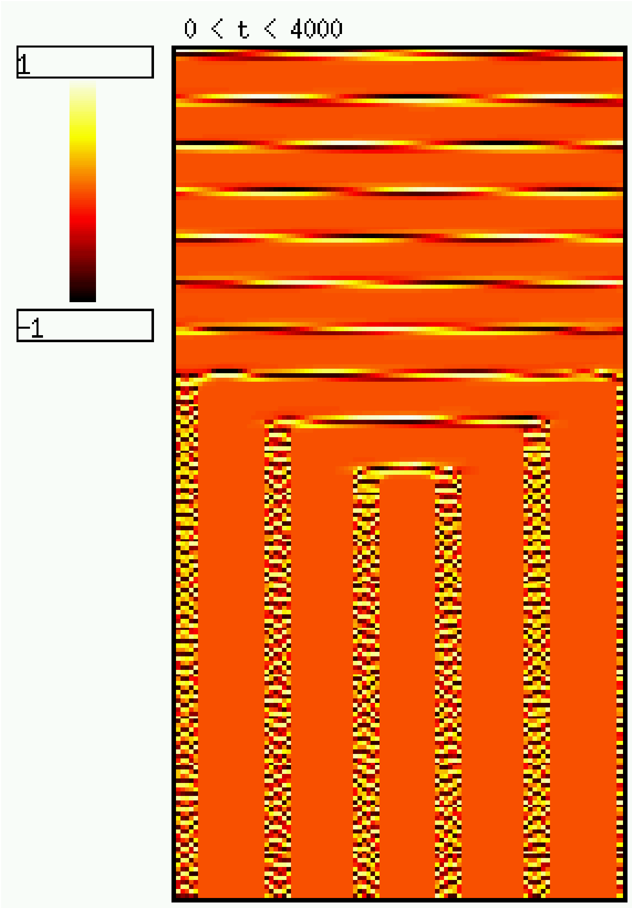
Normal form for coupled elliptic bursters

$$\frac{\partial z}{\partial t} = z(c + a|z|^2 - |z|^4 - dK(x) * s(x))$$
$$\tau \frac{\partial s}{\partial t} = (|z|^2 - s)$$

Simulation



Explanation I.

- Let $r = |z|^2$ and look for stationary solns
- Get simple equation:

$$0 = r(x)(c - dK(x) * r(x) + ar(x) - r(x)^2)$$

- Solns include $r(x) > 0$ on $x \in \Omega$ where

$$\Omega = \bigcup_{\zeta} (\alpha_\zeta, \beta_\zeta)$$

- “neutrally stable”

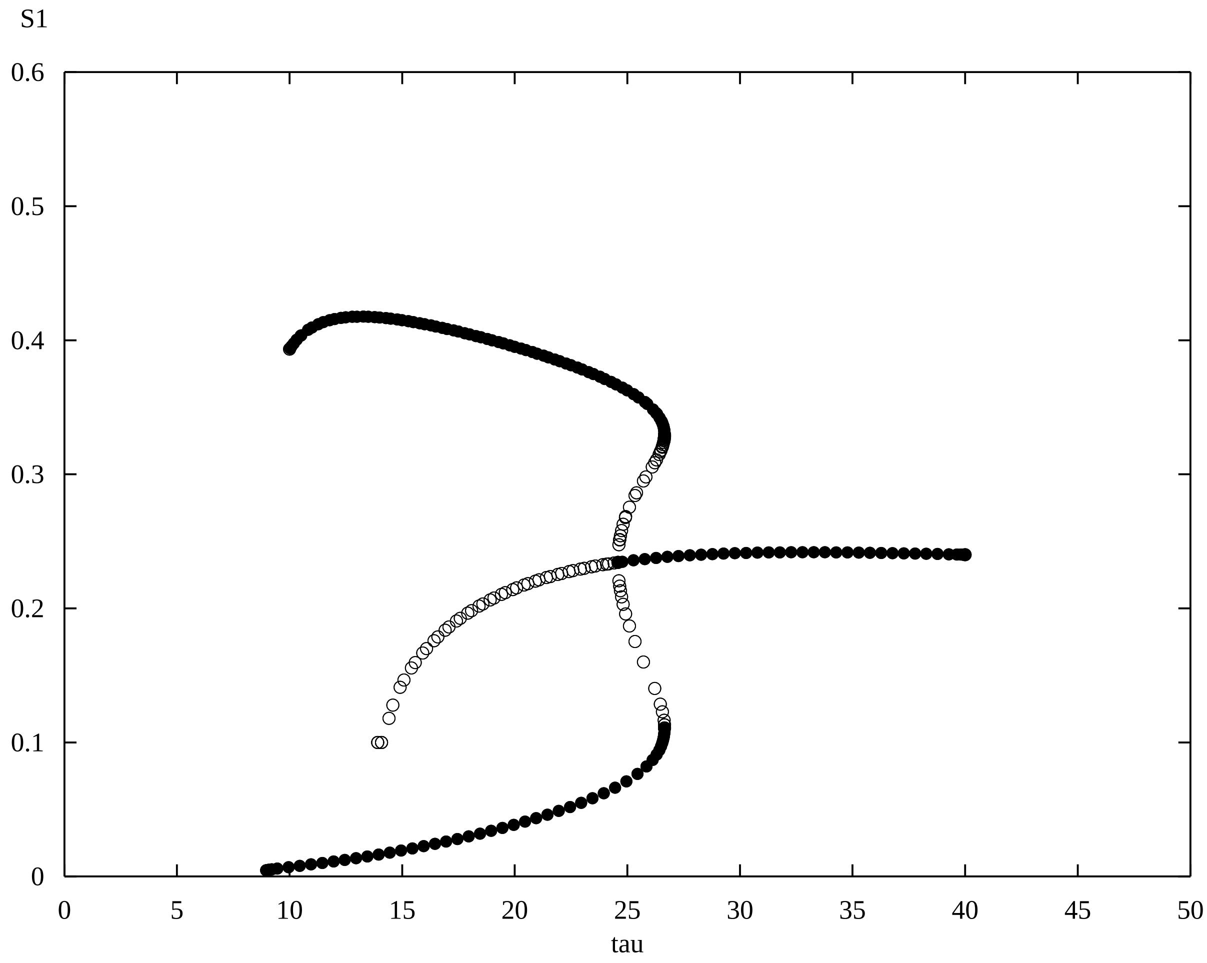
Explanation II.

- Transition is best understood with a pair:

$$\begin{aligned} r_j' &= r_j(c - d(s_1 + s_2) + ar_j - r_j^2) + \epsilon \\ s_j' &= (r_j - s_j)/\tau \end{aligned}$$

- Bifurcation as τ decreases
- Synchrony loses stability at pitchfork

Diagram



Questions etc

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- If not, casts suspicion on depolarization block as only means of termination
- What determines splinter spacing?

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