

## Appendix: a simple chaos program

We can study the effect of iterating these maps by the following QBASIC program on a PC.

```
10 X=0.4137 20 INPUT "MU=";MU 30 PRINT X 40 PITCH = 220 * 4 ^ X 50
SOUND PITCH, 4 60 X=MU*X*(1-X) 70 GOTO 30
```

*Notes.*

**Line 10** sets  $X$  to a value chosen randomly; almost any  $X \in (0, 1)$  will do.

**Line 20** inputs the parameter  $\mu$ .

**Line 30** prints the value of  $X$  on the screen.

**Line 40** interprets  $X$  as a pitch, measured in Hertz.

**Line 50** creates the sound, at the chosen pitch, for a time 4, measured in units of 1/18.2 seconds.

**Line 60** iterates the function to get the next value of  $X$ .

**Line 70** loops back. The program continues indefinitely until the ESCAPE key is pressed.

This program may be used on any computer with a BASIC interpreter/compiler, with appropriate modifications to lines 40 and 50.

Suitable values of  $\mu$  are:-

**2.5** rapid convergence to a fixed point;

**2.9** slow convergence to a fixed point;

**3.3** period 2;

**3.5** period 4;

**3.56** period 8;

**3.57** chaos; the limit of the  $2^n$  cycles;

**3.74** period 5;

**3.83** period 3;

**3.90** chaotic;

**3.906** period 5;