Isothermal Reaction

exd13

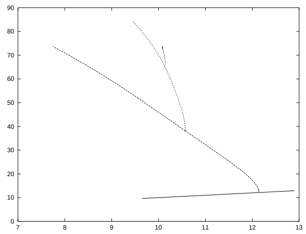
Variables and parameter:
$y_i(t)$: chemical species, $i = 1, 2, 3$
λ: reaction rate

$$\begin{aligned}
\dot{y}_1 &= y_1(30 - 0.25y_1 - y_2 - y_3) + 0.001y_2^2 + 0.1 \\
\dot{y}_2 &= y_2(y_1 - 0.001y_2 - \lambda) + 0.1 \\
\dot{y}_3 &= y_3(16.5 - y_1 - 0.5y_3) + 0.1
\end{aligned}$$

There is a Hopf bifurcation at $\lambda_0 = 12.1435$, and a sequence of period doubling bifurcations.

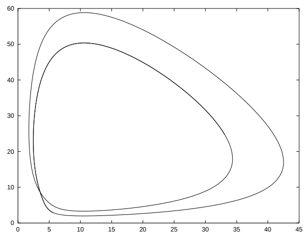
Figures:

1



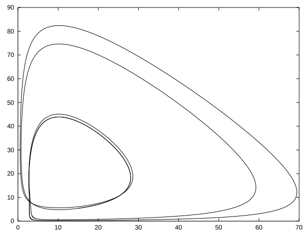
Bifurcation diagram, $y_1(0)$ versus λ.

2



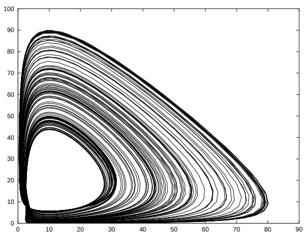
Isothermal reaction, periodic orbit, $\lambda = 10.55$, projection to (y_1, y_2) plane.

3



Isothermal reaction, periodic orbit, $\lambda = 10.13$, projection to (y_1, y_2) plane.

4



Isothermal reaction, chaotic orbit, $\lambda = 10$, projection to (y_1, y_2) plane.

Comments and explanations:

Original source is K. D. Williamowski, O. E. Rössler (1979), quoted in: C. B. Smith, B. Kuszta, G. Lyberatos, J. E. Bailey: Period doubling and complex dynamics in an isothermal chemical reaction system. Chem. Eng. Sci. **38** (1983) 425–430.
Four parameter values of period doubling are

$$\begin{aligned} \lambda_1 &= 10.5710 \\ \lambda_2 &= 10.1465 \\ \lambda_3 &= 10.0912 \\ \lambda_4 &= 10.0808. \end{aligned}$$

The expected accumulation point is $\lambda_\infty = 10.078$.