

work on H-H and

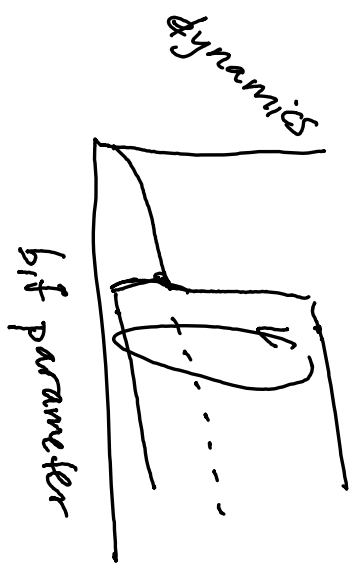
Fitzhugh-Nagumo

(phase planes, computational work)

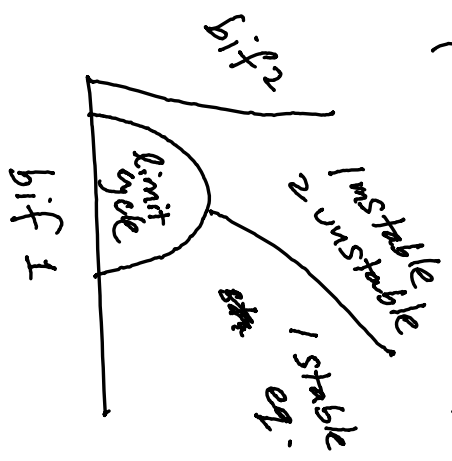
INTRODUCTION TO CHAOS •

- H-H model.

$V, m$  phase plane



DDs for  
Innocenti et al  
2007  
by Tues PM



1 March 2021

NUMERICAL •

~ hard to

see UNSTABLE  
attractors

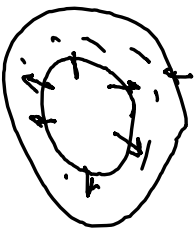
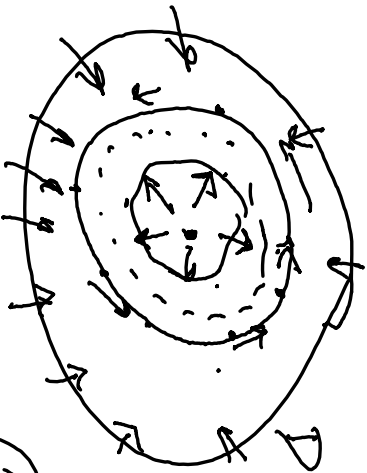
(reverse time?)

# Poincaré-Bendixon theorem

(Mar 2021)

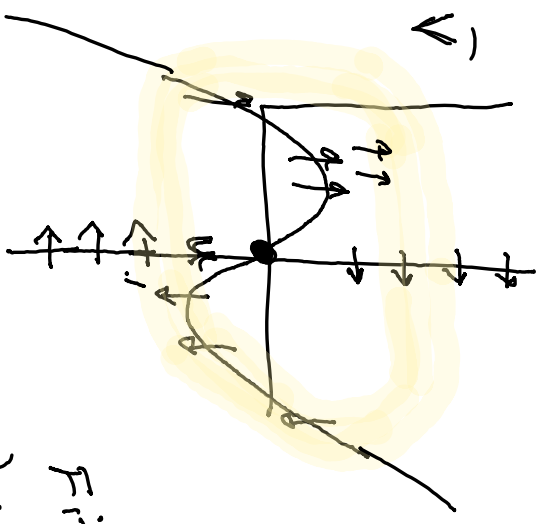
Edelstein-Kesket: CURIC nullclines

P-B: bounded traj that don't approach a singular pt are closed & periodic  
OR approach a closed & periodic orbit



- bounded region w/ 1 unstable eq.
- bounded annulus w/ no equilibria

$v=0$  cubic system:



$$\frac{dv}{dt} = v - G(v)$$

( $G(v)$  is <sup>OPD</sup>cubic)

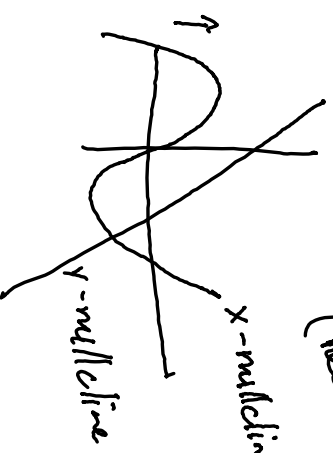
$$\frac{dv}{dt} = -u$$

$$G(-u) = -G(u)$$

Fitzhugh-Nagumo model  $\leftarrow$  applied voltage

(voltage)  $\frac{dx}{dt} = c(y + x - \frac{x^3}{3} + z(t))$

(recovery)  $dy = -x + \frac{a+by}{c}$



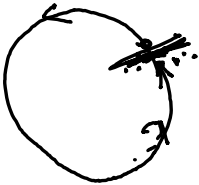
$ISI =$  interspike interval

LYAPUNOV exponents

• stability of eq points

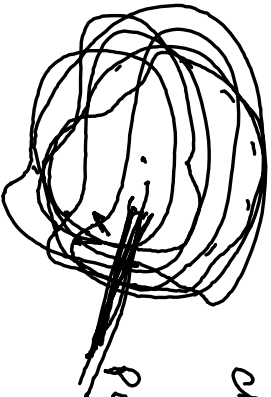


UNIT circle

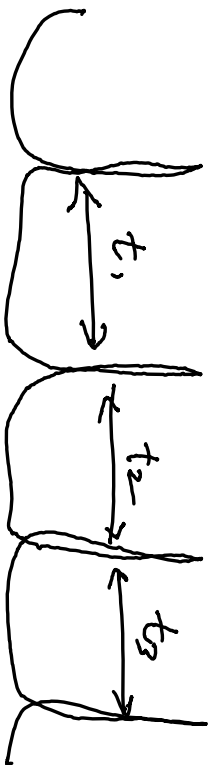


Floquet multiplier  
eigenvalue

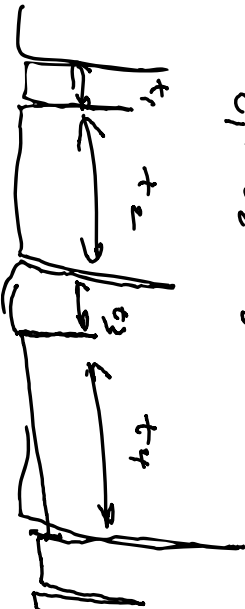
chaos?



POINCARÉ section  
Lyapunov:  $\lambda$



$$t_1 = t_2 = t_3 = \dots$$



$$\{ t_1, t_2, t_3, t_4, \dots \}$$

$$\int \lambda(t) dt \geq 0 ?$$

$\lambda > 0 =$  chaos  
 $\lambda < 0 =$  limit cycle.