

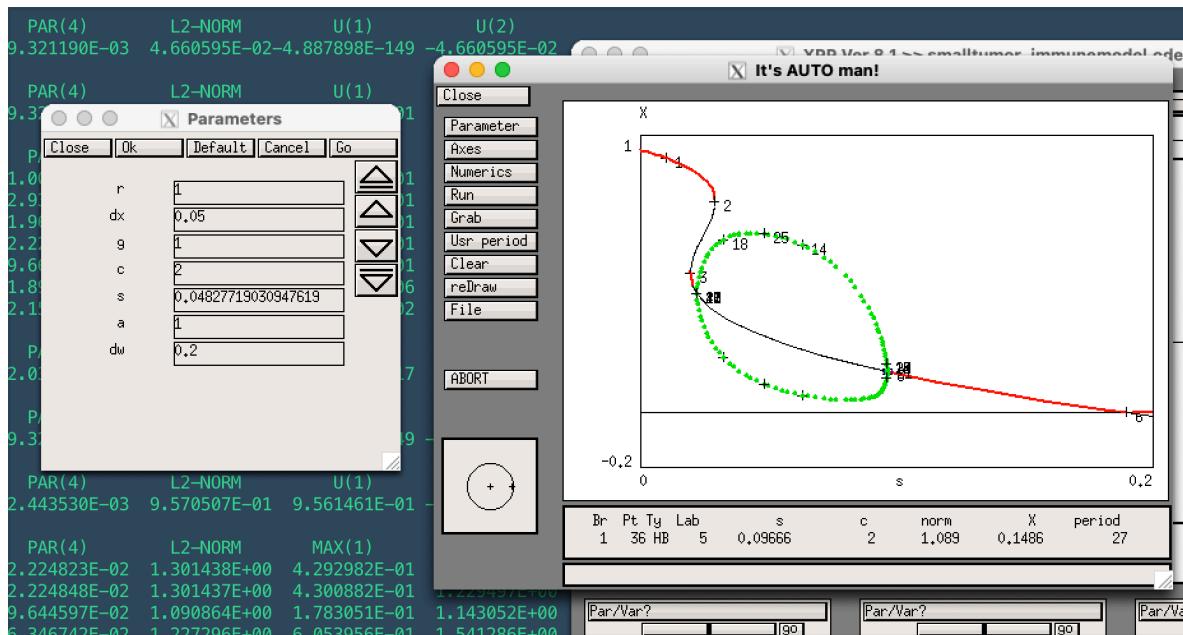
Maths en Action - Dynamique cellulaire et systèmes complexes

Hiver 2023 - Samuel Bernard (bernard@math.univ-lyon1.fr)

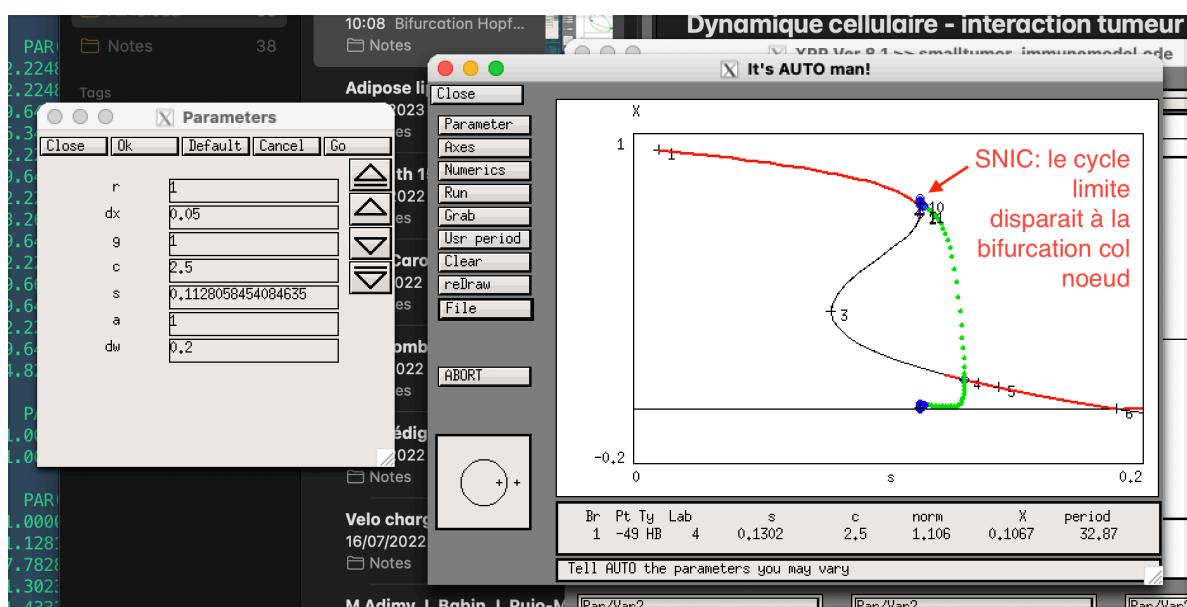
Interaction tumeur immune

```
dx/dt=r*x*(1-x) - dx*x - g*x*w*exp(-c*x) # tumeur
dw/dt=s + a*x*w*exp(-c*x) - dw*w           # système
immunitaire
```

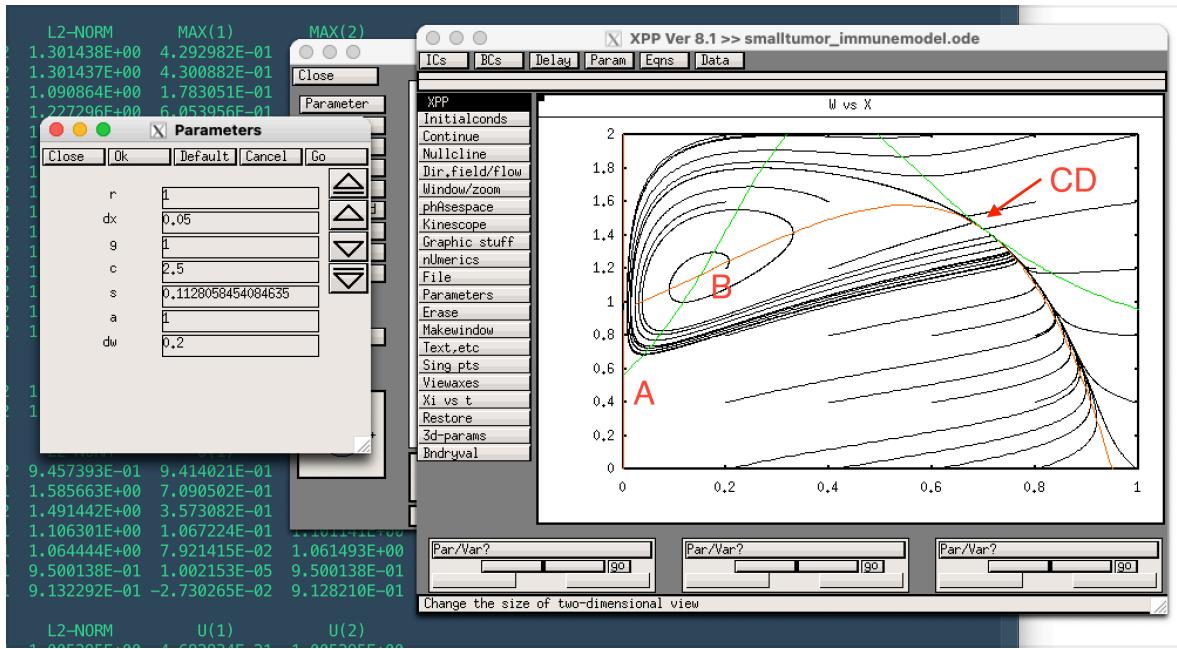
Bifurcation Hopf - Hopf



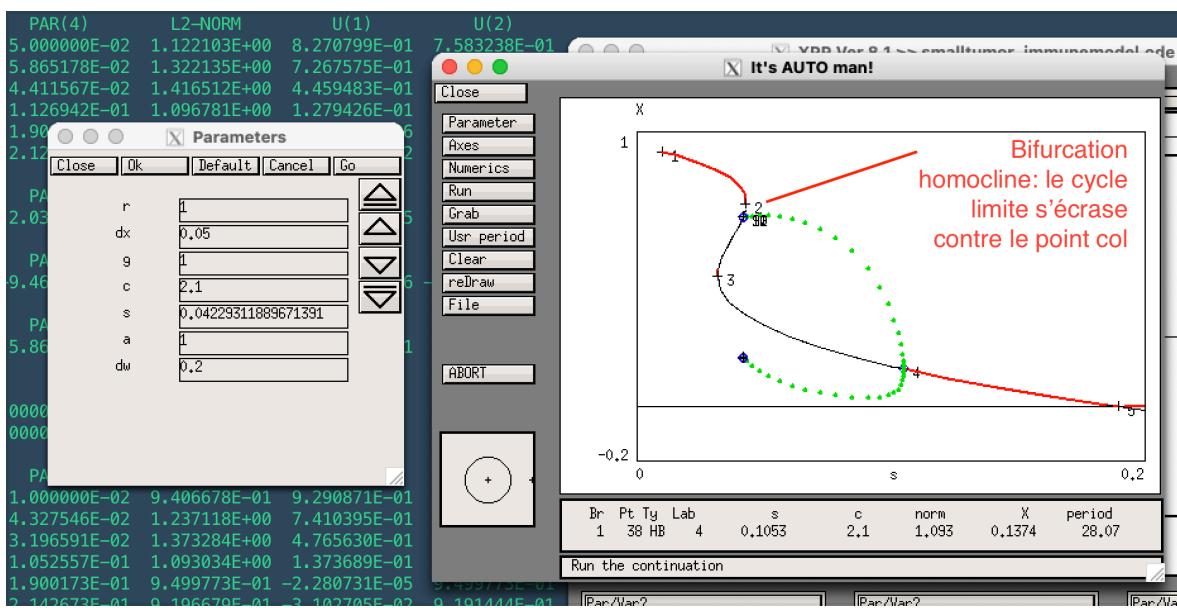
Bifurcation SNIC (Saddle-Node on an Invariant Cycle)



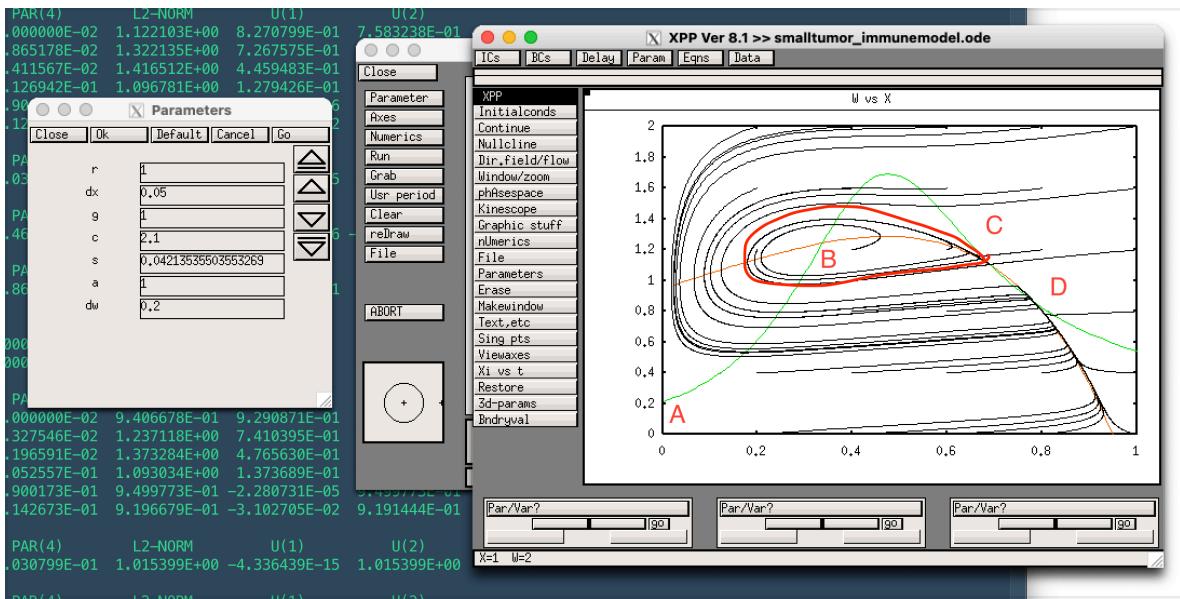
Portrait de phase à la bifurcation SNIC



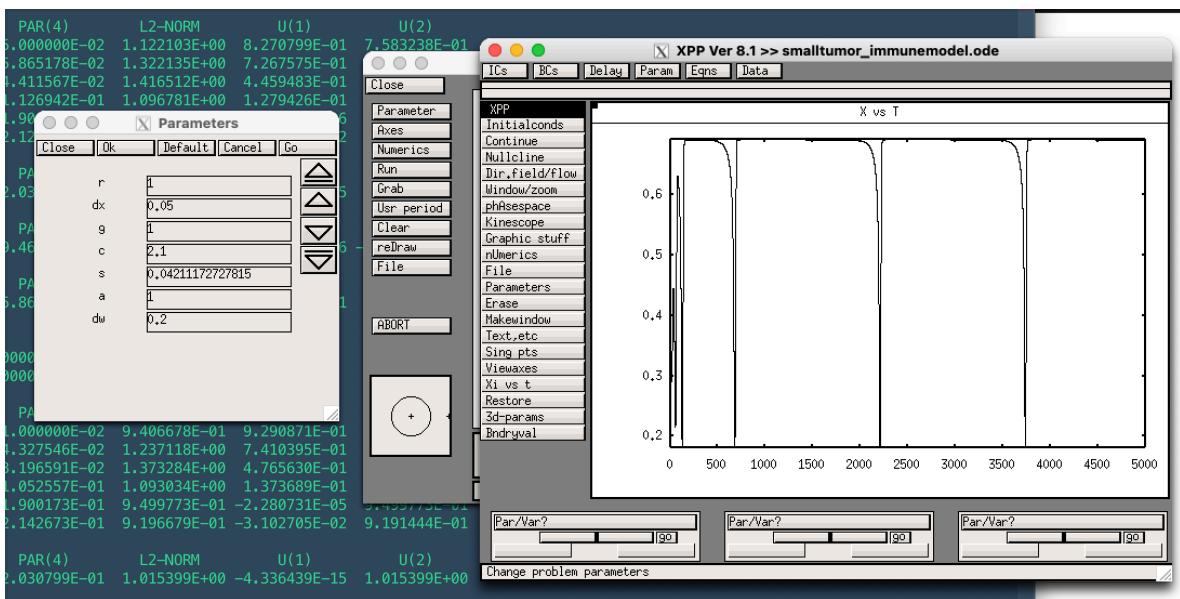
Bifurcation homocline



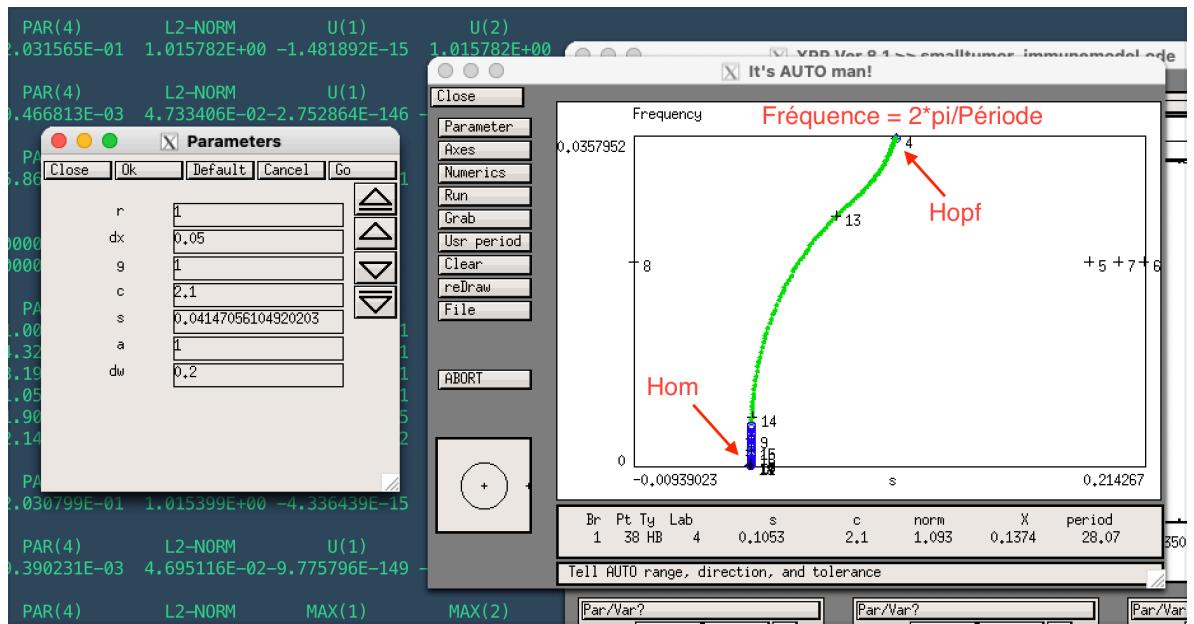
Portrait de phase à la bifurcation homocline



Vers la bifurcation, le cycle limite atteint une période très élevée



La fréquence du cycle limite converge vers 0



Codes (XPPAUT: <https://sites.pitt.edu/~phase/bard/bardware/xpp/xpp.html>)

```
# smalltumor_immunemodel.ode

dx/dt=r*x*(1-x) -dx*x - g*x*w*exp(-c*x)
dw/dt=s + a*x*w*exp(-c*x) - dw*w

p r=1.0 ,dx=0.05 ,g=1 ,c=2.0
p s=0.05 ,a=1 ,dw=0.2

init x=1,w=1

@ meth=qualrk ,total=1000

d
```