Gata3 - Julia and PyDSTool

June 19, 2018

In [1]:
```
using DifferentialEquations
using PyDSTool
using Plots; gr()
```

Out[1]:
```
Plots.GRBackend()
```

In [2]:
```
# see DifferentialEquations version number
display(Pkg.installed("DifferentialEquations"))

# see PyDSTool version number
display(Pkg.installed("PyDSTool"))
```

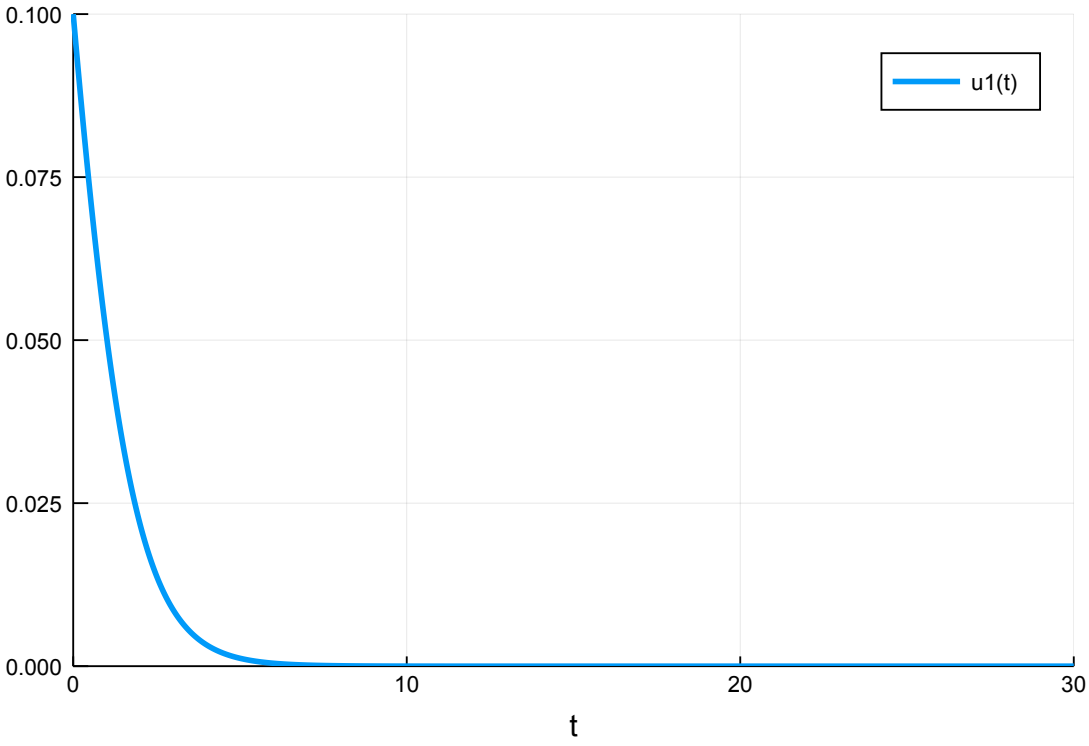
```
v"4.5.0"
```

```
v"0.4.0"
```

1 Solving ODE

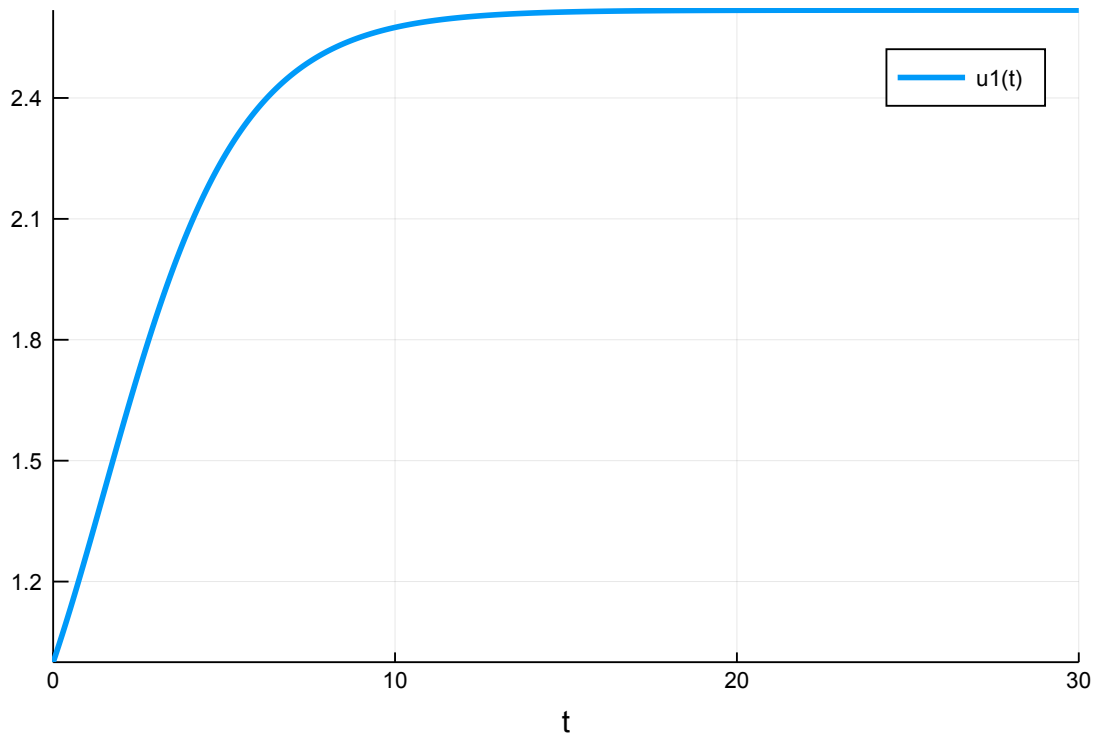
In [3]:
```
alpha, k_g, k, S = (0.02, 5.0, 1.0, 0.0)
f2(u,p,t) = alpha*S + k_g*u^(2.0)/(1.0+u)^(2.0) - k*u
u0 = 0.1 # initial condition
tspan = (0.0,30.0) # integration time
prob = ODEProblem(f2,u0,tspan)
sol = solve(prob,Tsit5(),reltol=1e-8,abstol=1e-8)
plot(sol)
```

Out[3]:



In [4]:
```
u0 = 1.0 # initial condition
prob = ODEProblem(f2,u0,tspan)
sol = solve(prob,Tsit5(),reltol=1e-8,abstol=1e-8)
plot(sol)
```

Out[4]:



2 Preparing bifurcations

```
In [5]: f = @ode_def GataSystem begin
         dGata3= alpha*S + (k_g*Gata3^2.0)/((1.0+Gata3)^2.0)-k*Gata3
        end alpha k_g k S

Out[5]: (::GataSystem) (generic function with 9 methods)

In [6]: u0 = 0 # initial condition
        tspan = [0;30] # integration time
        p = [0.02, 5.0, 1.0, 0.0] # parameter array

Out[6]: 4-element Array{Float64,1}:
         0.02
         5.0
         1.0
         0.0

In [7]: dsargs = build_ode(f,u0,tspan,p)

        ode = ds[:Generator][:Vode_ODEsystem](dsargs)
        ode[:set](pars = Dict("S"=>0.0)) #initialize with a parameter (the initial value of th
        ode[:set](ics  = Dict("Gata3"=>0.001)) # initial condition: close to a steady state
```

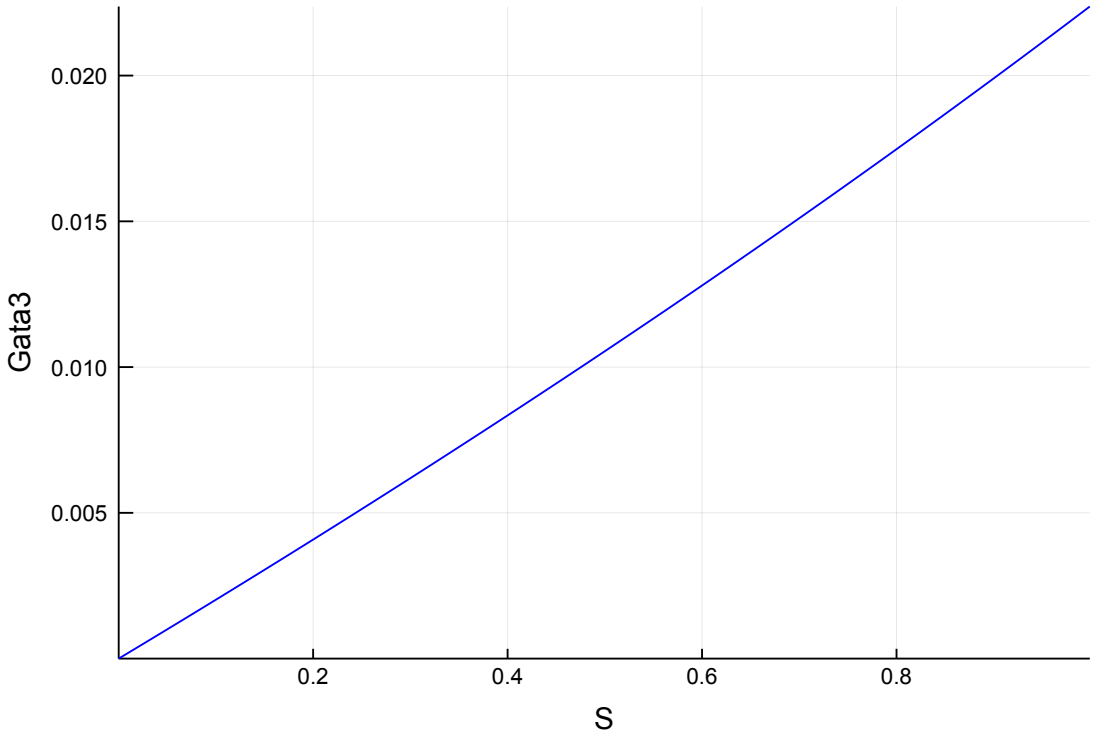
3 Experiment 1: tiny steps -> lower branch OK

In [8]:
```
PC = ds[:ContClass](ode)

        bif = bifurcation_curve(PC,
                                "EP-C",
                                ["S"], #S is the bifurcation parameter
                                max_num_points=1000,
                                max_stepsize=1e-3,
                                min_stepsize=1e-4,
                                stepsize=1e-3,
                                loc_bif_points="all",
                                calc_stab=true,
                                save_eigen=true,
                                name="EQ1",
                                print_info=true)

        plot(bif,(:S,:Gata3))
```

```
Warning: Variable dimension must be larger than 1 to detect Hopf points.
PyCont curve EQ1 (type EP-C)
Using model: GataSystem

Model Info
----------

  Variables : Gata3
  Parameters: alpha, S, k, k_g

Continuation Parameters
-----------------------

name  =  EQ1
auxpars  =  []
freepars  =  ['S']
MaxNumPoints  =  1000
MaxCorrIters  =  5
MaxTestIters  =  10
MaxStepSize  =  0.001
MinStepSize  =  0.0001
StepSize  =  0.001
VarTol  =  1e-06
FuncTol  =  1e-06
TestTol  =  0.0001
LocBifPoints  =  ['B', 'SP', 'BP', 'LP']
verbosity  =  1
ClosedCurve  =  50
SaveJacobian  =  False
```

```
SaveEigen  =  True
Corrector  =  <bound method EquilibriumCurve._MoorePenrose of PyCont curve EQ1 (type EP-C)>
UseAuto  =  False
StopAtPoints  =  []
SPOut  =  None


Special Points
--------------

P1, P2
```

Out[8]:



4 Experiment 2: more number of points -> lower branch "gets" unstable

In [9]:
```
PC = ds[:ContClass](ode)
bif = bifurcation_curve(PC,
                        "EP-C",
                        ["S"], #S is the bifurcation parameter
                        max_num_points=4000,
                        max_stepsize=1e-3,
```

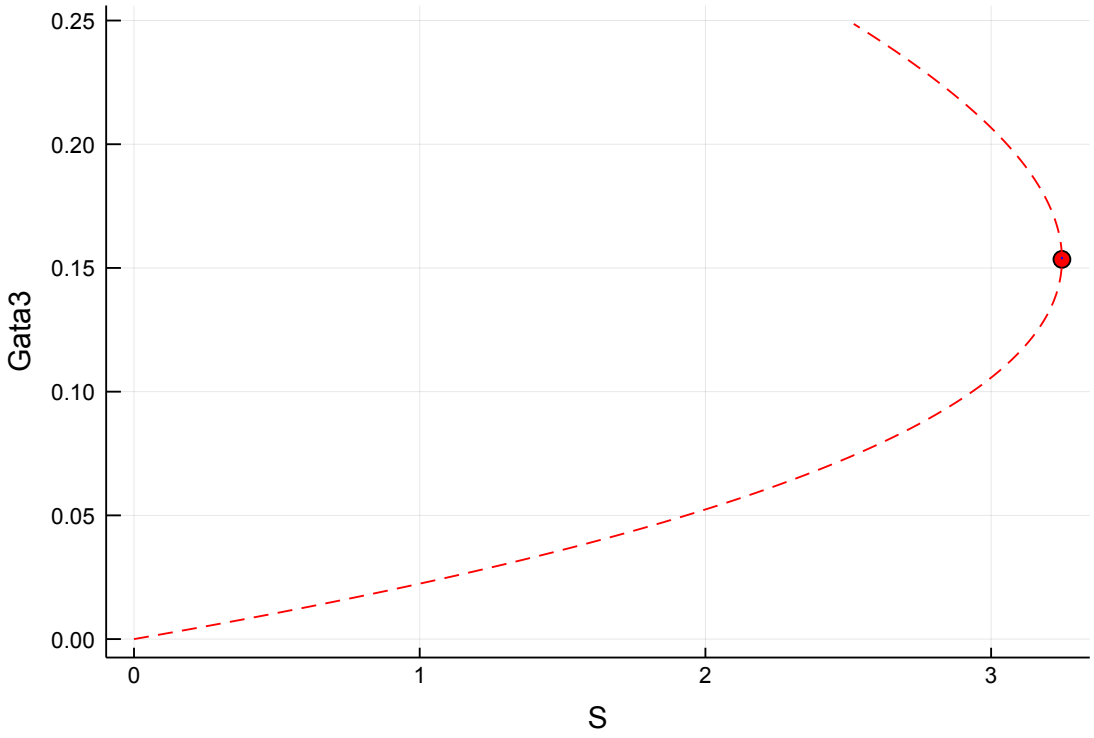
```
                                    min_stepsize=1e-4,
                                    stepsize=1e-3,
                                    loc_bif_points="all",
                                    calc_stab=true,
                                    save_eigen=true,
                                    name="EQ1",
                                    print_info=true)

        plot(bif,(:S,:Gata3))
```

```
Warning: Variable dimension must be larger than 1 to detect Hopf points.
LP Point found
PyCont curve EQ1 (type EP-C)
Using model: GataSystem

Model Info
----------

  Variables : Gata3
  Parameters: alpha, S, k, k_g

Continuation Parameters
-----------------------

name  =  EQ1
auxpars  =  []
freepars  =  ['S']
MaxNumPoints  =  4000
MaxCorrIters  =  5
MaxTestIters  =  10
MaxStepSize  =  0.001
MinStepSize  =  0.0001
StepSize  =  0.001
VarTol  =  1e-06
FuncTol  =  1e-06
TestTol  =  0.0001
LocBifPoints  =  ['B', 'SP', 'BP', 'LP']
verbosity  =  1
ClosedCurve  =  50
SaveJacobian  =  False
SaveEigen  =  True
Corrector  =  <bound method EquilibriumCurve._MoorePenrose of PyCont curve EQ1 (type EP-C)>
UseAuto  =  False
StopAtPoints  =  []
SPOut  =  None


Special Points
```

```
--------------
```

```
P1, P2, LP1
```

Out[9]:



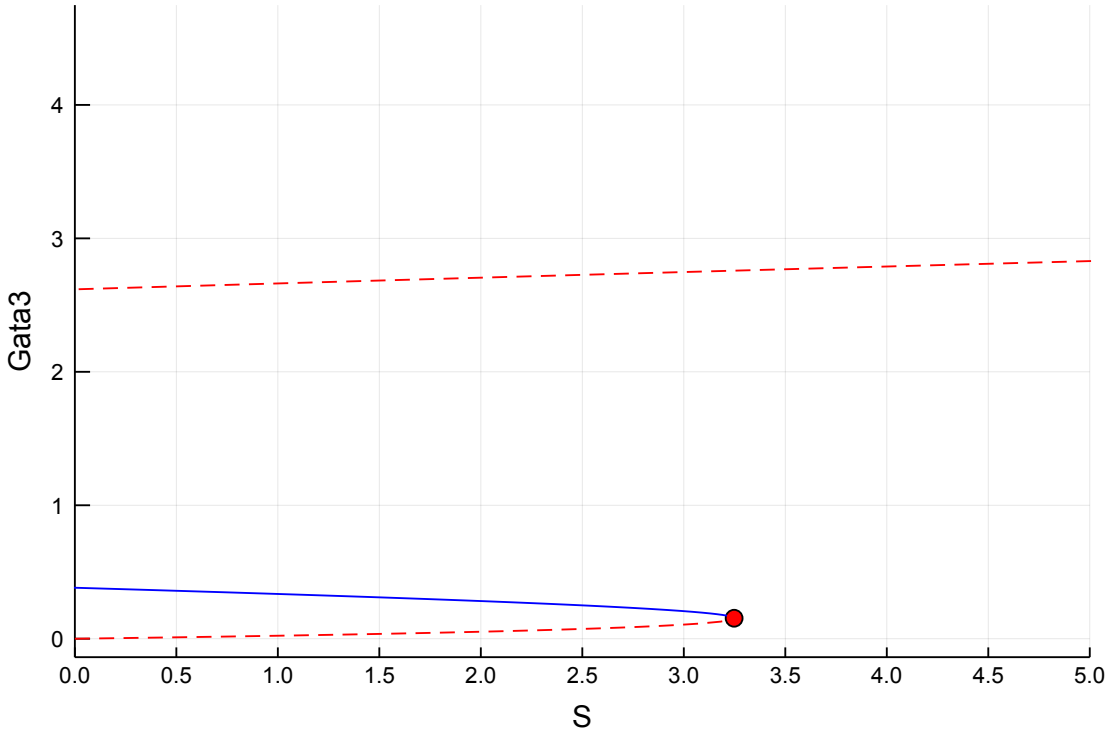
5 Experiment 3: greater steps -> getting reversed stability

```
In [10]: PC = ds[:ContClass](ode)
         bif = bifurcation_curve(PC,
                                 "EP-C",
                                 ["S"], #S is the bifurcation parameter
                                 max_num_points=1000,
                                 max_stepsize=1e-1,
                                 min_stepsize=1e-4,
                                 stepsize=1e-2,
                                 loc_bif_points="all",
                                 calc_stab=true,
                                 save_eigen=true,
                                 name="EQ1",
                                 print_info=true)
```

```
        plot(bif,(:S,:Gata3))
        plot!(xlims=(0,5),xticks=0:0.5:5)
```

```
Warning: Variable dimension must be larger than 1 to detect Hopf points.
LP Point found
LP Point found
PyCont curve EQ1 (type EP-C)
Using model: GataSystem

Model Info
----------

  Variables : Gata3
  Parameters: alpha, S, k, k_g

Continuation Parameters
-----------------------

name  =  EQ1
auxpars  =  []
freepars  =  ['S']
MaxNumPoints  =  1000
MaxCorrIters  =  5
MaxTestIters  =  10
MaxStepSize  =  0.1
MinStepSize  =  0.0001
StepSize  =  0.1
VarTol  =  1e-06
FuncTol  =  1e-06
TestTol  =  0.0001
LocBifPoints  =  ['B', 'SP', 'BP', 'LP']
verbosity  =  1
ClosedCurve  =  50
SaveJacobian  =  False
SaveEigen  =  True
Corrector  =  <bound method EquilibriumCurve._MoorePenrose of PyCont curve EQ1 (type EP-C)>
UseAuto  =  False
StopAtPoints  =  []
SPOut  =  None


Special Points
--------------

P1, P2, LP1, LP2
```

Out[10]:


Gata3
S
0
1
2
3
4
0.0
0.5
1.0
1.5
2.0
2.5
3.0
3.5
4.0
4.5
5.0