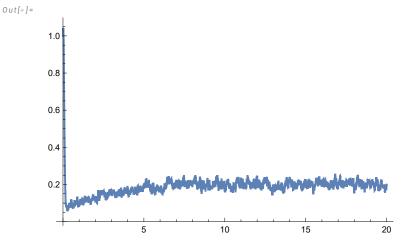
```
dt = 0.001;
      tmax = 20;
      Nn = Evaluate[tmax / dt] // Round;
In[0]:= tT = Table[idt, {i, 0, Nn}];
ln[e]:= \xi 1 = RandomVariate[NormalDistribution[0, <math>\sqrt{dt}], Nn];
      \xi 2 = RandomVariate [NormalDistribution [0, \sqrt{dt}], Nn];
      \xi3 = RandomVariate [NormalDistribution [0, \sqrt{dt}], Nn];
      \xi4 = RandomVariate [NormalDistribution [0, \sqrt{dt}], Nn];
      \xi5 = RandomVariate [NormalDistribution [0, \sqrt{dt}], Nn];
      \xi 6 = RandomVariate [NormalDistribution [0, \sqrt{dt}], Nn];
      \xi7 = RandomVariate [NormalDistribution [0, \sqrt{dt}], Nn];
      \xi8 = RandomVariate [NormalDistribution [0, \sqrt{dt}], Nn];
      \xi9 = RandomVariate [NormalDistribution [0, \sqrt{dt}], Nn];
      \xi10 = RandomVariate [NormalDistribution [0, \sqrt{dt}], Nn];
      \xi11 = RandomVariate NormalDistribution \left[0, \sqrt{dt}\right], Nn;
      \xi12 = RandomVariate NormalDistribution \left[0, \sqrt{dt}\right], Nn;
In[@]:= X = ConstantArray[1, Nn + 1];
      y = ConstantArray[1, Nn + 1];
      z = ConstantArray[1, Nn + 1];
In[*]:= V = 1000;
```

Steady State

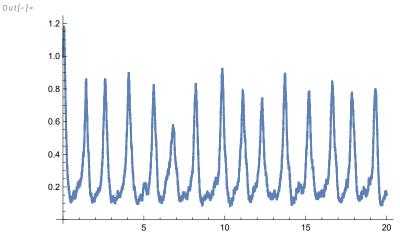
$$\begin{aligned} &\text{To}[\epsilon] z = & \text{VValSSS} = & \{ \text{V0} \to 2 \text{, V1} \to 2 \text{, V4} \to 5 \text{, kf} \to 1 \text{, k} \to 10 \text{, } \beta \to 0.01 \text{, } \epsilon \to 0.1 \text{, VM2} \to 6 \text{, } k2 \to 0.1 \text{, } \\ &\text{VM3} \to 20 \text{, m} \to 2 \text{, kx} \to 0.5 \text{, ky} \to 0.2 \text{, kz} \to 0.2 \text{, VM5} \to 30 \text{, k5} \to 0.3 \text{, kd} \to 0.5 \text{, p} \to 2 \text{, n} \to 4 \} \text{; } \\ &\text{For} \left[\text{i} = 1 \text{, i} \leq \text{Nn, i} + + \text{, } \right] \\ &\text{x} \left[\text{i} + 1 \right] = \\ & \left[\text{x} \left[\text{i} \right] + \left(\text{V0} + \text{V1} \beta - \text{k} \times \left[\text{i} \right] - \frac{\text{VM2} \times \left[\text{i} \right]^2}{\text{k2}^2 + \text{x} \left[\text{i} \right]^2} + \text{kf} \text{y} \left[\text{i} \right] + \frac{\text{VM3} \times \left[\text{i} \right]^m \text{y} \left[\text{i} \right]^2 \text{z} \left[\text{i} \right]^4}{\left(\text{kx}^m + \text{x} \left[\text{i} \right]^m \right) \left(\text{ky}^2 + \text{y} \left[\text{i} \right]^2 \right) \left(\text{kz}^4 + \text{z} \left[\text{i} \right]^4 \right) \right) } \right) \\ & \text{dt} + \frac{1}{\sqrt{V}} \left(\frac{\sqrt{V0} \text{ } \epsilon 1 \left[\text{i} \right] + \sqrt{\sqrt{V1} \beta} \text{ } \epsilon 2 \left[\text{i} \right] - \sqrt{\text{VM2}} \frac{\text{x} \left[\text{i} \right]^2}{\text{k2}^2 + \text{x} \left[\text{i} \right]^2} \text{ } \epsilon 3 \left[\text{i} \right] + \frac{\text{VM3} \times \left[\text{i} \right]^m}{\text{kx}^m + \text{x} \left[\text{i} \right]^m} \frac{\text{y} \left[\text{i} \right]^2}{\text{k2}^2 + \text{x} \left[\text{i} \right]^2} \text{ } \epsilon 3 \left[\text{i} \right] + \frac{\text{VM3} \times \left[\text{i} \right]^m}{\text{kx}^m + \text{x} \left[\text{i} \right]^m} \text{ } \left(\text{ky}^2 + \text{y} \left[\text{i} \right]^2 \right) \left(\text{kz}^4 + \text{z} \left[\text{i} \right]^4 \right) \right) \\ & \text{y} \left[\text{i} + 1 \right] = \left(\text{y} \left[\text{i} \right] + \left(\frac{\text{VM2} \times \left[\text{i} \right]^2}{\text{k2}^2 + \text{x} \left[\text{i} \right]^2} - \text{kf} \text{y} \left[\text{i} \right] - \frac{\text{VM3} \times \left[\text{i} \right]^m \text{y} \left[\text{i} \right]^2 \text{z} \left[\text{i} \right]^4}{\text{kx}^4 + \text{z} \left[\text{i} \right]^m} \right) \right) \right) \\ & \text{y} \left[\text{i} + 1 \right] = \left(\text{y} \left[\text{i} \right] + \left(\frac{\text{VM2} \times \left[\text{i} \right]^2}{\text{k2}^2 + \text{x} \left[\text{i} \right]^2} - \text{kf} \text{y} \left[\text{i} \right] - \frac{\text{VM3} \times \left[\text{i} \right]^m \text{y} \left[\text{i} \right]^2 \text{z} \left[\text{i} \right]^4}{\text{kx}^4 + \text{z} \left[\text{i} \right]^3} \right) \right) \right) \right) \\ & \text{y} \left[\text{i} + 1 \right] = \left(\text{y} \left[\text{i} \right] + \left(\frac{\text{VM2} \times \left[\text{i} \right]^2}{\text{k2}^2 + \text{x} \left[\text{i} \right]^2} - \text{kf} \text{y} \left[\text{i} \right] - \frac{\text{VM3} \times \left[\text{i} \right]^m \text{y} \left[\text{i} \right]^2 \text{z} \left[\text{i} \right]^4}{\text{k2}^4 + \text{z} \left[\text{i} \right]^m} \right) \left(\text{ky}^2 + \text{y} \left[\text{i} \right]^2 \right) \right) \right) \right) \right) \right) \\ & \text{z} \left[\text{i} + 1 \right] = \left(\text{y} \left[\text{i} \right] + \left(\frac{\text{VM2} \times \left[\text{i} \right]^2}{\text{k2}^2 + \text{x} \left[\text{i} \right]^2} - \text{kf} \left[\text{y} \left[\text{i} \right] + \left(\frac{\text{i} \left[\text{i} \right]^2}{\text{k2}^2} + \text{y} \left[\text{i} \right]^2} \right) \right)$$

In[*]:= ListLinePlot[Transpose[{tT, x}], PlotRange \rightarrow All]



$$\begin{aligned} &\text{To}[\epsilon] := & \text{ Va1SSP0} = & \text{ $\{V0 \to 2, V1 \to 2, V4 \to 2, kf \to 1, k \to 10, \beta \to 0.5, \epsilon \to 0.1, VM2 \to 6, k2 \to 0.1, \\ & \text{ $VM3 \to 20, m \to 2, kx \to 0.5, ky \to 0.2, kz \to 0.2, VM5 \to 5, k5 \to 1, kd \to 0.4, p \to 2, n \to 4\}; \\ &\text{For} \left[\text{$i = 1, i \le Nn, i + +, } \right. \\ &\text{$\times\mathbb{E}[i + 1] = } \\ & \left(\text{$\times\mathbb{E}[i] + \left(V0 + V1 \beta - k \times \mathbb{E}[i] - \frac{VM2 \times \mathbb{E}[i]^2}{k2^2 + x \mathbb{E}[i]^2} + kf y \mathbb{E}[i] + \frac{VM3 \times \mathbb{E}[i]^m y \mathbb{E}[i]^2 \times \mathbb{E}[i]^4}{(kx^m + x \mathbb{E}[i]^m) \left(ky^2 + y \mathbb{E}[i]^2 \right) \left(kz^4 + z \mathbb{E}[i]^4 \right)} \right) * \\ & \text{$dt + \frac{1}{\sqrt{V}} \left(\sqrt{V0} \, \mathcal{E}[i] + \sqrt{V1} \, \mathcal{E}[i] + \sqrt{V1} \, \mathcal{E}[i] + \sqrt{V1} \, \mathcal{E}[i]^2} \right) \times \frac{\mathbb{E}[i]^4}{k2^2 + x \mathbb{E}[i]^2} } & \mathcal{E}[i] + \frac{VM3 \times \mathbb{E}[i]^m y \mathbb{E}[i]^2 \times \mathbb{E}[i]^4}{kx^m + x \mathbb{E}[i]^m} } & \mathcal{E}[i] + \frac{VM2 \times \mathbb{E}[i]^2}{k2^2 + x \mathbb{E}[i]^2} - \mathcal{E}[i] - \frac{VM3 \times \mathbb{E}[i]^m y \mathbb{E}[i]^2 \times \mathbb{E}[i]^4}{(kx^m + x \mathbb{E}[i]^m) \left(ky^2 + y \mathbb{E}[i]^2 \right) \left(kz^4 + z \mathbb{E}[i]^4 \right)} \right) dt + \frac{1}{\sqrt{V}} \\ & \left(\sqrt{VM2} \, \frac{\mathbb{E}[i]^2}{k2^2 + x \mathbb{E}[i]^2} \, \mathcal{E}[i] - \sqrt{VM3} \, \frac{\mathbb{E}[i]^m y \mathbb{E}[i]^m \times \mathbb{E}[i]^m \times \mathbb{E}[i]^m}{(kx^m + x \mathbb{E}[i]^m)} \, \mathcal{E}[i]^m \right) \right) dt + \frac{1}{\sqrt{V}} \left(\sqrt{V4} \, \mathcal{E}[i]^m \right) \right] \\ & z \mathbb{E}[i + 1] = \left(z \mathbb{E}[i] + \left(V4 \, \beta - \varepsilon z \mathbb{E}[i] - \frac{VM5 \times \mathbb{E}[i]^n z \mathbb{E}[i]^p}{(kd^n + x \mathbb{E}[i]^n)} \right) dt + \frac{1}{\sqrt{V}} \left(\sqrt{V4} \, \mathcal{E}[i]^m \right) \right) \right) \\ & \sqrt{VM5} \, \frac{z \mathbb{E}[i]^p}{k5^p + z \mathbb{E}[i]^p} \, \frac{\mathbb{E}[i]^n}{kd^n + x \mathbb{E}[i]^n} \, \mathcal{E}[1]^m \right) \left(k5^p + z \mathbb{E}[i]} \, \mathcal{E}[1]^m \right) \left(VValsSP0 \right); \right] \end{aligned}$$

 $\textit{In[*]} := \texttt{ListLinePlot[Transpose[\{tT, x\}], PlotRange} \rightarrow \texttt{All]}$



Out[0]=

Bursting

$$\begin{aligned} & \text{VValsB} = & \text{VVa} + 2, \text{VI} \rightarrow 2, \text{VI} \rightarrow 2, \text{VI} \rightarrow 2, \text{Kf} \rightarrow 1, \text{K} \rightarrow 10, \beta \rightarrow 0.46, \epsilon \rightarrow 0.1, \text{VM2} \rightarrow 6, \text{K2} \rightarrow 0.1, \\ & \text{VM3} \rightarrow 20, \text{m} \rightarrow 4, \text{Kx} \rightarrow 0.3, \text{Ky} \rightarrow 0.2, \text{Kz} \rightarrow 0.1, \text{VM5} \rightarrow 30, \text{K5} \rightarrow 1, \text{Kd} \rightarrow 0.6, p \rightarrow 1, n \rightarrow 2); \\ & \text{For} \left[\text{i} = 1, \text{i} \leq \text{Nn, i} + +, \\ & \text{X[i]} + \left[\text{VØ} + \text{VI} \beta - \text{K} \times \text{[i]} \right] - \frac{\text{VM2} \times \text{[i]}^2}{\text{K2}^2 + \text{X[i]}^2} + \text{Kf} \text{y[i]} + \frac{\text{VM3} \times \text{[i]}^m \text{y[i]}^2 \text{z[i]}^4}{(\text{Kx}^m + \text{X[i]}^m)} \left(\text{Ky}^2 + \text{y[i]}^2 \right) \left(\text{Kz}^4 + \text{z[i]}^4 \right) \right) \star \\ & \text{dt} + \frac{1}{\sqrt{V}} \left(\sqrt{VØ} \ \mathcal{E}1[\text{i}] + \sqrt{VI} \ \beta \ \mathcal{E}2[\text{ii}] - \sqrt{\text{VM2}} \frac{\text{x[i]}^2}{\text{K2}^2 + \text{x[i]}^2}} \ \mathcal{E}3[\text{ii}] + \\ & \sqrt{\text{VM3}} \frac{\text{x[i]}^m}{\text{Kx}^m + \text{x[i]}^m} \frac{\text{y[i]}^2}{\text{Ky}^2 + \text{y[i]}^2} \frac{\text{z[i]}^4}{\text{kz}^4 + \text{z[i]}^4} \ \mathcal{E}4[\text{ii}] + \\ & \sqrt{\text{kf} \text{y[i]}} \ \mathcal{E}5[\text{ii}] - \sqrt{\text{kx}} \ \mathcal{E}6[\text{ii}] \right) / \text{VValsB} \right); \\ & \text{y[i]} + 1] = \left(\text{y[i]} + \left(\frac{\text{VM2} \times \text{[i]}^2}{\text{K2}^2 + \text{x[i]}^2} - \text{Kf} \text{y[i]} - \frac{\text{VM3} \times \text{[i]}^m}{(\text{Kx}^m + \text{X[i]}^m)} \left(\text{Ky}^2 + \text{y[i]}^2 \right) \left(\text{Kz}^4 + \text{z[i]}^4 \right) \right) \text{dt} + \\ & \frac{1}{\sqrt{V}} \left(\sqrt{\text{VM2}} \frac{\text{x[i]}^2}{\text{K2}^2 + \text{x[i]}^2} \ \mathcal{E}7[\text{ii}] - \sqrt{\text{VM3}} \frac{\text{x[i]}^m}{\text{kx}^m + \text{x[i]}^m} \ \mathcal{E}8[\text{ii}] - \sqrt{\text{kf} \text{y[i]}} \ \mathcal{E}9[\text{ii}] \right) / \text{VvalsB} \right); \\ & \text{z[i]} + 1] = \left(\text{z[i]} + \left(\text{V4} \ \beta - \epsilon \text{z[i]} - \frac{\text{VM5} \times \text{[i]}^n}{(\text{Kd}^n + \text{x[i]}^n)} \left(\text{K5}^p + \text{z[i]}^p \right) \right) \text{dt} + \frac{1}{\sqrt{V}} \left(\sqrt{\text{V4} \ \beta} \ \mathcal{E}10[\text{ii}] - \sqrt{\text{VV3}} \frac{\text{x[i]}^n}{\text{K}^n + \text{x[i]}^n} \right) \left(\text{VvalsB} \right); \right]$$

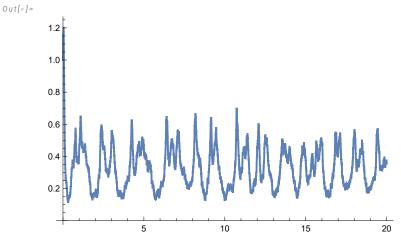
In[*]:= ListLinePlot[Transpose[{tT, x}], PlotRange \rightarrow All]

1.2 1.0 0.8 0.6 0.4 0.2 5 10 15 20

Chaos

$$\begin{aligned} &\text{To}[\phi] = \text{ V ValsC} = \{V\Theta \to 2, V1 \to 2, V4 \to 3, kf \to 1, k \to 10, \beta \to 0.65, \epsilon \to 13, VM2 \to 6, k2 \to 0.1, VM3 \to 30, \\ &\text{ $m \to 2, kx \to 0.6, ky \to 0.3, kz \to 0.1, VM5 \to 50, k5 \to 0.3194, kd \to 1, p \to 1, n \to 4\};} \\ &\text{For} \left[i = 1, i \le \text{Nn, } i + +, \\ &\text{$\times [i + 1] = $} \right] = \\ &\left(\text{$\times [i] + $} \left(\text{$V\Theta + V1 \beta - k \times [i] - \frac{VM2 \times [i]^2}{k2^2 + x [i]^2} + kf y [i] + \frac{VM3 \times [i]^m y [i]^2 z [i]^4}{(kx^m + x [i]^m) (ky^2 + y [i]^2) (kz^4 + z [i]^4)} \right) \times \\ &\text{$dt + \frac{1}{\sqrt{V}} \left(\sqrt{V\Theta} \ \mathcal{E}1[i] + \sqrt{V1 \beta} \ \mathcal{E}2[i] - \sqrt{VM2} \frac{x [i]^2}{k2^2 + x [i]^2} \ \mathcal{E}3[i] + \\ &\sqrt{VM3} \frac{x [i]^m}{kx^m + x [i]^m} \frac{y [i]^2}{ky^2 + y [i]^2} \frac{z [i]^4}{kz^4 + z [i]^4} \ \mathcal{E}4[i] + \\ &\sqrt{kf y [i]} \ \mathcal{E}5[i] - \sqrt{kx} \ \mathcal{E}6[i] \right) /. \ VvalsC \right); \\ &y [i + 1] = \left(y [i] + \left(\frac{VM2 \times [i]^2}{k2^2 + x [i]^2} - kf y [i] - \frac{VM3 \times [i]^m y [i]^2 z [i]^4}{(kx^m + x [i]^m) (ky^2 + y [i]^2) (kz^4 + z [i]^4)} \right) dt + \\ &\frac{1}{\sqrt{V}} \left(\sqrt{VM2} \frac{x [i]^2}{k2^2 + x [i]^2} \ \mathcal{E}7[i] - \sqrt{VM3} \frac{x [i]^m}{kx^m + x [i]^m} \ \mathcal{E}8[i] - \sqrt{kf y [i]} \ \mathcal{E}9[i] \right) /. \ VvalsC \right); \\ &z [i + 1] = \left(z [i] + \left(V4 \beta - \varepsilon z [i] - \frac{VM5 \times [i]^n z [i]^p}{(kd^n + x [i]^n) (kS^p + z [i]^p)} \right) dt + \frac{1}{\sqrt{V}} \right) \right) /. \ VvalsC \right); \end{aligned}$$

In[*]:= ListLinePlot[Transpose[{tT, x}], PlotRange \rightarrow All]



Period Doubling Sequences

$$\begin{aligned} &\text{VvalsPDS} &= \{\text{VØ} \rightarrow 2, \text{V1} \rightarrow 2, \text{V4} \rightarrow 3, \text{ kf} \rightarrow 1, \text{ k} \rightarrow 10, \beta \rightarrow 0.7, \epsilon \rightarrow 13, \text{VM2} \rightarrow 6, \text{k2} \rightarrow 0.1, \\ &\text{VM3} \rightarrow 30, \text{ m} \rightarrow 2, \text{ kx} \rightarrow 0.6, \text{ ky} \rightarrow 0.3, \text{ kz} \rightarrow 0.1, \text{ VM5} \rightarrow 50, \text{ k5} \rightarrow 0.3194, \text{ kd} \rightarrow 1, \text{ p} \rightarrow 1, \text{ n} \rightarrow 4\}; \\ &\text{For} \left[\text{i} = 1, \text{i} \leq \text{Nn}, \text{i} + +, \\ &\text{x[i]} + \left[\text{VØ} + \text{V1} \beta - \text{k} \times \text{[i]} - \frac{\text{VM2} \times \text{[i]}^2}{\text{k2}^2 + \text{x[i]}^2} + \text{kf} \text{y[i]} + \frac{\text{VM3} \times \text{[i]}^m \text{y[i]}^2 \text{z[i]}^4}{(\text{kx}^m + \text{x[i]}^m) \left(\text{ky}^2 + \text{y[i]}^2 \right) \left(\text{kz}^4 + \text{z[i]}^4 \right)} \right) \star \\ &\text{dt} + \frac{1}{\sqrt{V}} \left(\sqrt{VØ} \ \varepsilon 1[\text{ii}] + \sqrt{V1} \beta \ \varepsilon 2[\text{ii}] - \sqrt{VM2} \frac{\text{x[i]}^2}{\text{k2}^2 + \text{x[i]}^2} \ \varepsilon 3[\text{ii}] + \\ &\sqrt{\text{VM3}} \frac{\text{x[i]}^m}{\text{kx}^m + \text{x[i]}^m} \frac{\text{y[i]}^2}{\text{ky}^2 + \text{y[i]}^2} \frac{\text{z[i]}^4}{\text{kz}^4 + \text{z[i]}^4} \ \varepsilon 4[\text{ii}] + \\ &\sqrt{\text{kf} \text{y[i]}} \ \varepsilon 5[\text{ii}] - \sqrt{\text{kx}} \ \varepsilon 6[\text{ii}] \right) / . \text{ VvalspDS} \right]; \\ &\text{y[i]} + 1] = \left(\text{y[i]} + \left(\frac{\text{VM2} \times \text{[i]}^2}{\text{k2}^2 + \text{x[i]}^2} - \text{kf} \text{y[i]} - \frac{\text{VM3} \times \text{[i]}^m}{\text{(kx}^m + \text{x[i]}^m)} \left(\text{ky}^2 + \text{y[i]}^2 \right) \left(\text{kz}^4 + \text{z[i]}^4 \right) \right) \text{dt} + \frac{1}{\sqrt{V}} \\ &\left(\sqrt{\text{VM2}} \frac{\text{x[i]}^2}{\text{k2}^2 + \text{x[i]}^2} \ \varepsilon 7[\text{ii}] - \sqrt{\text{VM3}} \frac{\text{x[i]}^m}{\text{kx}^m + \text{x[i]}^m} \ \varepsilon 8[\text{ii}] - \sqrt{\text{kf} \text{y[i]}} \ \varepsilon 9[\text{ii}] \right) / . \text{ VvalspDS} \right); \\ &\text{z[i]} + 1] = \left(\text{z[i]} + \left(\sqrt{\text{V4}} \beta - \text{e} \text{z[i]} - \frac{\text{VM5}}{\text{(kd}^n + \text{x[i]}^n} \right) \left(\text{k5}^p + \text{z[i]}^p \right) \right) \text{dt} + \frac{1}{\sqrt{V}} \left(\sqrt{\text{V4}} \beta \ \varepsilon 10[\text{ii}] - \sqrt{\text{VV4}} \beta \ \varepsilon 10[\text{ii}] - \sqrt{\text{e} \text{z[i]}} \beta \ \varepsilon 10[\text{ii}]} \right) / . \text{ VvalspDS} \right); \\ &\text{z[i]} + 1 = \left(\text{z[i]} + \left(\sqrt{\text{V4}} \beta - \text{e} \text{z[i]} - \frac{\text{x[i]}^n}{\text{(kd}^n + \text{x[i]}^n} \right) \left(\text{k5}^p + \text{z[i]} \beta \right) \right) \text{dt} + \frac{1}{\sqrt{V}} \left(\sqrt{\text{V4}} \beta \ \varepsilon 10[\text{ii}] - \sqrt{\text{VV4}} \beta \ \varepsilon 10[\text{ii}] - \sqrt{\text{vvalspDS}} \right); \right]$$

In[*]:= ListLinePlot[Transpose[{tT, x}], PlotRange → All]

