$$x\prod_{k=1}^{\infty}\left(1-\frac{x^2}{k^2\pi^2}\right)=\sin(x)$$

we will find p derivative

$$p'\left[x\cdot\left[\prod_{k=1}^{\infty}\left(1-\frac{x^2}{k^2\pi^2}\right)\right]\right]=p'(\sin(x)) \rightarrow e^{\frac{1}{x}}\left(\prod_{k=1}^{\infty}e^{\frac{2x}{x^2-k^2\pi^2}}\right)=e^{\frac{1}{\tan(x)}} \rightarrow \frac{1}{x}+\sum_{k=1}^{\infty}\frac{2x}{x^2-k^2\pi^2}=\frac{1}{\tan(x)} \quad x=\frac{\pi}{4}$$

+

we will find L derivative

$$L'\left[x\left[\prod_{k=1}^{\infty}\left(1-\frac{x^2}{k^2\pi^2}\right)\right]\right]=L'(\sin(x)) \rightarrow 1+\sum_{k=1}^{\infty}\frac{2x^2}{x^2-k^2\pi^2}=\frac{x}{\tan(x)} \rightarrow \frac{1}{x}+\sum_{k=1}^{\infty}\frac{2x}{x^2-k^2\pi^2}=\frac{1}{\tan(x)}$$

$$\frac{4}{\pi}+\sum_{k=1}^{70}\frac{1}{\pi\left(0.125-2k^2\right)}=1.002257489 \qquad \frac{1}{\tan\left(\frac{\pi}{4}\right)}=1$$

$$\prod_{k=1}^{\infty}\left[1-\frac{4x^2}{(2k-1)^2\pi^2}\right]=\cos(x)$$

we will find p derivative

$$p'\left[\prod_{k=1}^{\infty}\left[1-\frac{4x^2}{(2k-1)^2\pi^2}\right]\right]=p'(\cos(x)) \rightarrow \prod_{k=1}^{\infty}e^{\frac{-8x}{(2k-1)^2\pi^2-4x^2}}=e^{-\tan(x)} \rightarrow \sum_{k=1}^{\infty}\frac{8x}{(2k-1)^2\pi^2-4x^2}=\tan(x) \quad x=\frac{\pi}{4}$$

we will find L derivative

$$L'\left[\prod_{k=1}^{\infty}\left[1-\frac{4x^2}{(2k-1)^2\pi^2}\right]\right]=L'(\cos(x)) \rightarrow \sum_{k=1}^{\infty}\frac{-8x^2}{(2k-1)^2\pi^2-4x^2}=-x\tan(x) \rightarrow \sum_{k=1}^{\infty}\frac{8x}{(2k-1)^2\pi^2-4x^2}=\tan(x)$$

$$\sum_{k=1}^{70}\frac{2}{\pi\cdot\left[(2k-1)^2-\frac{1}{4}\right]}=0.997726387 \qquad \tan\left(\frac{\pi}{4}\right)=1$$

$$\prod_{k=1}^{\infty}\left[1+\frac{4x^2}{(2k-1)^2\pi^2}\right]=\cosh(x)$$ we will find p derivative $$p'\left[\prod_{k=1}^{\infty}\left[1+\frac{4x^2}{(2k-1)^2\pi^2}\right]\right]=p'(\cosh(x)) \rightarrow \prod_{k=1}^{\infty} e^{\frac{8x}{(2k-1)^2\pi^2+4x^2}}=e^{\tanh(x)} \rightarrow \sum_{k=1}^{\infty}\frac{8x}{(2k-1)^2\pi^2+4x^2}=\tanh(x) \quad x=1$$

we will find L derivative $$L'\left[\prod_{k=1}^{\infty}\left[1+\frac{4x^2}{(2k-1)^2\pi^2}\right]\right]=L'(\cosh(x)) \rightarrow \sum_{k=1}^{\infty}\frac{8x^2}{(2k-1)^2\pi^2+4x^2}=x\tanh(x) \rightarrow \sum_{k=1}^{\infty}\frac{8x}{(2k-1)^2\pi^2+4x^2}=\tanh(x)$$

$$\sum_{k=1}^{70}\frac{8}{(2k-1)^2\pi^2+4}=0.758699334 \qquad \tanh(1)=0.761594156$$

$$x\prod_{k=1}^{\infty}\left(1+\frac{x^2}{k^2\pi^2}\right)=\sinh(x)$$ we will find p derivative $$p'\left[x\cdot\prod_{k=1}^{\infty}\left(1+\frac{x^2}{k^2\pi^2}\right)\right]=p'(\sinh(x)) \rightarrow e^{\frac{1}{x}}\left(\prod_{k=1}^{\infty} e^{\frac{2x}{k^2\pi^2+x^2}}=e^{\frac{1}{\tanh(x)}}\right) \rightarrow \frac{1}{x}+\sum_{k=1}^{\infty}\frac{2x}{k^2\pi^2+x^2}=\frac{1}{\tanh(x)} \quad x=4$$

we will find L derivative $$L'\left[x\cdot\prod_{k=1}^{\infty}\left(1+\frac{x^2}{k^2\pi^2}\right)\right]=L'(\sinh(x)) \rightarrow 1+\sum_{k=1}^{\infty}\frac{2x^2}{k^2\pi^2+x^2}=\frac{x}{\tanh(x)} \rightarrow \frac{1}{x}+\sum_{k=1}^{\infty}\frac{2x}{k^2\pi^2}=\frac{1}{\tanh(x)}$$

$$0.25+\sum_{k=1}^{70}\frac{8}{k^2\pi^2+16}=0.989175154 \qquad \frac{1}{\tanh(4)}=1.00067115$$

$$\prod_{k=0}^{\infty}\left(1+x^{2^k}\right)=\frac{1}{1-x}\quad |x|<1$$ we will find p derivative $$p'\left[\prod_{k=0}^{\infty}\left(1+x^{2^k}\right)\right]=p'\left(\frac{1}{1-x}\right)\rightarrow\prod_{k=0}^{\infty}e^{\frac{2^k\cdot x^{2^k-1}}{1+x^{2^k}}}=e^{\frac{1}{1-x}}\rightarrow\sum_{k=0}^{\infty}\frac{2^k x^{2^k-1}}{1+x^{2^k}}=\frac{1}{1-x}\quad x=0.2\quad \sum_{k=0}^{70}\frac{2^k\cdot 0.2^{2^k-1}}{1+0.2^{2^k}}=1.25\quad \frac{1}{1-0.2}=1.25$$

we will find L derivative $$L'\left[\prod_{k=0}^{\infty}\left(1+x^{2^k}\right)\right]=L'\left(\frac{1}{1-x}\right)\rightarrow\sum_{k=0}^{\infty}\frac{2^k x^{2^k}}{1+x^{2^k}}=\frac{x}{x-1}\quad x=0.2\quad \sum_{k=0}^{70}\frac{2^k\cdot 0.2^{2^k}}{1+0.2^{2^k}}=0.25\quad \frac{0.2}{1-0.2}=0.25$$

$$\prod_{k=1}^{\infty}\cos\left(\frac{x}{2^k}\right)=\frac{\sin(x)}{x}$$ we will find p derivative $$p'\left(\prod_{k=1}^{\infty}\cos\left(\frac{x}{2^k}\right)\right)=p'\left(\frac{\sin(x)}{x}\right)\rightarrow\prod_{k=1}^{\infty}e^{\frac{-\tan\left(\frac{x}{2^k}\right)}{2^k}}=e^{\frac{1}{\tan(x)}+\frac{-1}{x}}\rightarrow\sum_{k=1}^{\infty}\frac{\tan\left(\frac{x}{2^k}\right)}{2^k}=\left(\frac{1}{x}\right)-\frac{1}{\tan(x)}$$

we will find L derivative $$L'\left(\prod_{k=1}^{\infty}\cos\left(\frac{x}{2^k}\right)\right)=L'\left(\frac{\sin(x)}{x}\right)\rightarrow\sum_{k=1}^{\infty}\frac{x\cdot\tan\left(\frac{x}{2^k}\right)}{2^k}=1-\frac{x}{\tan(x)}\rightarrow\sum_{k=1}^{\infty}\frac{\tan\left(\frac{x}{2^k}\right)}{2^k}=\left(\frac{1}{x}\right)-\frac{1}{\tan(x)}$$

$$x=\frac{\pi}{4}\quad \sum_{k=1}^{70}\frac{\tan\left(\frac{\pi}{2^{k+2}}\right)}{2^k}=0.273239545\quad \frac{4}{\pi}-\frac{1}{\tan\left(\frac{\pi}{4}\right)}=0.273239545\quad x=2\quad \sum_{k=1}^{70}\frac{\tan\left(\frac{2}{2^k}\right)}{2^k}=0.957657554\quad \frac{1}{2}-\frac{1}{\tan(2)}=0.957657554$$

$$\prod_{k=1}^{\infty} \cosh\left(\frac{x}{2^k}\right) = \frac{\sinh(x)}{x}$$

we will find p derivative

$$p'\left(\prod_{k=1}^{\infty} \cosh\left(\frac{x}{2^k}\right)\right) = p'\left(\frac{\sinh(x)}{x}\right) \rightarrow \prod_{k=1}^{\infty} e^{\frac{\tanh\left(\frac{x}{2^k}\right)}{2^k}} = e^{\frac{1}{\tanh(x)}-\frac{1}{x}} \rightarrow \sum_{k=1}^{\infty} \frac{\tanh\left(\frac{x}{2^k}\right)}{2^k} = \frac{1}{\tanh(x)} - \frac{1}{x}$$

we will find L derivative

$$L'\left(\prod_{k=1}^{\infty} \cosh\left(\frac{x}{2^k}\right)\right) = L'\left(\frac{\sinh(x)}{x}\right) \rightarrow \left(\sum_{k=1}^{\infty} \frac{x\cdot\tanh\left(\frac{x}{2^k}\right)}{2^k}\right) = \frac{x}{\tanh(x)} - 1 \rightarrow \sum_{k=1}^{\infty} \frac{\tanh\left(\frac{x}{2^k}\right)}{2^k} = \frac{1}{\tanh(x)} - \frac{1}{x}$$

$$x = 0.5 \qquad \sum_{k=1}^{70} \frac{\tanh\left(\frac{1}{2^{k+1}}\right)}{2^k} = 0.163953414 \qquad \frac{1}{\tanh(0.5)} - 2 = 0.163953414$$

$$x = 0.9 \qquad \sum_{k=1}^{70} \frac{\tanh\left(\frac{0.9}{2^k}\right)}{2^k} = 0.284956142 \qquad \frac{1}{\tanh(0.9)} - \frac{1}{0.9} = 0.284956142$$

The system of differerential equations defines parametric equations for curve in spase

$$\frac{d}{dt}x(t) = a\cdot x(t)\cdot \ln(x(t)\cdot z(t)) \qquad \left[P'x(t) = (x(t)\cdot z(t))^{a}\right] \qquad a := 0.001 \qquad c := 1.54 \quad r := 0.51$$

$$\frac{d}{dt}y(t) = (y(t) - x(t)\cdot z(t) + c\cdot x(t))\cdot y(t) \qquad D(t,Q) := \begin{bmatrix} a\cdot Q_0\cdot \ln\left(Q_0\cdot Q_2\right) \\ \left(Q_1 - Q_0\cdot Q_2 + c\cdot Q_0\right)\cdot Q_1 \\ \left(Q_0\cdot Q_1 - r\cdot Q_2\right)\cdot Q_2 \end{bmatrix}$$

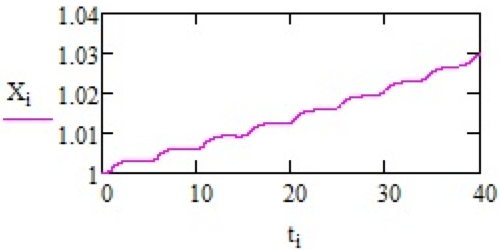
$$\frac{d}{dt}z(t) = (x(t)\cdot y(t) - r\cdot z(t))\cdot z(t)$$

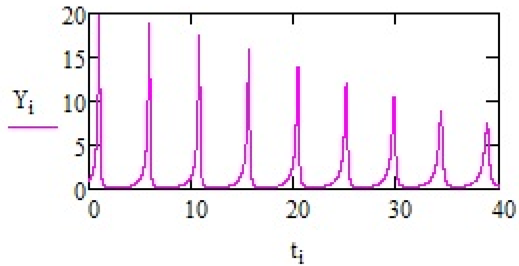
$$Npts := 10000$$

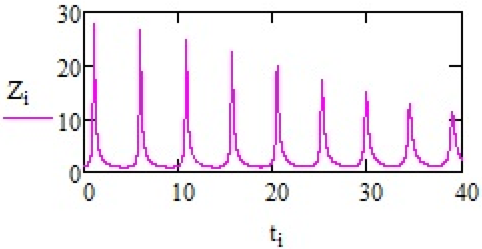
$$L := \text{rkfixed}\left[\begin{pmatrix} 1 \\ 1 \\ 1 \end{pmatrix}, 0, 50, Npts, D\right]$$

Can look at the individual components as two dimensional

$$t := L^{\langle 0 \rangle} \qquad X := L^{\langle 1 \rangle} \qquad Y := L^{\langle 2 \rangle} \qquad Z := L^{\langle 3 \rangle} \qquad i := 0..Npts \qquad \varepsilon := 0.00001$$





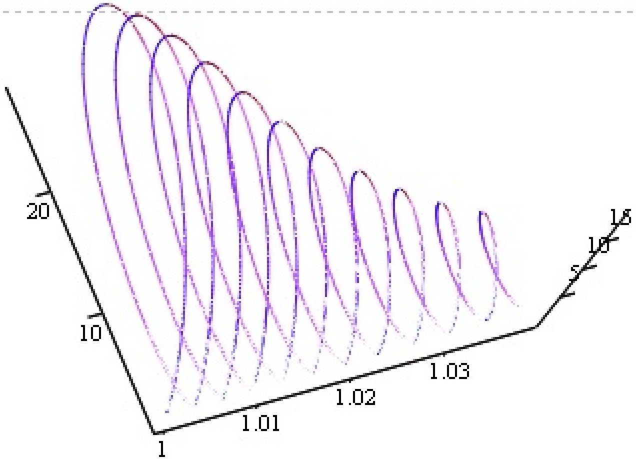


Can view this space curve as parametric surface plot

$a = 0.001 \quad c = 1.54 \quad r = 0.51 \quad \varepsilon = 0.00001$

$R^{\langle 0 \rangle} := X \quad R^{\langle 1 \rangle} := X + \varepsilon \quad S^{\langle 0 \rangle} := Y \quad S^{\langle 1 \rangle} := Y + \varepsilon \quad T^{\langle 0 \rangle} := Z \quad T^{\langle 1 \rangle} := Z + \varepsilon$

$x(t) \neq 0 \quad z(t) \neq 0 \quad x(t) \cdot z(t) > 0$



(R, S, T)

Find the situation equilibrium of this system

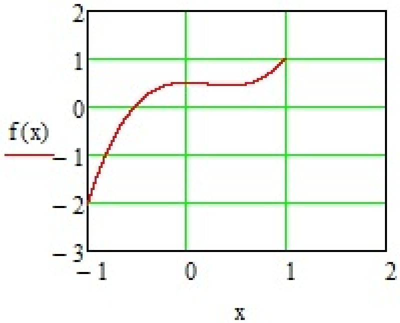
$$\begin{cases} a \cdot x(t) \cdot \ln(x(t) \cdot z(t)) = 0 \\ (y(t) - x(t) \cdot z(t) + c \cdot x(t)) \cdot y(t) = 0 \\ (x(t) \cdot y(t) - r \cdot z(t)) \cdot z(t) = 0 \end{cases}$$

hence obtain $c \cdot x^3 - x^2 + r = 0$ $\quad y = 1 - c \cdot x$ $\quad z = \frac{1}{x}$ $\quad$ let $\quad a = 0.001 \quad c = 1.54 \quad r = 0.51$

then you get the equation $f(x) := 1.54 \cdot x^3 - x^2 + 0.51$

the initial approximation of the root of the equation is $x := -0.5$ $s := \text{root}(f(x), x)$ $s = -0.52992764$

$x := -1, -0.999 .. 1$



$y := 1 - 1.54s$ $y = 1.81608857$ $z := \frac{1}{s}$ $z = -1.88705007$

Then point A(−0.52992764, 1.81608857, −1.88705007) is the situation equilibrium of this system

Let $u(t) = x(t) + 0.5299$ $v(t) = y(t) - 1.8161$ $q(t) = z(t) + 1.8870$ thus

$$\begin{cases} u'(t) = a \cdot (u - 0.5299) \cdot \ln[(u - 0.5299) \cdot (q - 1.8870)] \\ v'(t) = [(v + 1.8161) - (u - 0.5299) \cdot (q - 1.8870) + 1.54(u - 0.5299)] \cdot (v + 1.8161) \\ q'(t) = [(u - 0.5299)(v + 1.8161) - 0.51(q - 1.8870)] \cdot (q - 1.8870) \end{cases}$$

Linearization of this system is

$$u'(t) = 0.0099992 \cdot u + 0 \cdot v + 0.0028082 \cdot q$$

$$v'(t) = 6.2237747 \cdot u + 1.8162327 \cdot v + 0.9623514 \cdot q$$

$$q'(t) = -3.4269807 \cdot u + 0.9999214 v + 0.9623886 \cdot q$$

$$M := \begin{pmatrix} 0.0099992 & 0 & 0.0028082 \\ 6.2237747 & 1.8162327 & 1.792 \\ -3.4269807 & 0.9999214 & 0.9623886 \end{pmatrix}$$

The eigevalue of this matrix is

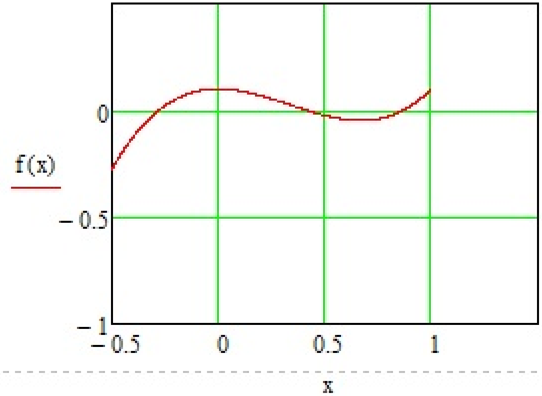
$$\text{eigenvals}(M) = \begin{pmatrix} -0.00337652 + 0.11106767i \\ -0.00337652 - 0.11106767i \\ 2.79537355 \end{pmatrix}$$

So the situation equilibrium of this system is unstable

If $a = 0.001$ $c = 1.0$ $r = 0.1$ than of this system has three situation equilibrium

$$f(x) := x^3 - x^2 + 0.1$$

$x := 0.5$ $s := \text{root}(f(x), x)$ $s = 0.41260557$ $x := -1, -0.999 .. 1$



$$\begin{pmatrix} .500000000000000000000 \\ -.30901699437494742410 \\ .80901699437494742410 \end{pmatrix}$$

$$\frac{d}{dt}x(t) = a \cdot x(t) \cdot \ln(x(t) \cdot z(t))$$

$$\left[P'x(t) = (x(t) \cdot z(t))^{a}\right]$$

$a := 0.001 \quad c := 1 \quad r := 0.1$

$$\frac{d}{dt}y(t) = (y(t) - x(t) \cdot z(t) + c \cdot x(t)) \cdot y(t)$$

$$D(t,Q) := \begin{bmatrix} a \cdot Q_0 \cdot \ln(Q_0 \cdot Q_2) \\ (Q_1 - Q_0 \cdot Q_2 + c \cdot Q_0) \cdot Q_1 \\ (Q_0 \cdot Q_1 - r \cdot Q_2) \cdot Q_2 \end{bmatrix}$$

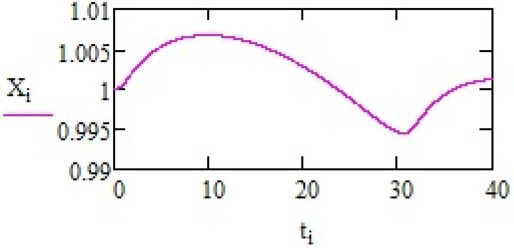
$$\frac{d}{dt}z(t) = (x(t) \cdot y(t) - r \cdot z(t)) \cdot z(t)$$

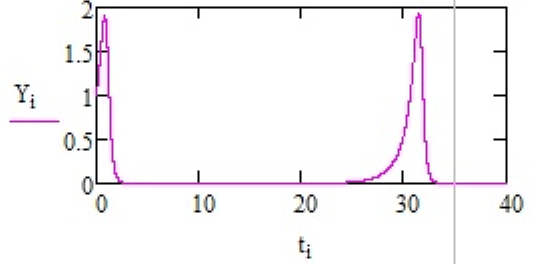
$Npts := 10000$

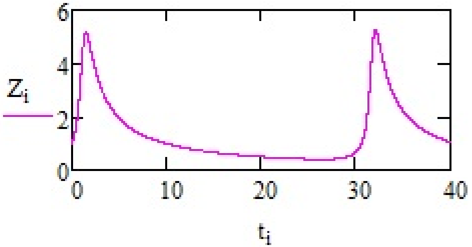
$$L := \text{rkfixed}\left[\begin{pmatrix} 1 \\ 1 \\ 1 \end{pmatrix}, 0, 50, Npts, D\right]$$

Can look at the individual components as two dimensional

$t := L^{\langle 0 \rangle} \quad X := L^{\langle 1 \rangle} \quad Y := L^{\langle 2 \rangle} \quad Z := L^{\langle 3 \rangle} \quad i := 0..Npts \quad \varepsilon := 0.00001$





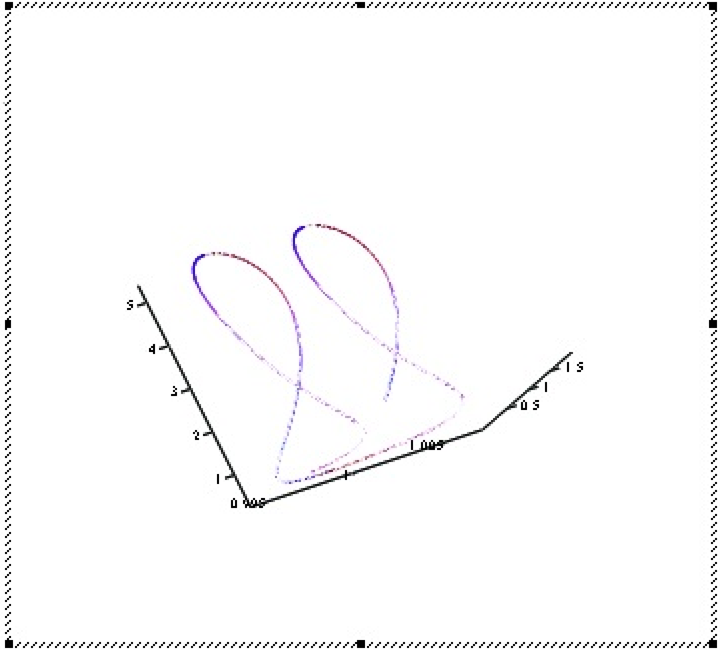


Can view this space curve as parametric surface plot

$a = 0.001 \quad c = 1.0 \quad r = 0.1 \quad \varepsilon \equiv 0.00001$

$R^{\langle 0 \rangle} := X \quad R^{\langle 1 \rangle} := X + \varepsilon \quad S^{\langle 0 \rangle} := Y \quad S^{\langle 1 \rangle} := Y + \varepsilon \quad T^{\langle 0 \rangle} := Z \quad T^{\langle 1 \rangle} := Z + \varepsilon$

$x(t) \neq 0 \quad z(t) \neq 0 \quad x(t) \cdot z(t) > 0$



(R, S, T)

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The system of differerential equations defines parametric equations for curve in spase

$a := 0.01$ $c := 1$ $r := 2$ $Npts := 500$ $x(t) > 0$ $y(t) > 0$ $z(t) > 0$ $a \neq 1$

$$\frac{d}{dt}x(t) = x(t)\ln\left(\frac{x(t)^a}{y(t)+z(t)}\right) \qquad p'x(t) = \frac{x(t)^a}{y(t)+z(t)}$$

$$\frac{d}{dt}y(t) = y(t)\cdot\ln\left(\frac{c\cdot z(t)}{x(t)\cdot y(t)}\right) \qquad p'y(t) = \frac{c\cdot z(t)}{x(t)+y(t)}$$

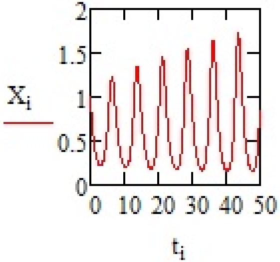
$$\frac{d}{dt}z(t) = z(t)\cdot\ln\left(\frac{r\,x(t)}{y(t)+z(t)}\right) \qquad p'z(t) = \frac{r\cdot x(t)}{y(t)+z(t)}$$

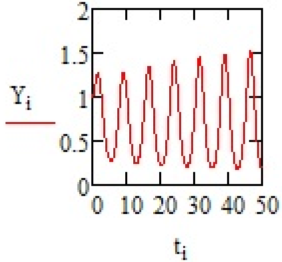
$$D(t,Q) := \begin{bmatrix} Q_0\cdot\ln\left[\frac{(Q_0)^a}{Q_1+Q_2}\right] \\ Q_1\cdot\ln\left(\frac{c\cdot Q_2}{Q_0\cdot Q_1}\right) \\ Q_2\cdot\ln\left(\frac{r\,Q_0}{Q_1+Q_2}\right) \end{bmatrix}$$

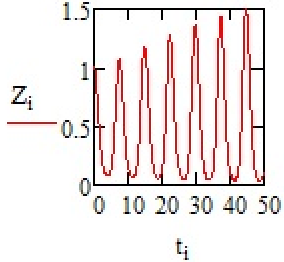
$$L := \text{rkfixed}\left[\begin{pmatrix}1\\1\\1\end{pmatrix}, 0, 50, Npts, D\right]$$

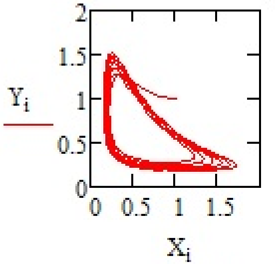
Can look at the individual components as two dimensional

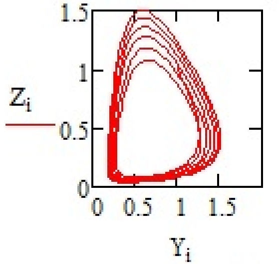
$t := L^{\langle 0\rangle}$ $X := L^{\langle 1\rangle}$ $Y := L^{\langle 2\rangle}$ $Z := L^{\langle 3\rangle}$ $i := 0..Npts$ $\varepsilon := 0.0001$

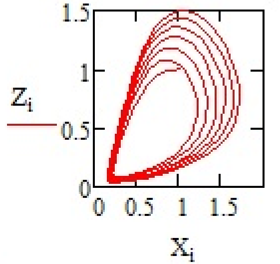






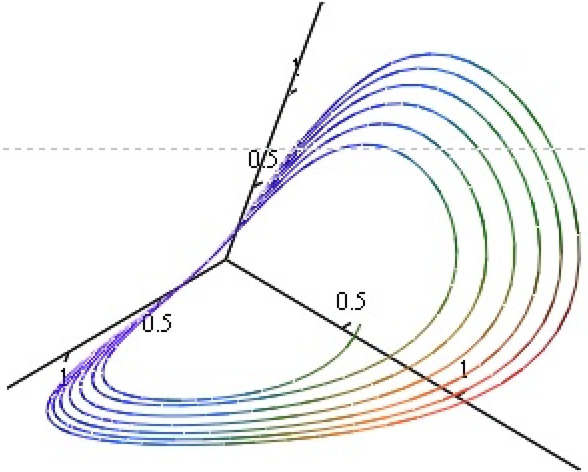






Can view this space curve as parametric surface plot

$R^{\langle 0 \rangle} := X \quad R^{\langle 1 \rangle} := X + \varepsilon \quad S^{\langle 0 \rangle} := Y \quad S^{\langle 1 \rangle} := Y + \varepsilon \quad T^{\langle 0 \rangle} := Z \quad T^{\langle 1 \rangle} := Z + \varepsilon$



(R , S , T)

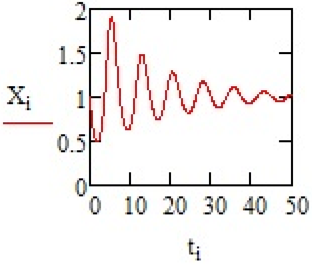
$a := 0.1 \qquad c := 1 \qquad r := 1$

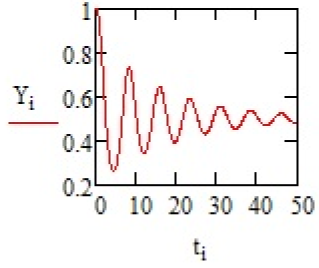
$$D(t,Q) := \begin{bmatrix} Q_0 \cdot \ln\left[\dfrac{(Q_0)^a}{Q_1 + Q_2}\right] \\ Q_1 \cdot \ln\left(\dfrac{c \cdot Q_2}{Q_0 \cdot Q_1}\right) \\ Q_2 \cdot \ln\left(\dfrac{r\,Q_0}{Q_1 + Q_2}\right) \end{bmatrix}$$

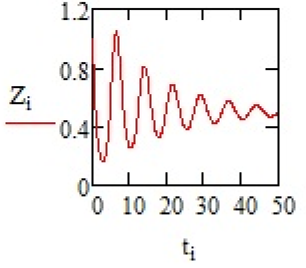
$$L := \text{rkfixed}\left[\begin{pmatrix} 1 \\ 1 \\ 1 \end{pmatrix}, 0, 50, Npts, D\right]$$

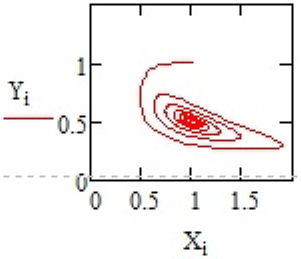
$t := L^{\langle 0 \rangle} \qquad X := L^{\langle 1 \rangle} \qquad Y := L^{\langle 2 \rangle} \qquad Z := L^{\langle 3 \rangle} \qquad i := 0..Npts \qquad \varepsilon := 0.00001$

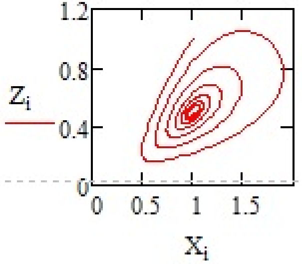
$R^{\langle 0 \rangle} := X \qquad R^{\langle 1 \rangle} := X + \varepsilon \qquad S^{\langle 0 \rangle} := Y \qquad S^{\langle 1 \rangle} := Y + \varepsilon \qquad T^{\langle 0 \rangle} := Z \qquad T^{\langle 1 \rangle} := Z + \varepsilon$

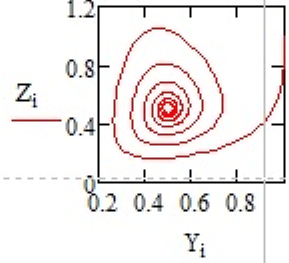


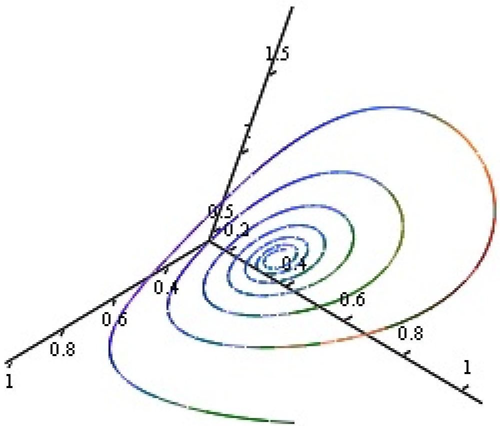












(R, S, T)

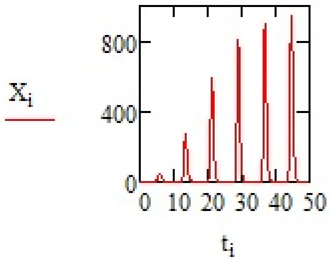
$a := 0.01 \quad c := 10 \quad r := 1$

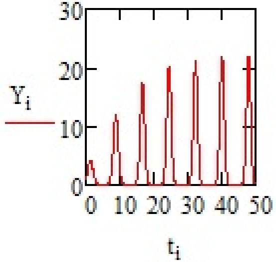
$$D(t,Q) := \begin{bmatrix} Q_0 \cdot \ln\left[\dfrac{(Q_0)^a}{Q_1 + Q_2}\right] \\ Q_1 \cdot \ln\left(\dfrac{c \cdot Q_2}{Q_0 \cdot Q_1}\right) \\ Q_2 \cdot \ln\left(\dfrac{r\, Q_0}{Q_1 + Q_2}\right) \end{bmatrix}$$

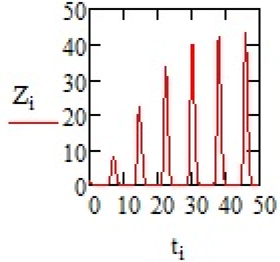
$$L := \mathrm{rkfixed}\left[\begin{pmatrix} 1 \\ 1 \\ 1 \end{pmatrix}, 0, 50, \mathrm{Npts}, D\right]$$

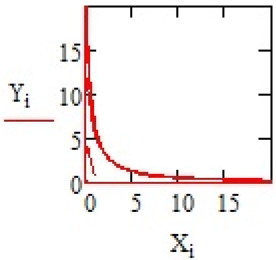
$t := L^{\langle 0 \rangle}$ $X := L^{\langle 1 \rangle}$ $Y := L^{\langle 2 \rangle}$ $Z := L^{\langle 3 \rangle}$ $i := 0..Npts$ $\varepsilon := 0.0001$

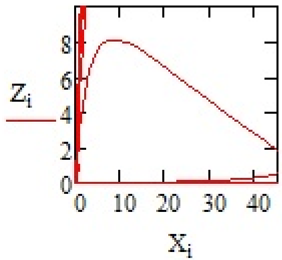
$R^{\langle 0 \rangle} := X$ $R^{\langle 1 \rangle} := X + \varepsilon$ $S^{\langle 0 \rangle} := Y$ $S^{\langle 1 \rangle} := Y + \varepsilon$ $T^{\langle 0 \rangle} := Z$ $T^{\langle 1 \rangle} := Z + \varepsilon$

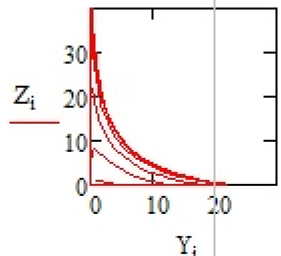


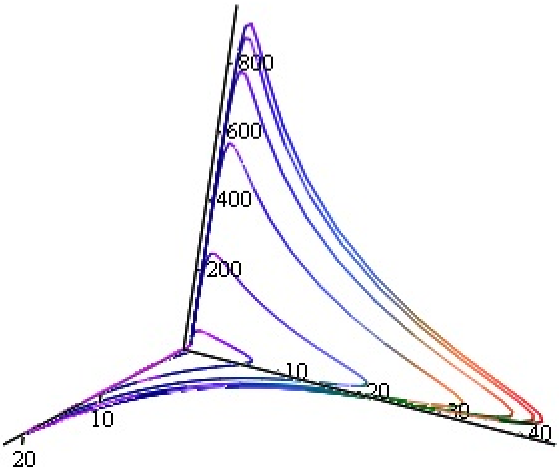












Find the situation equilibrium of this system

$$x \cdot \ln\left(\frac{x^a}{y+z}\right) = 0$$

$$y \cdot \ln\left(\frac{c \cdot z}{x \cdot y}\right) = 0 \qquad \Rightarrow$$

$$z \cdot \ln\left(\frac{r \cdot x}{y+z}\right) = 0$$

(R , S , T)

$$x = r^{\frac{1}{a-1}} \quad y = \frac{c \cdot r^{\frac{a}{a-1}}}{c + r^{\frac{1}{a-1}}} \quad z = \frac{r^{\frac{a+1}{a-1}}}{c + r^{\frac{1}{a-1}}}$$

If $c = 1$ $r = 1$ then $x = 1$ $y = 0.5$ $z = 0.5$

$u(t) = x(t) - 1 \quad v(t) = y(t) - 0.5 \quad q = z(t) - 0.5 \quad A(x_0, y_0, z_0) \leftrightarrow A_1(u_0, v_0, q_0) = A_1(0,0,0)$

$$\begin{cases} u'(t) = (u+1)\cdot\ln\left[\dfrac{(u+1)^a}{v+q+1}\right] \\ v'(t) = (v+0.5)\cdot\ln\left[\dfrac{q+0.5}{(u+1)\cdot(v+0.5)}\right] \\ q'(t) = (q+0.5)\cdot\ln\left(\dfrac{u+1}{v+q+1}\right) \end{cases}$$

Linearization of this system is

$$u'(t) = a\cdot u - a\cdot v - a\cdot q$$

$$v'(t) = -0.5u - v + q$$

$$q'(t) = 0.5u - 0.5v - 0.5q$$

Find the eigenvalue μ of this system

$$\begin{pmatrix} a-\mu & -a & -a \\ -0.5 & -1-\mu & 1 \\ 0.5 & -0.5 & -0.5-\mu \end{pmatrix} = 0 \Rightarrow \mu\cdot\left(\mu^2 + \mu(1.5-a) - 1.5a + 1\right) = 0$$

$\mu_1 = 0 \quad \mu_{2,3} = \dfrac{\pm\sqrt{a^2 + 3a - \frac{7}{4}} + a - 1.5}{2}$ If $a > \dfrac{2}{3}$ the root $\mu_2 = \dfrac{\sqrt{a^2 + 3a - \frac{7}{4}} + a - 1.5}{2} > 0$

There is the bifurcation point at a = 2/3 If a=0.5 then

$$M := \begin{pmatrix} a & -a & -a \\ -0.5 & -1 & 1 \\ 0.5 & -0.5 & -0.5 \end{pmatrix} \qquad |M| = 0$$

The eigenvalue of this matrix is

$$\text{eigenvals}(M) = \begin{pmatrix} 0 \\ -0.745 + 0.656i \\ -0.745 - 0.656i \end{pmatrix}$$

Hence the situation equilibrium(1, 0.5, 0.5) of this system is stable(for c = 1,r = 1)

If a=1 then the situation equilibrium of this system is

$$x = \gamma \quad y = \frac{c\cdot\gamma}{} \quad z = \frac{\gamma^2}{}$$

where γ>0 is an arbitrary number

Referens . In wikipedia , in the article multiplicative there are definition of several forms of derivatives .

The anaquadrat derivative $\left[Df_{\circ}\right](h) = \left[D\overline{f}\right]\left(\overline{h}^{2}\right)$.

The biguadrat derivative $\left[Df_{\circ}^{\circ}\right](h) = \left[\left[D\overline{f}\right]\left(\overline{h}\right)\right]^{\frac{1}{2}}$.

The harmonic derivative $\left[Df^{\odot}\right](h) = \dfrac{1}{\left[D(1//f)\right](h)}$, where $1//f = \begin{cases} \dfrac{1}{x} , & \text{if } x \neq 0 \\ 0 , & \text{if } x = 0 \end{cases}$.

The anaharmon derivative $\left[Df_{\odot}\right](a) = \left[D\overline{f}\right](1//a)$.

The anageomet derivative $D^{*}(f) = \lim\limits_{x \to h} \dfrac{f(x) - f(h)}{\ln(x) - \ln(h)}$.

The quadrat derivative $\left[Df^{\circ}\right](h) = \left[\left[D\left(\overline{f}^{2}\right)\right](h)\right]^{\frac{1}{2}^{\circ}}$, where $x^{\frac{1}{2}^{\circ}} = \begin{cases} \sqrt{x} , & \text{if } x \geq 0 \\ -\sqrt{-x} , & \text{if } x < 0 \end{cases}$, $\overline{x}^{2} = \begin{cases} x^{2} , & \text{if } x \geq 0 \\ -x^{2} , & \text{if } x < 0 \end{cases}$.

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The bigarmon derivative $\left[Df_{\odot}^{\bigcirc}\right](a)=1//\left[D\overline{f}\right](\overline{a})$.