対立概念を通じて見たダイナミカルシステム・アプローチ（DSA）（図）

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第1章　決定論 vs. 非決定論

$$x(n+1) = 1 - \mu x^2(n), \quad x \in (-1, 1), \quad \mu \in (0, 2). \tag{1.8}$$

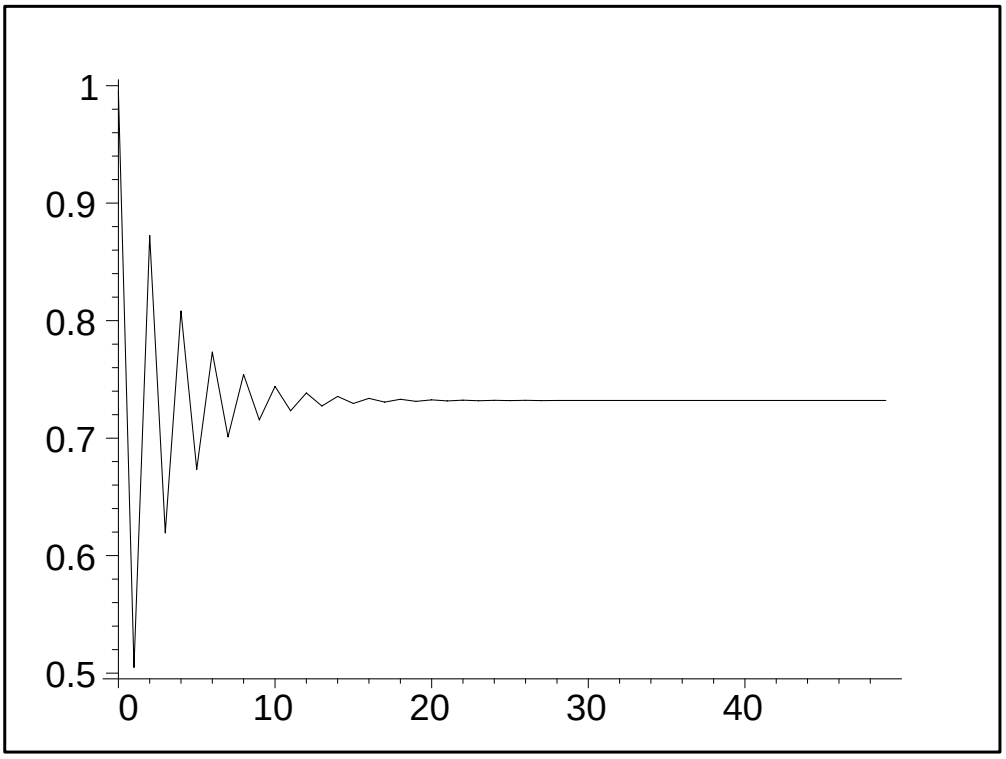

図 1.1: An orbit of the logistic map in the case when μ=0.5

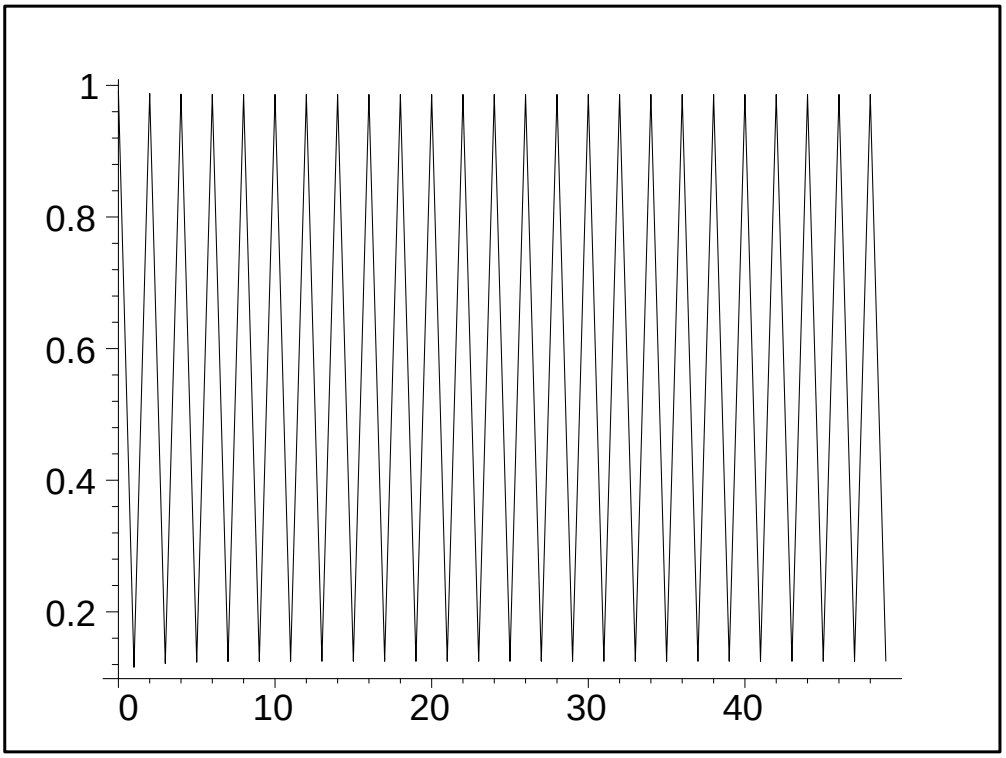

図 1.2: A 2-cycles of the logistic map in the case when μ=0.9

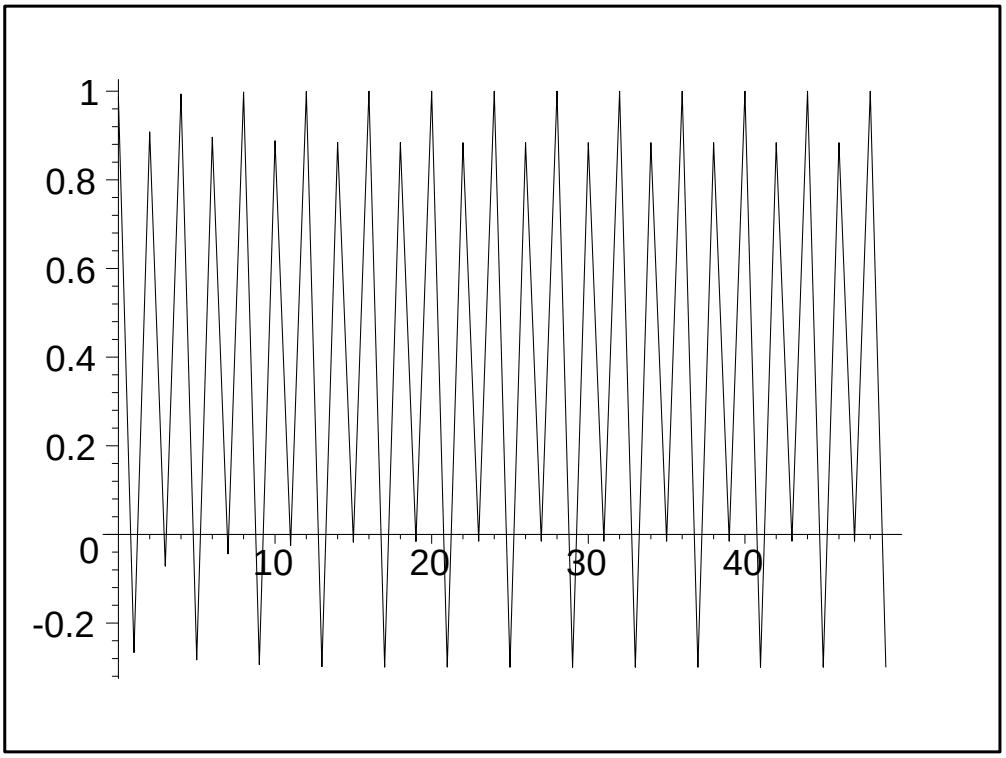

図 1.3: A 4-cycles of the logistic map in the case when μ=1.3

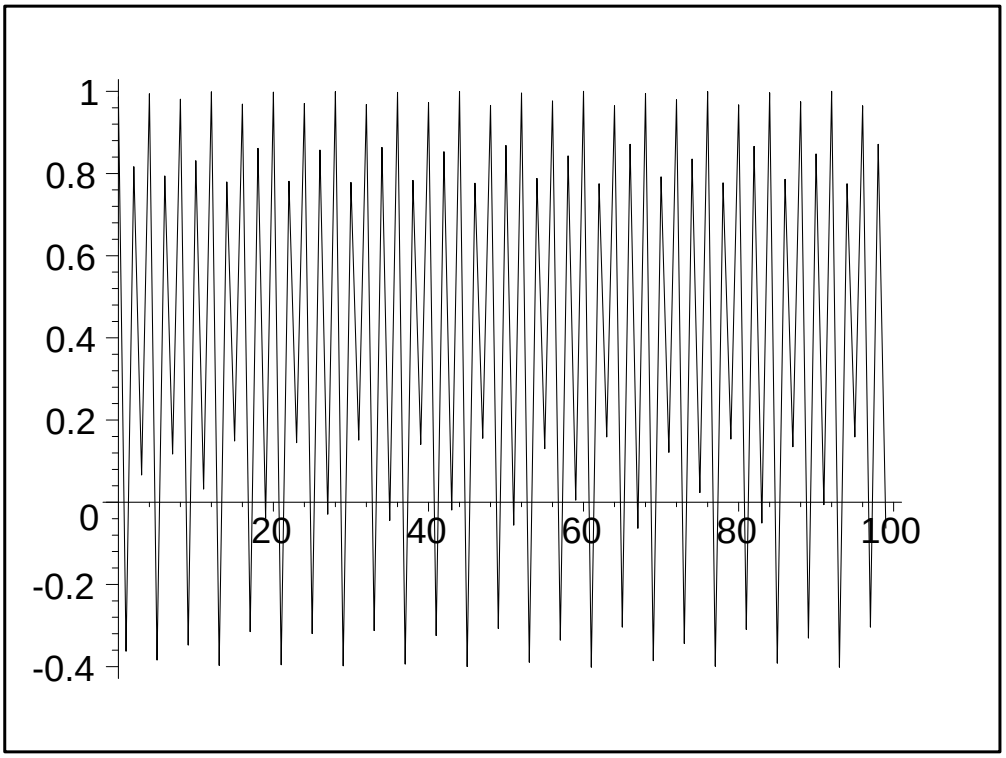

図 1.4: Near the boundary of chaos of the logistic map in the case when μ=1.401155

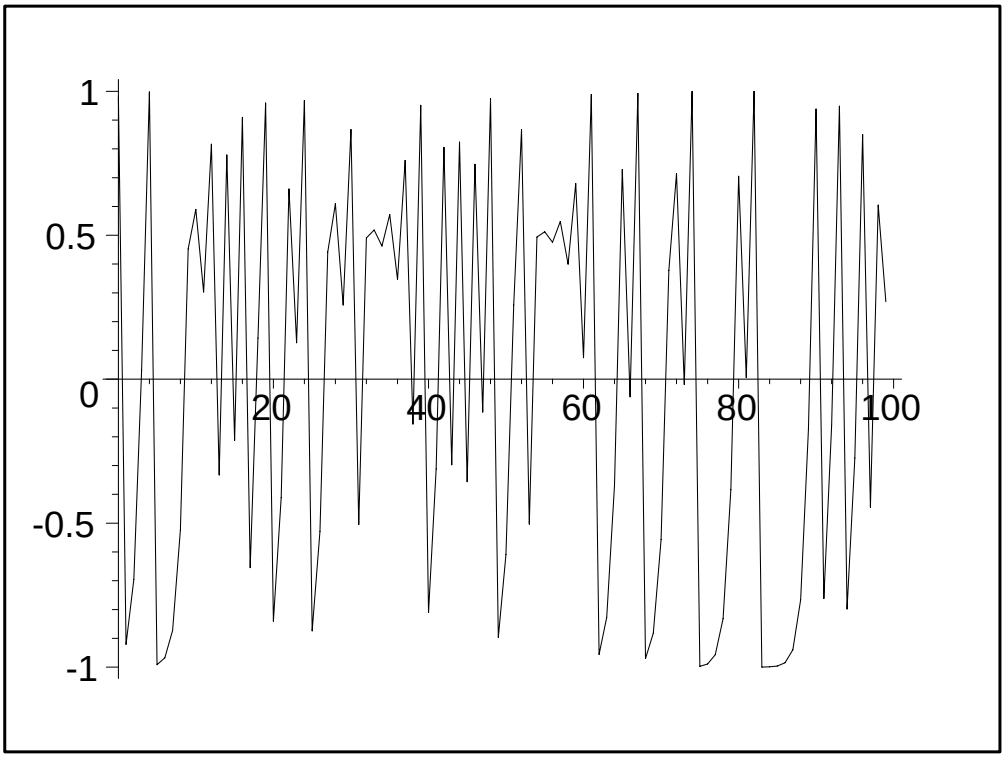

図 1.5: An orbit of the logistic map in the case when μ=2.0

ロジスティック写像の分岐図

(1.8) 式のロジスティック写像の分岐パラメータ μ の値をゼロから 2 まで変化させたときの分岐図を Maple に描かせたのがつぎの図である。

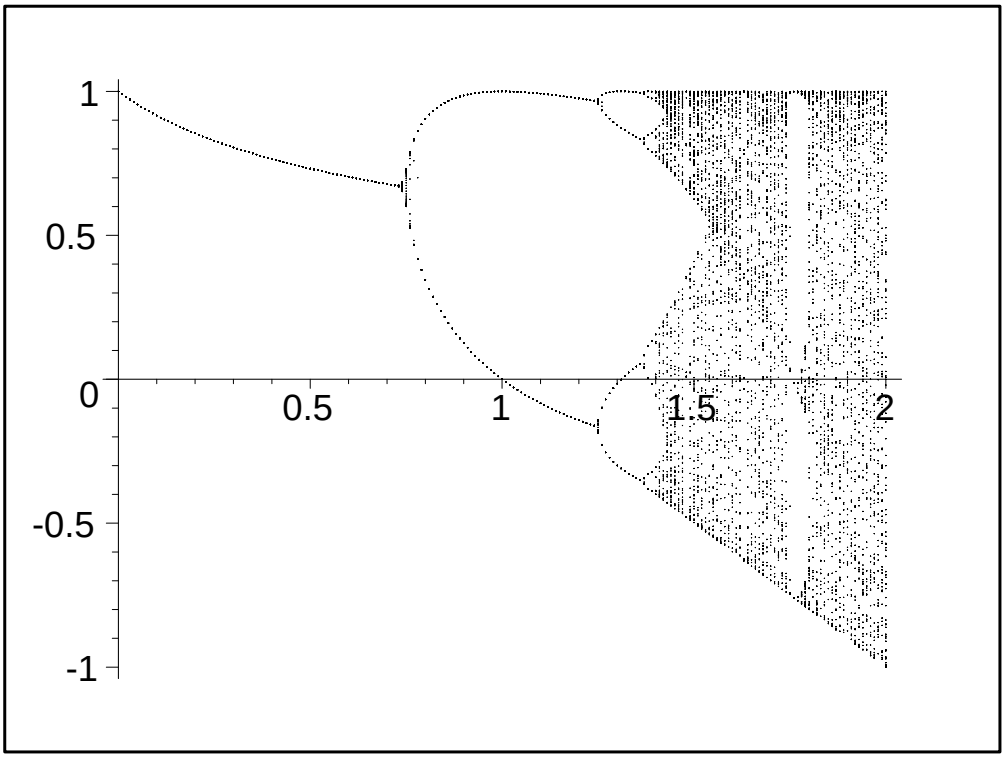

図 1.6: A bifurcation diagram of the logistic map

$1.74 \leq \mu \leq 1.80$ に見る自己相似構造

(1.8) 式のロジスティック写像の分岐パラメータ μ の値を例えば 1.74 から 1.80 までに絞って分岐図を拡大して描いたのがつぎの図である。いわゆる**自己相似構造** (the self-similar structure) が現れていることがわかる。この範囲の $\mu = 1.7548776\cdots$ には、3-周期点があり、その点の近くには (1.8) 式で表されるロジスティック写像の最大の周期窓 (a periodic window) が開いていることが 1 つ前の図 1.6 から明らかである。

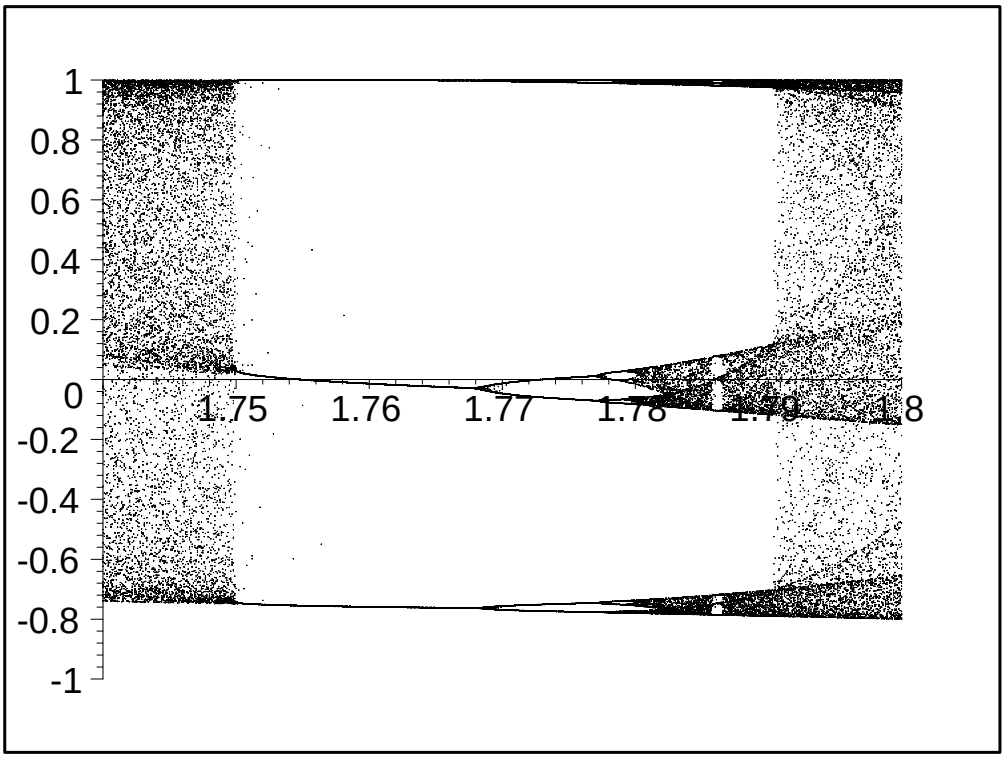

図 1.7: A self-similar structure of the logistic map in $1.74 \leq \mu \leq 1.80$

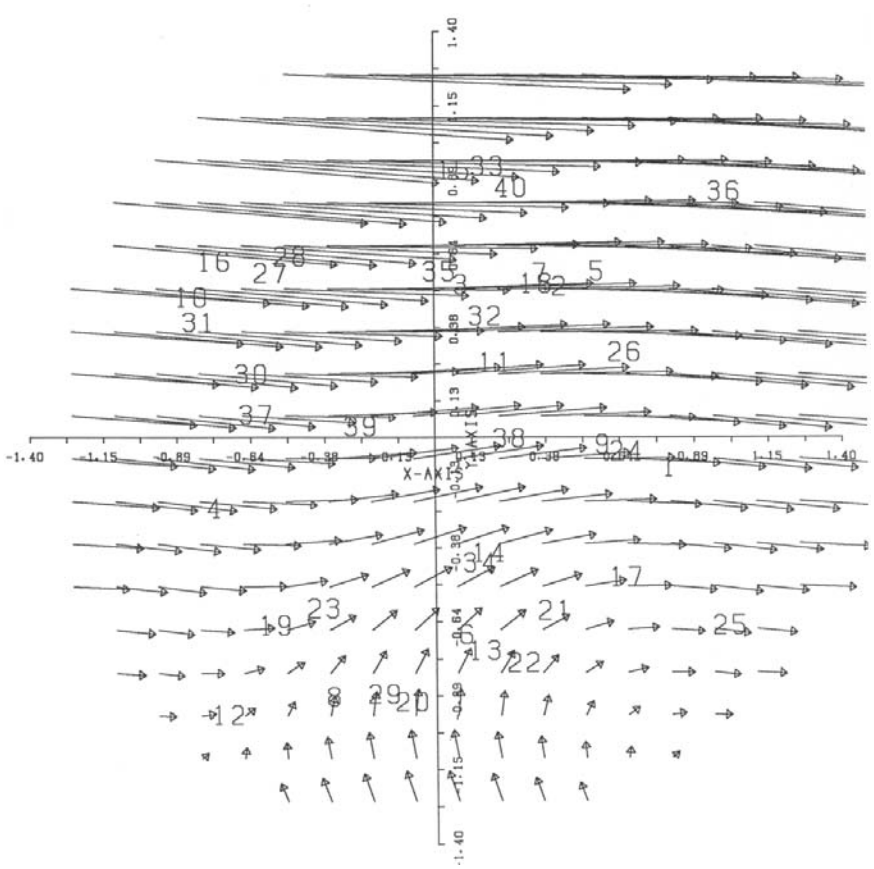

図 1.8: An orbit of the simulated system at $time = -3$

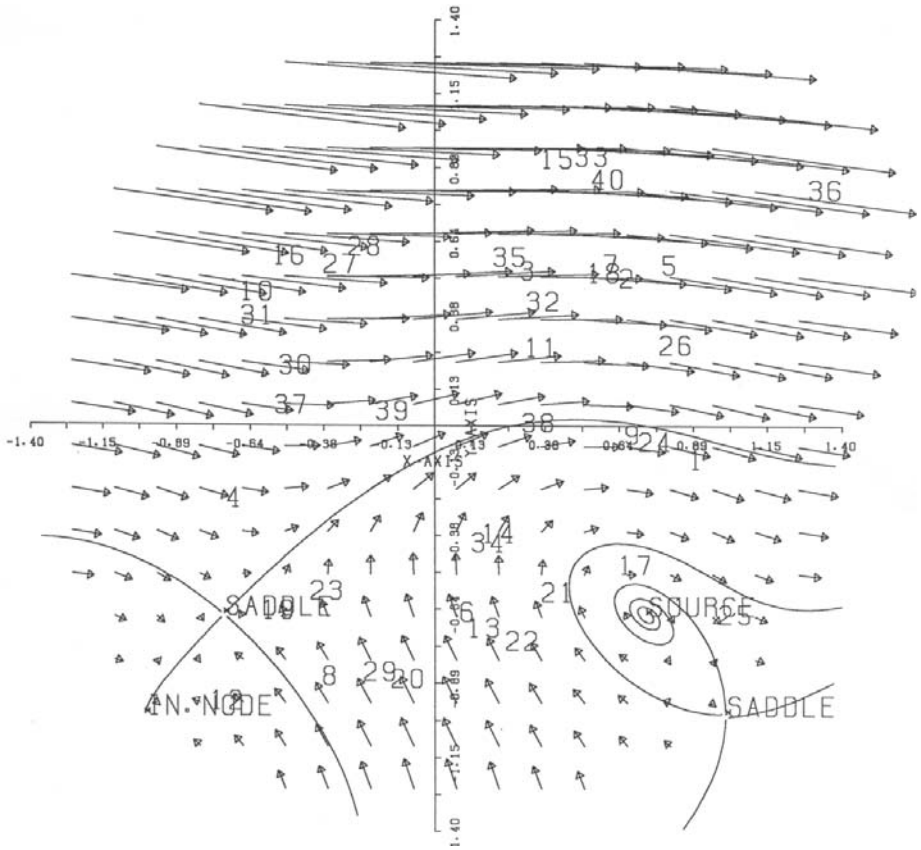

図 1.9: An orbit of the simulated system at $time = -2$

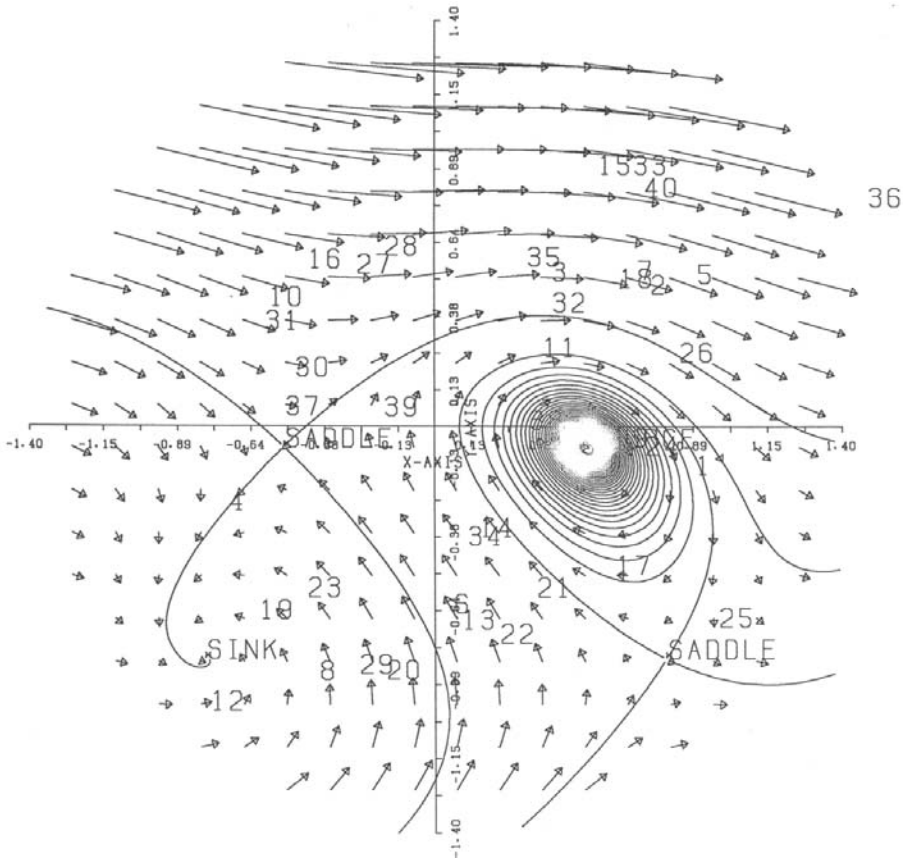

図 1.10: An orbit of the simulated system at $time = -1$

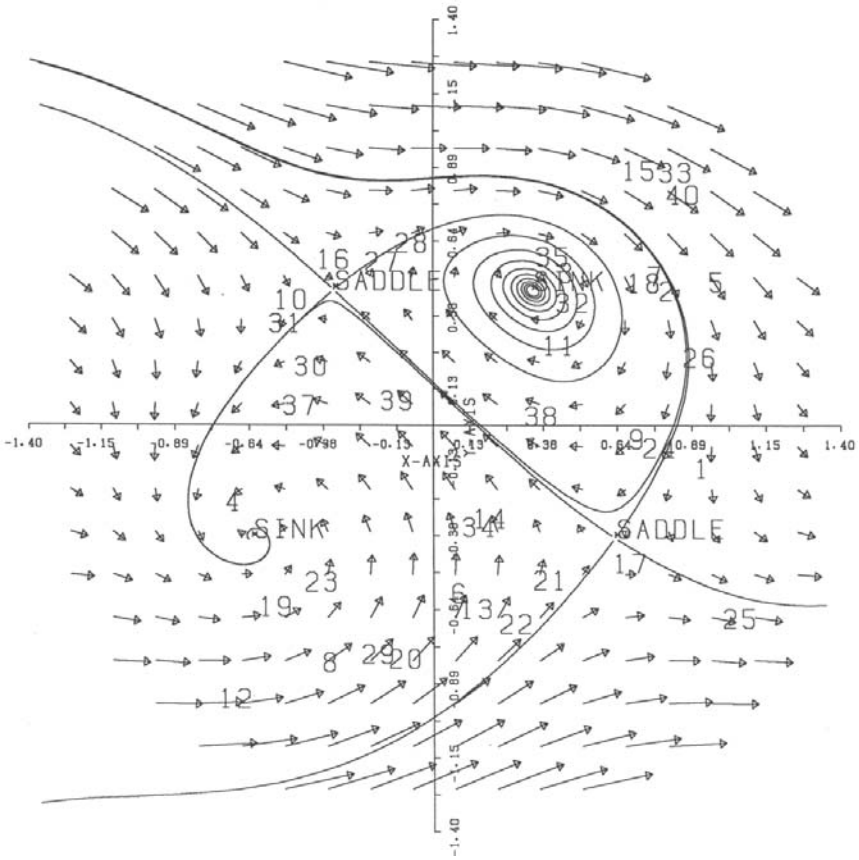

図 1.11: An orbit of the simulated system at $time = 0$

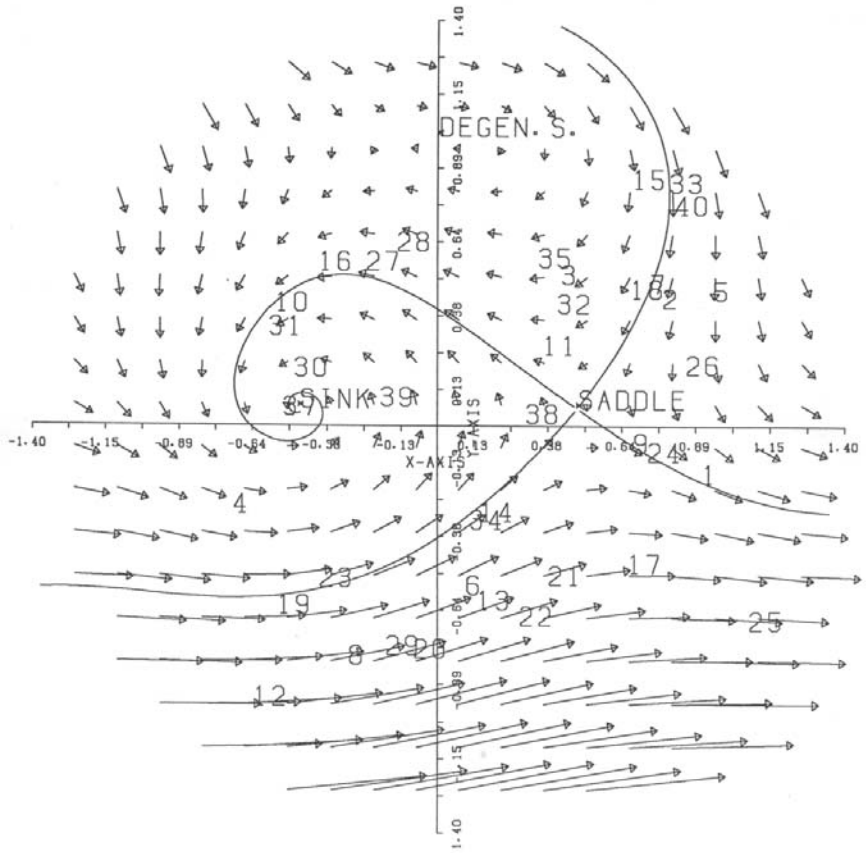

図 1.12: An orbit of the simulated system at $time = 1$

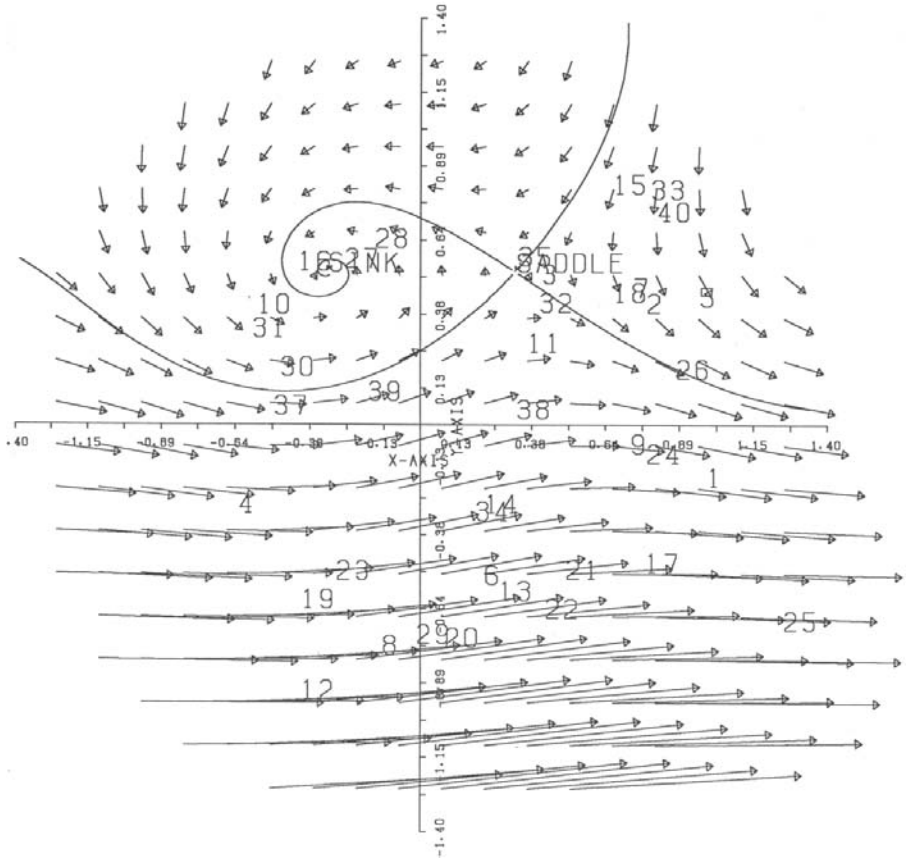

図 1.13: An orbit of the simulated system at $time = 2$

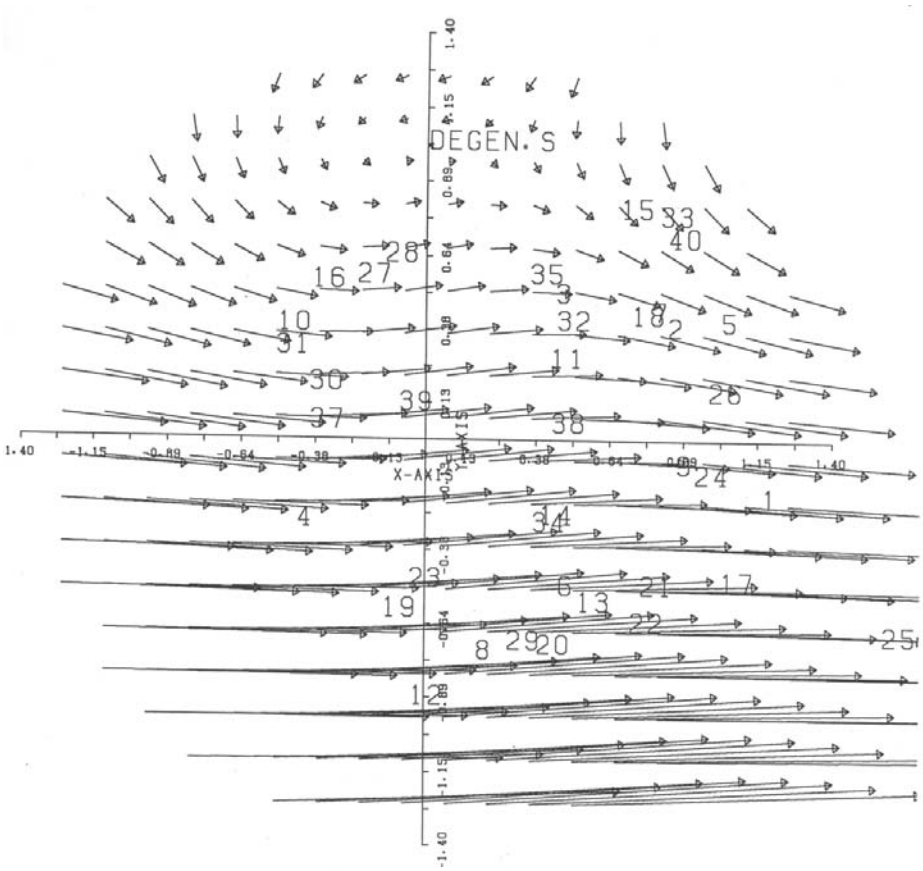

図 1.14: An orbit of the simulated system at $time = 3$

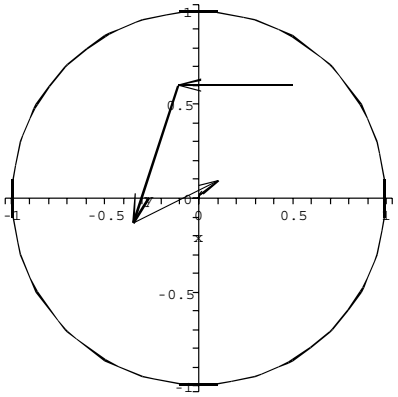

図 1.15: An orbit of the simplest Julia set with the initial value, $z_0 = 0.5 + 0.6i$

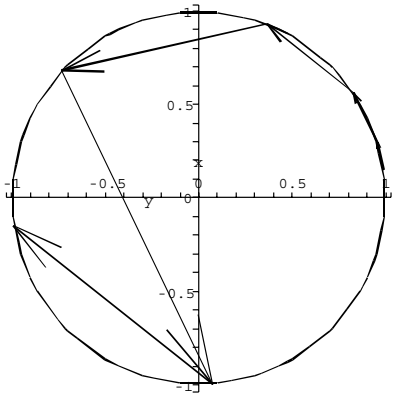

図 1.16: An orbit of the simplest Julia set with the initial value, $z_0 = cos(\pi/21) + i\, sin(\pi/21)$

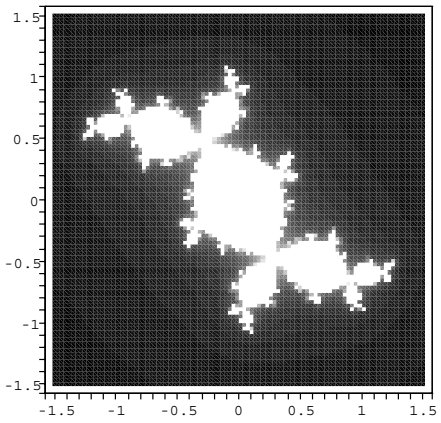

図 1.17: A Mandelbrot process with $c = -0.12 + 0.74i$

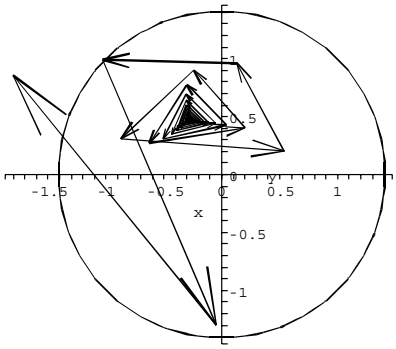

図 1.18: An orbit of the Mandelbrot process shown in Figure 7 with the initial value, $z_0 = -0.2738 + 0.4783i$

第2章　線形 vs. 非線形

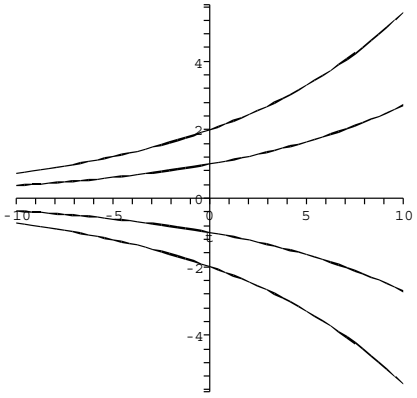

図 2.1: The simplest differential equations with initial values

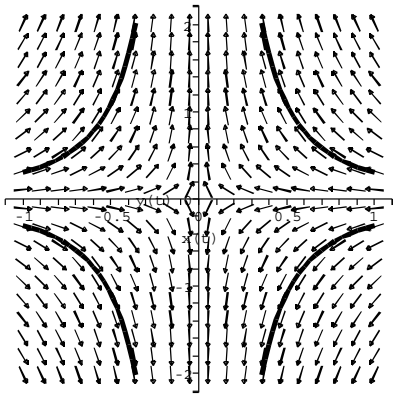

図 2.2: The vector field and some solution curves near a saddle with $\lambda_1 < 0 < \lambda_2$

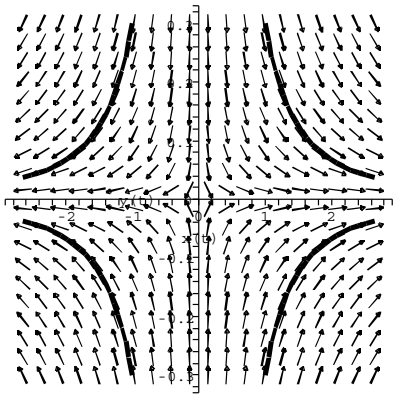

図 2.3: The vector field and some solution curves near a saddle with $\lambda_2 < 0 < \lambda_1$

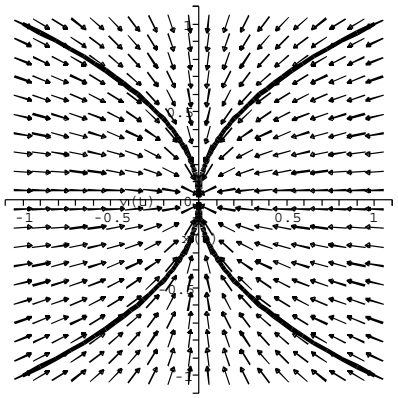

図 2.4: The vector field and some solution curves near an inward node with $\lambda_1 < \lambda_2 < 0$

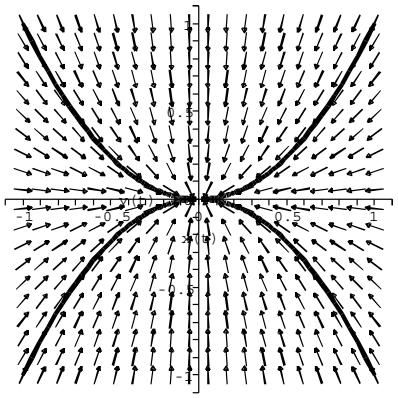

図 2.5: The vector field and some solution curves near an inward node with $\lambda_2 < \lambda_1 < 0$

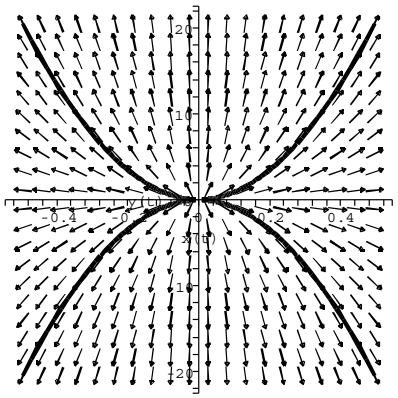

図 2.6: The vector field and some solution curves near an outward node with $0 < \lambda_1 < \lambda_2$

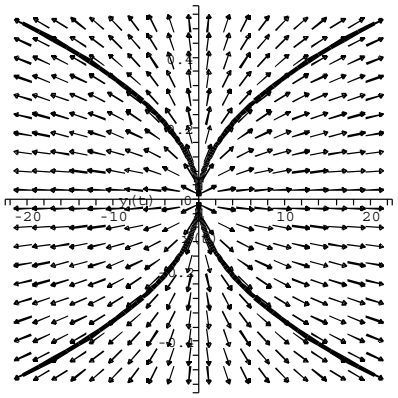

図 2.7: The vector field and some solution curves near an outward node with $0 < \lambda_2 < \lambda_1$

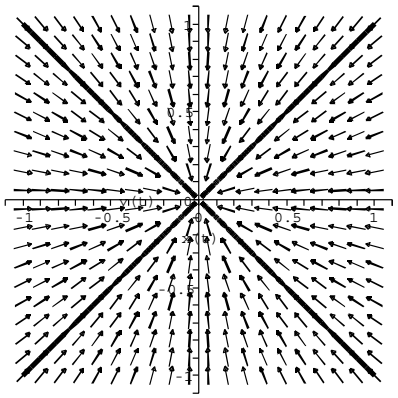

図 2.8: The vector field and some solution curves near an inward focus with $\lambda_1 = \lambda_2 < 0$

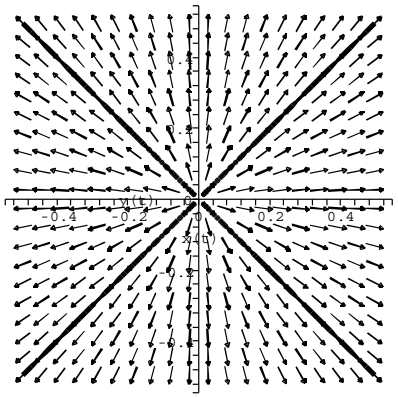

図 2.9: The vector field and some solution curves near an outward focus with $\lambda_1 = \lambda_2 > 0$

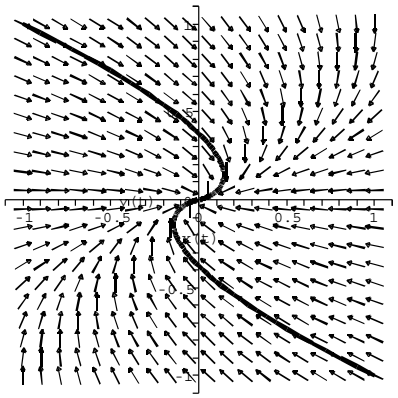

図 2.10: The vector field and some solution curves near an inward improper node with eqs.(3.21),$\lambda < 0$

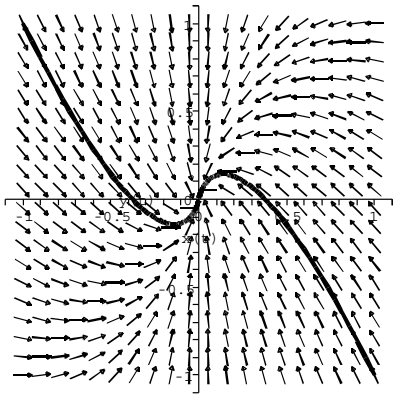

図 2.11: The vector field and some solution curves near an inward improper node with eqs.(3.18),$\lambda < 0$

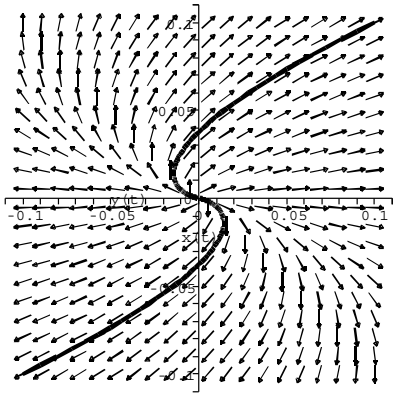

図 2.12: The vector field and some solution curves near an outward improper node with eqs.(3.21),$\lambda > 0$

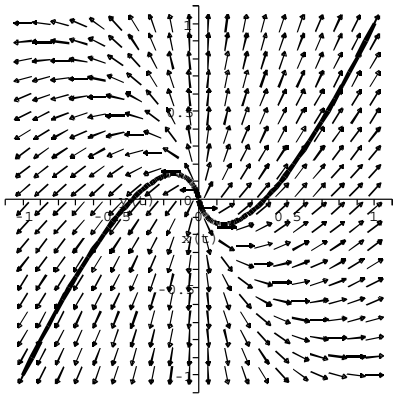

図 2.13: The vector field and some solution curves near an outward improper node with eqs.(3.18),$\lambda > 0$

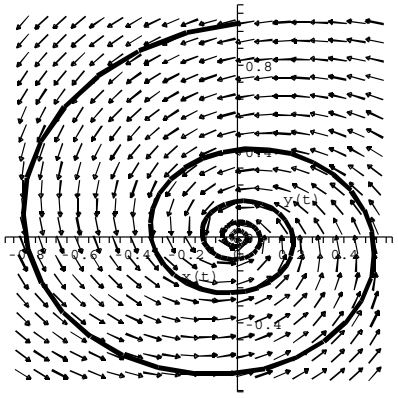

図 2.14: The vector field and some solution curves near a (counterclockwise) spiral sink

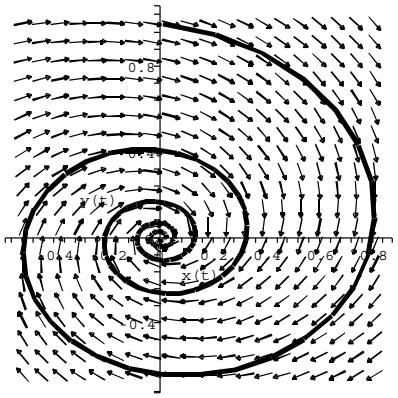

図 2.15: The vector field and some solution curves near a (clockwise) spiral sink

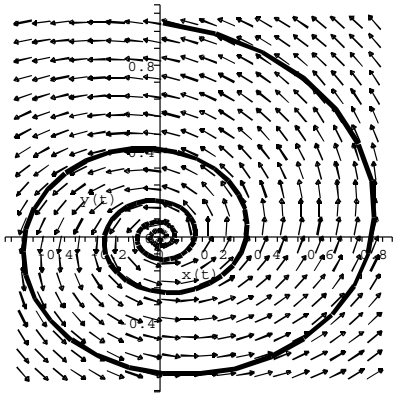

図 2.16: The vector field and some solution curves near a (counterclockwise) spiral source

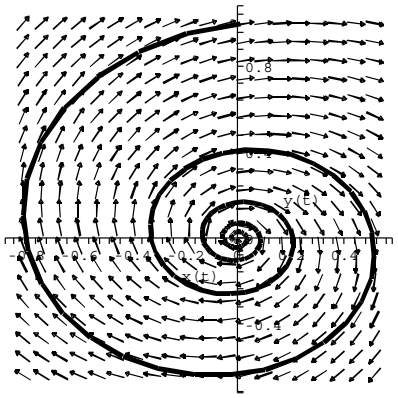

図 2.17: The vector field and some solution curves near a (clockwise) spiral source

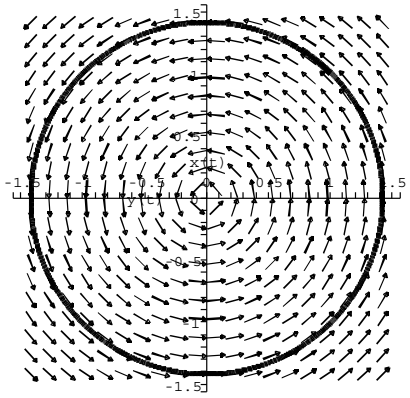

図 2.18: The vector field and some solution curves near a (counterclockwise) center

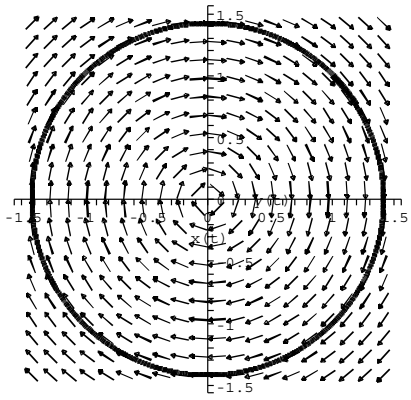

図 2.19: The vector field and some solution curves near a (clockwise) center

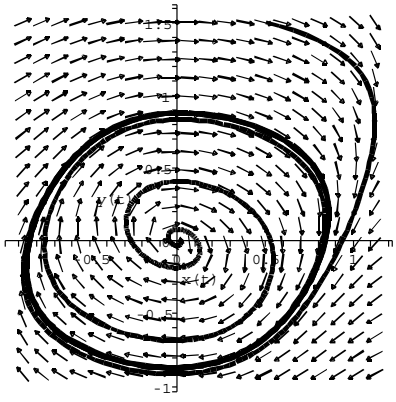

図 2.20: An ω-limit cycle

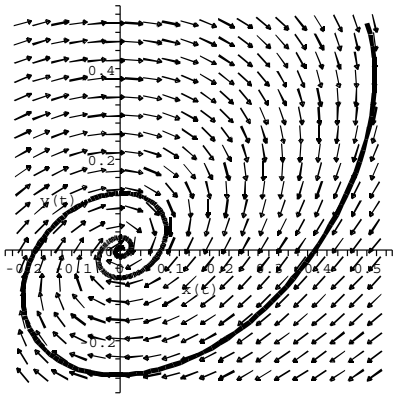

図 2.21: A spiral sink before an ω-limit cycle appears

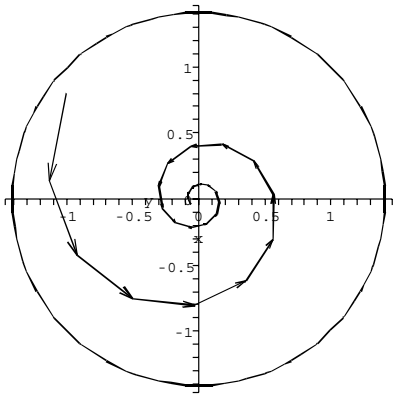

図 2.22: An orbit of a spiral sink with a=0.55 and b=0.7

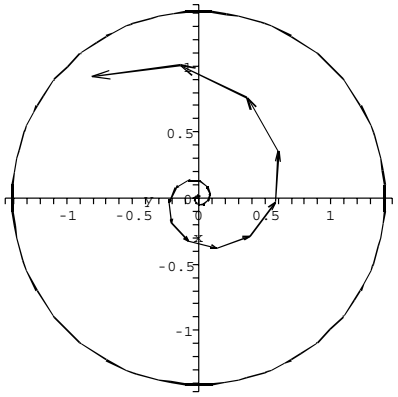

図 2.23: An orbit of a spiral source with a=-1.0 and b=0.8

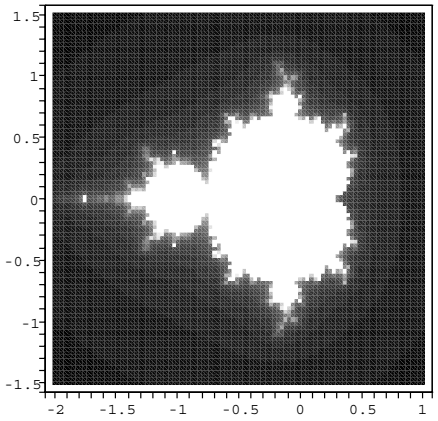

図 2.24: The Mandelbrot set