Chemistry 4010 Fall 2019 Assignment 4 solutions

1. My XPPAUT input file is the following:

```
# Model of a biochemical system with two autocatalytic loops
# Ref.: Berry, Chaos Solitons Fractals 18, 1001 (2003).
dm/dt=kg*f*g/(Mg+f) - m*p/(1+m) + r
df/dt=-kg*f*g/(Mg+f) + m*p/(1+m) - f*p/(1+f)
dp/dt=alpha*f^n/(MR^n + f^n) - ka*p^2
dg/dt=beta*f^q/(MS^q+f^q) - kd*g*p/(Md+g)

m(0)=10
f(0)=1
p(0)=0.01
g(0)=0.1

param MR=4.5, MS=1, alpha=0.026, beta=7.5e-4
param n=4, q=4
param Mg=0.1, Md=1.1, kg=0.05, kd=0.05
param ka=0.046, r=0.005

done
```

   The results are fairly tolerant to the numerical parameters. My bifurcation diagram is shown in Fig. 1.

   The bifurcation points are as follows:

Type	r
Andronov-Hopf	7.48×10^{-3}
period-doubling	8.57×10^{-3}
period-doubling	8.83×10^{-3}
period-doubling	8.90×10^{-3}
period-doubling	1.59×10^{-2}
period-doubling	1.63×10^{-2}
period-doubling	1.79×10^{-2}
Andronov-Hopf	3.55×10^{-2}

2. The left-hand period-doubling cascade seems to be accumulating near $r = 0.009$. At this value of r, I obtained the attractor shown in Fig. 2.

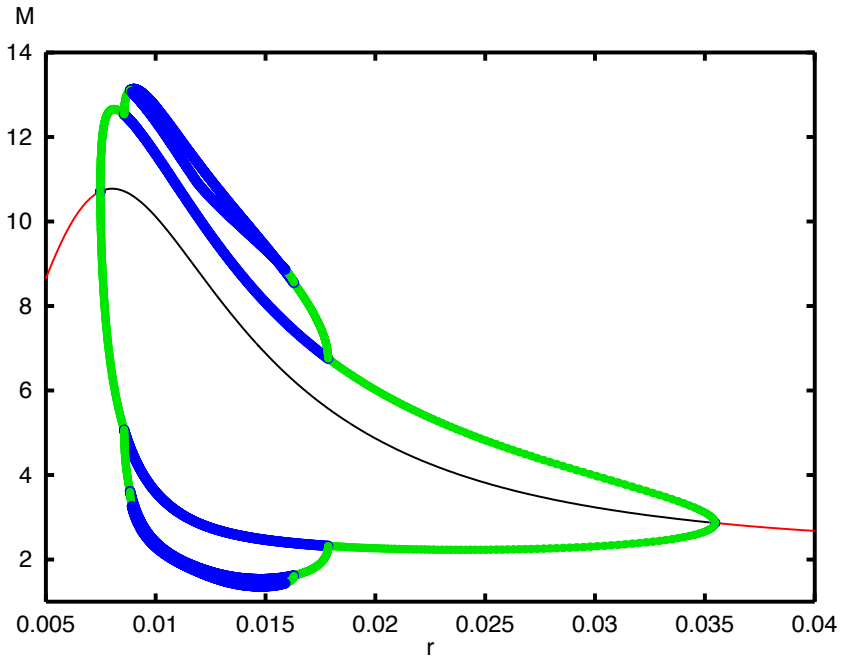

Figure 1: Bifurcation diagram obtained using AUTO.

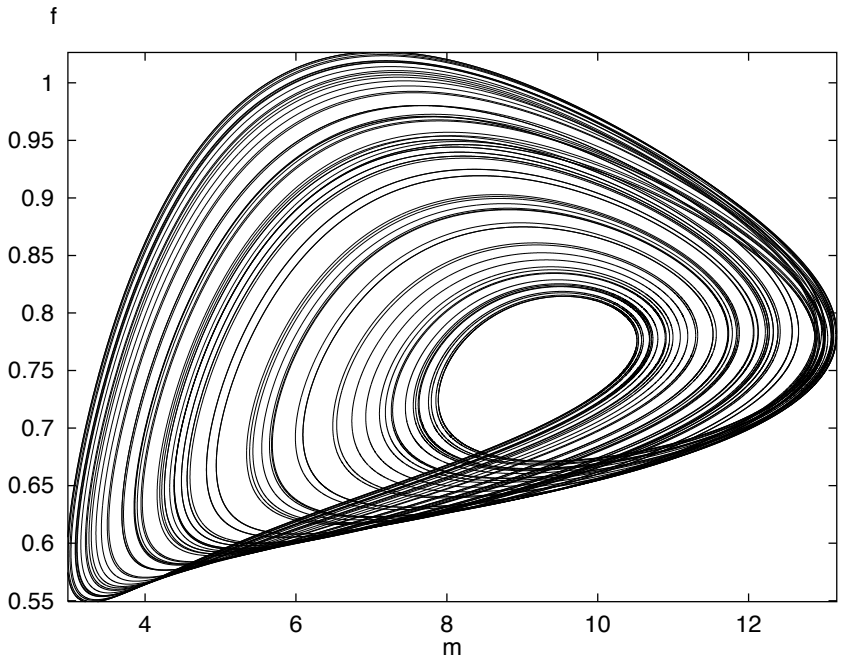

Figure 2: Chaotic attractor obtained at $r = 0.009$.