Increase in Complexity in Random Neural Networks

繁花曲线：随机神经网络的美与秩序

杨楚雪 田伟柏 王誉晨 谢尚恩

理论部分

实验模拟

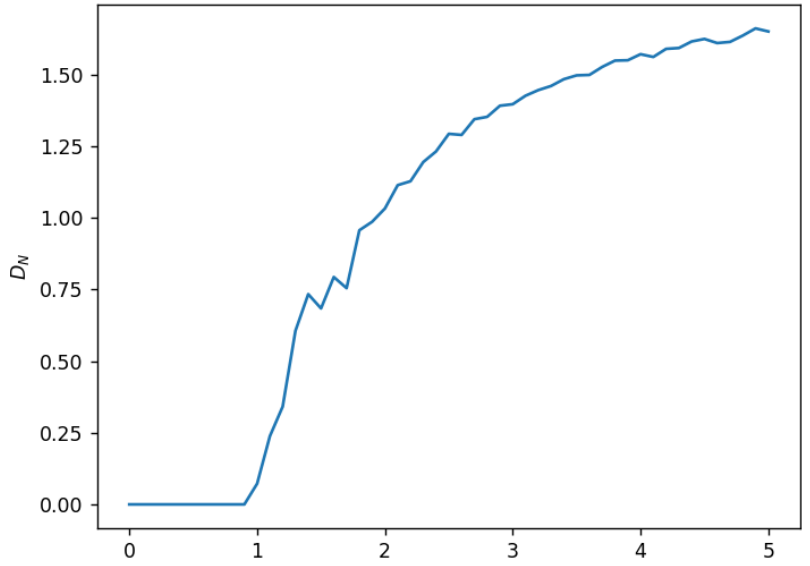
- $D_N = \frac{1}{N}\frac{1}{T}\Sigma_{t=1}^{T}\Sigma_{i=1}^{N}\left[u_i^1(t) - u_i^2(t)\right]^2$

RNN网络模型设定

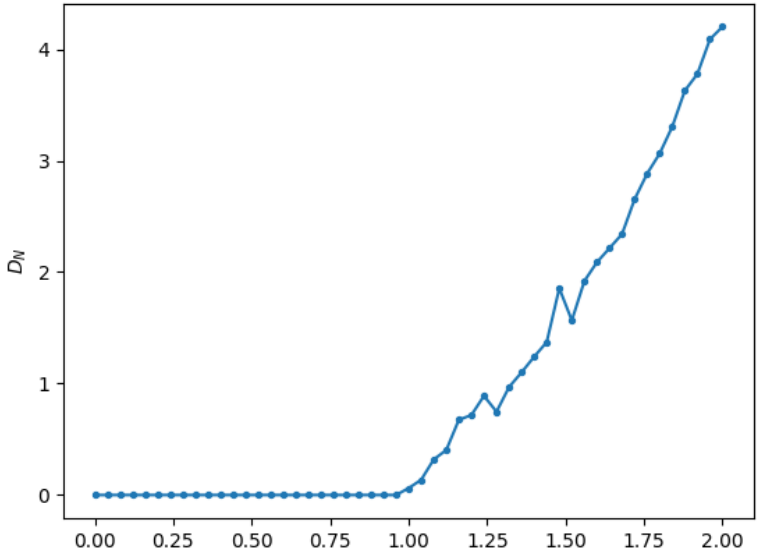
- $u_i(t+1) = \Sigma_{j=1}^{N} J_{ij} x_j(t) + \theta_i$
- $x_i(t+1) = f\left(u_i(t+1)\right)$
- $f(x) = \tanh(gx)$

- $J_{ij} \neq J_{ji}$
- $J_{ij} \sim N(0,1), E\left(J_{ij}\right) = \frac{\bar{J}}{N}, D\left(J_{ij}\right) = \frac{J^2}{N}$

- $\theta \sim N(0,1), E(\theta) = \bar{\theta}, D(\theta) = \sigma_\theta^2$



g

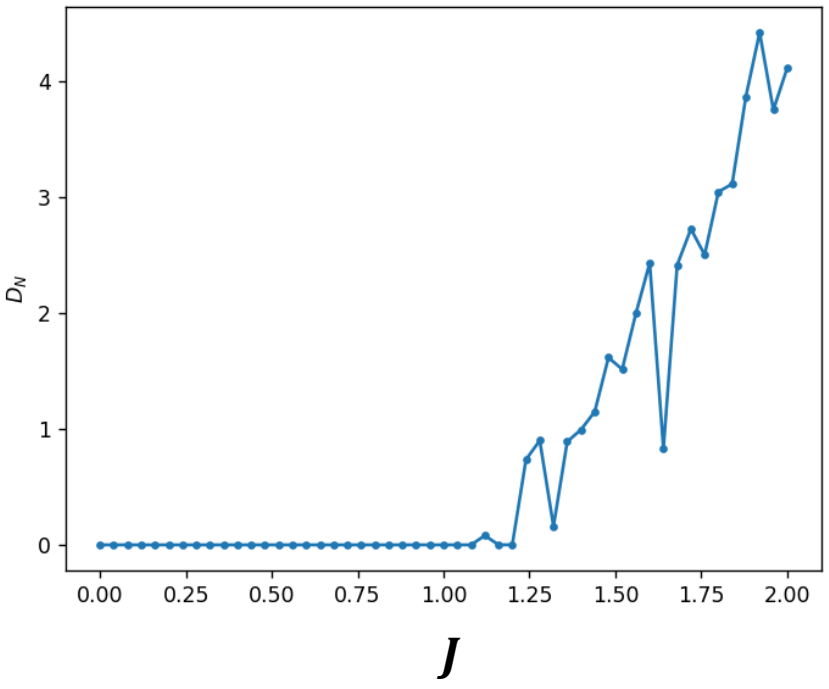


J

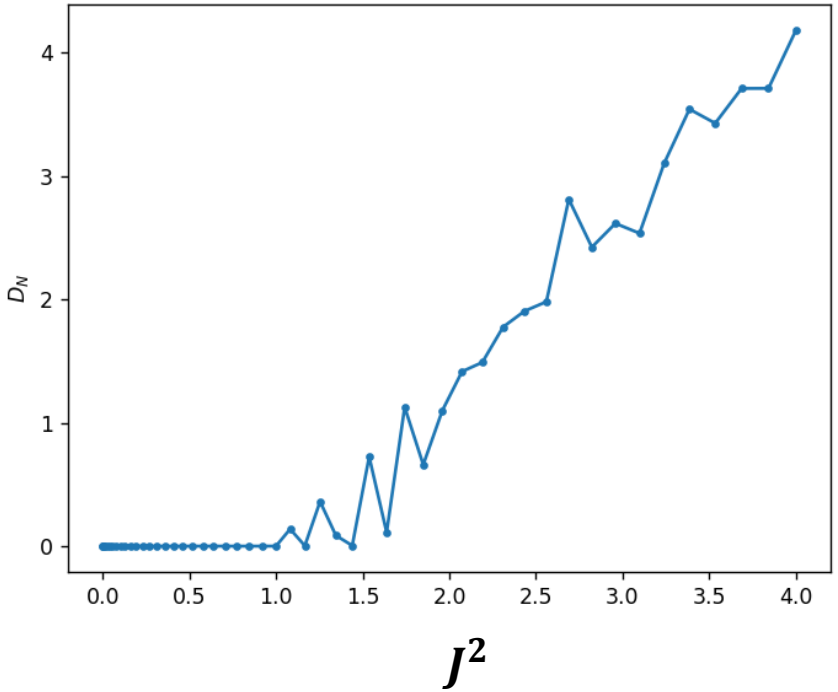
备注：我们发现横坐标选为g更符合老师在黑板上描述的现象

为什么是g

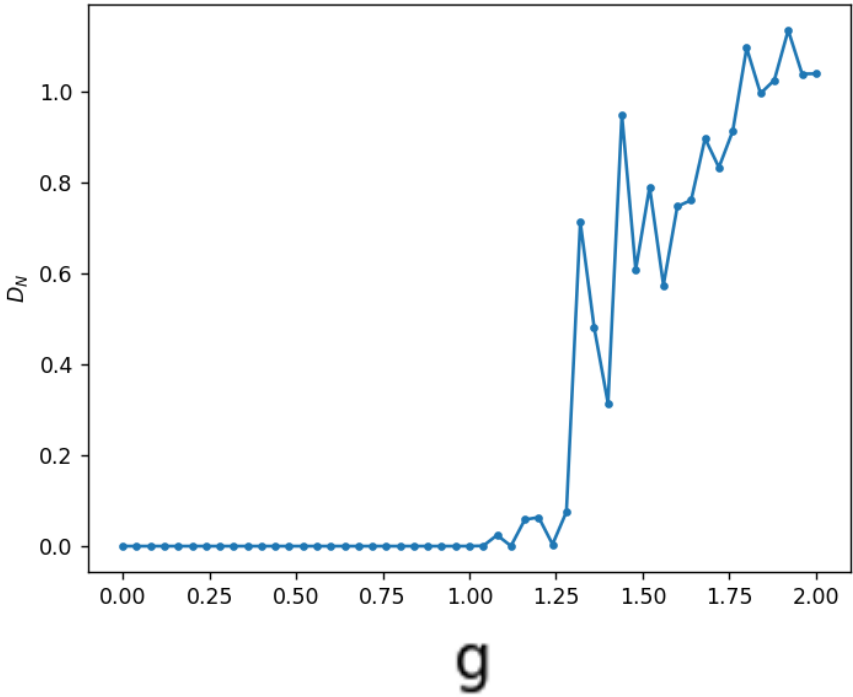
- $u_i(t+1) = \Sigma_{j=1}^{N} J_{ij} x_j(t) + \theta_i$
- $x_i(t+1) = f\big(u_i(t+1)\big) \quad f(x) = \tanh(gx)$



J



J^2

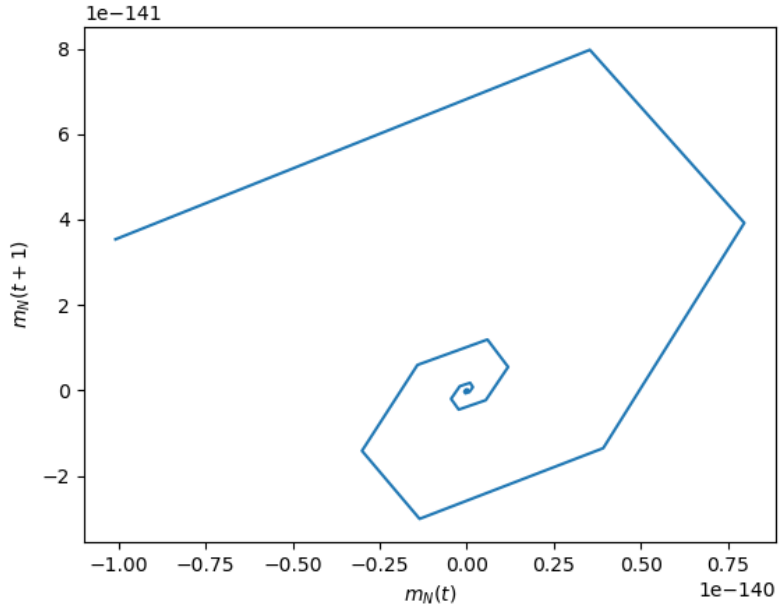


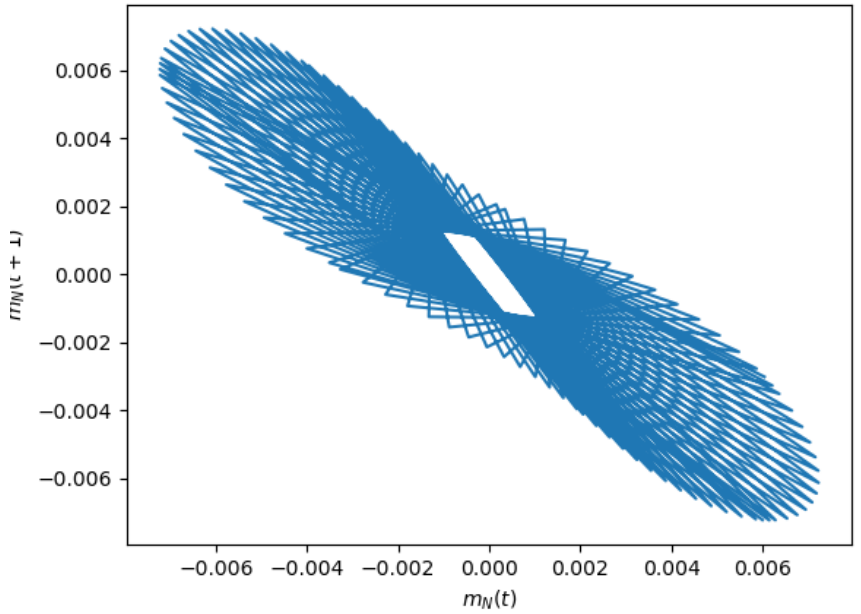
g

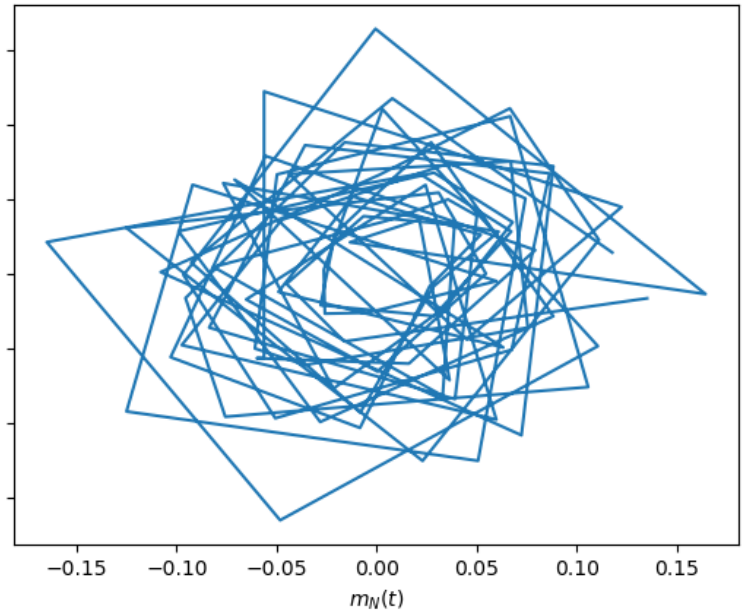
实验模拟

高维吸引子的二维投影

- $m_N = \frac{1}{N} x_i(t) \quad m_N(t) = f(m_N(t+1))$

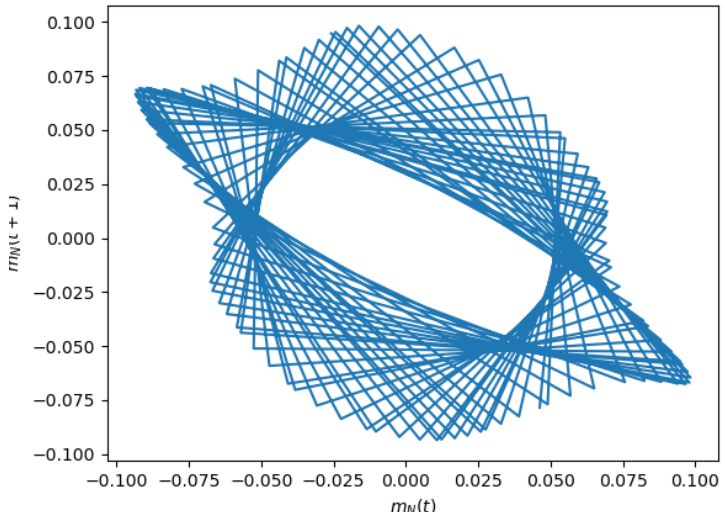


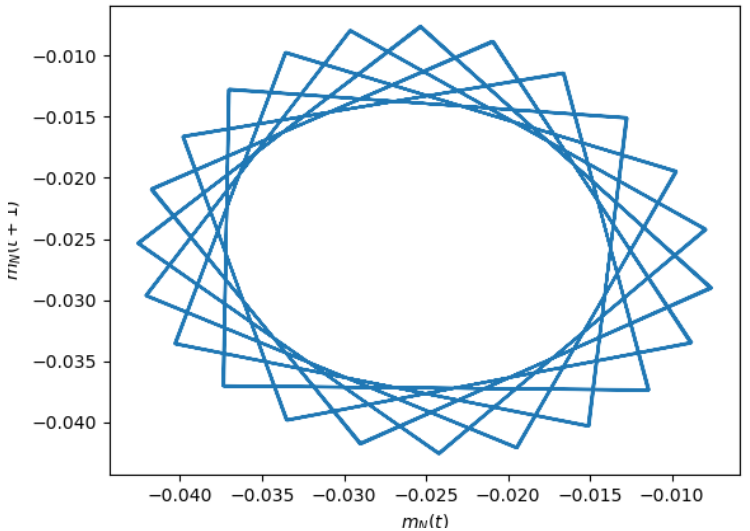


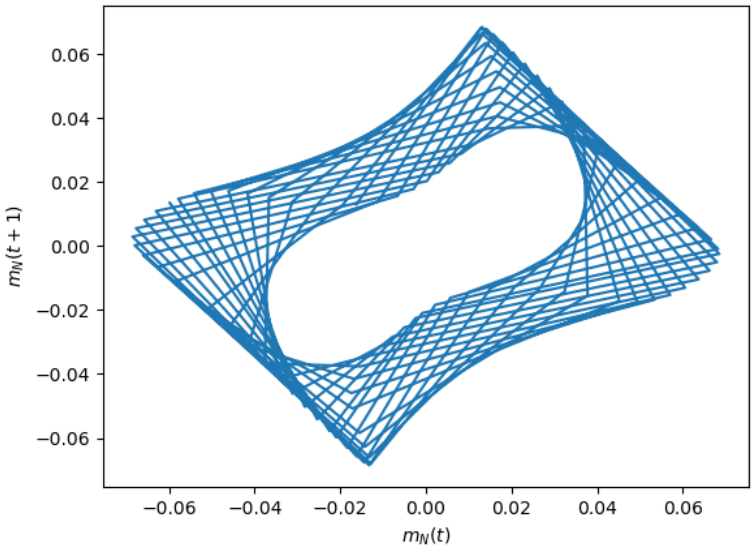


吸引子区间：J=0.7　　极限环区间：J=1.0　　混沌区间：J=1.4

好图共赏


0.100
0.075
0.050
0.025
0.000
−0.025
−0.050
−0.075
−0.100
−0.100 −0.075 −0.050 −0.025 0.000 0.025 0.050 0.075 0.100
$m_N(t)$
$m_N(t+1)$


−0.010
−0.015
−0.020
−0.025
−0.030
−0.035
−0.040
−0.040 −0.035 −0.030 −0.025 −0.020 −0.015 −0.010
$m_N(t)$
$m_N(t+1)$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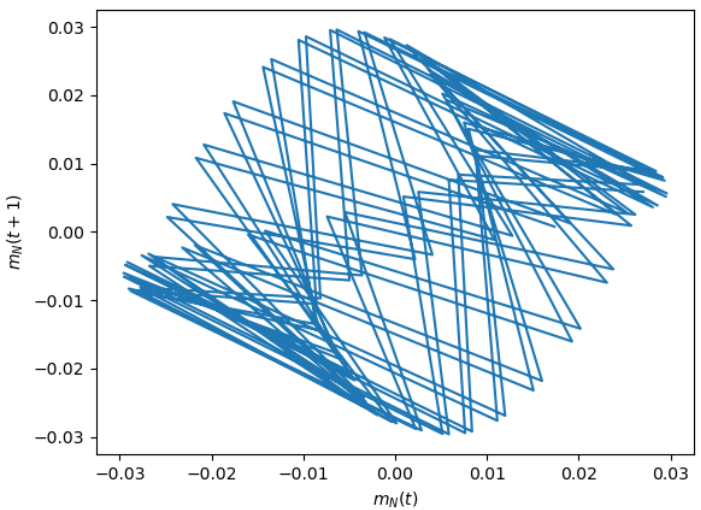
0.04
0.02
0.00
−0.02
−0.04
−0.06
−0.06 −0.04 −0.02 0.00 0.02 0.04 0.06
$m_N(t)$
$m_N(t+1)$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0.02
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0.00
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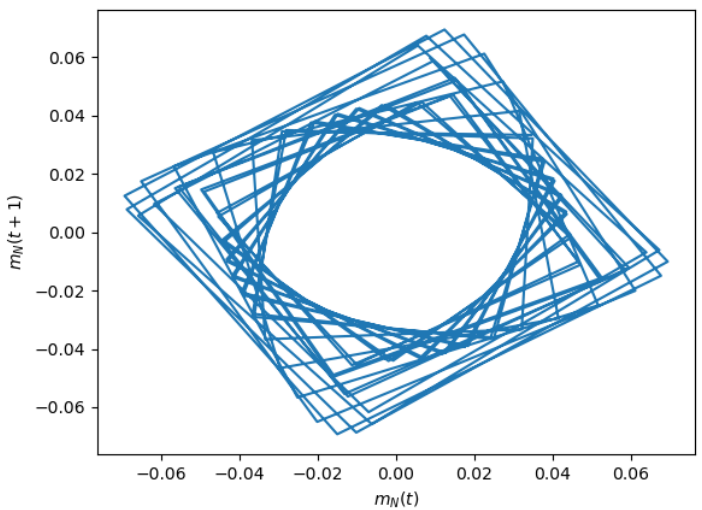
−0.03
−0.03 −0.02 −0.01 0.00 0.01 0.02 0.03
$m_N(t)$
$m_N(t+1)$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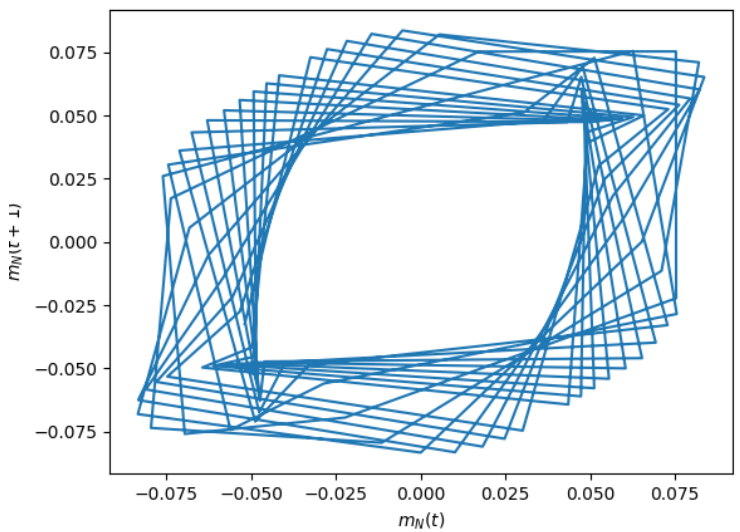
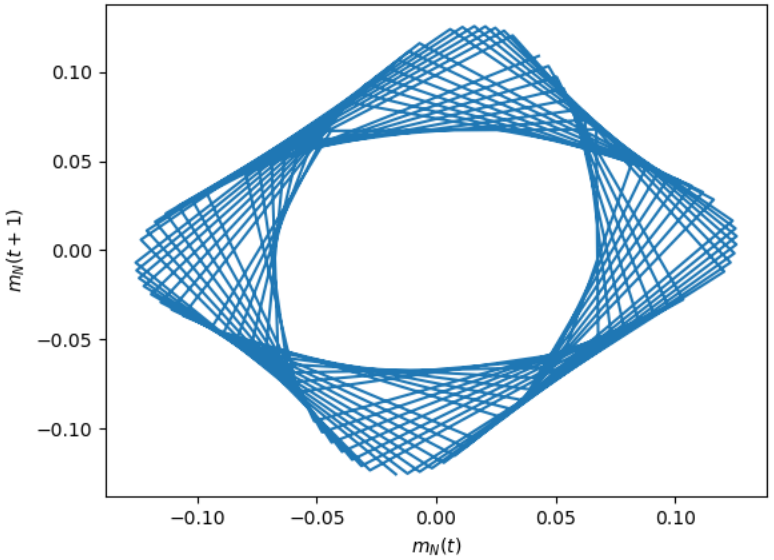
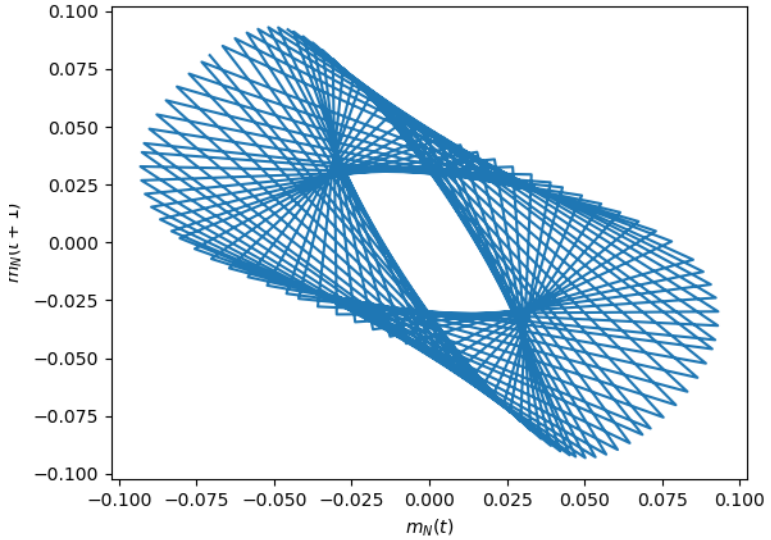
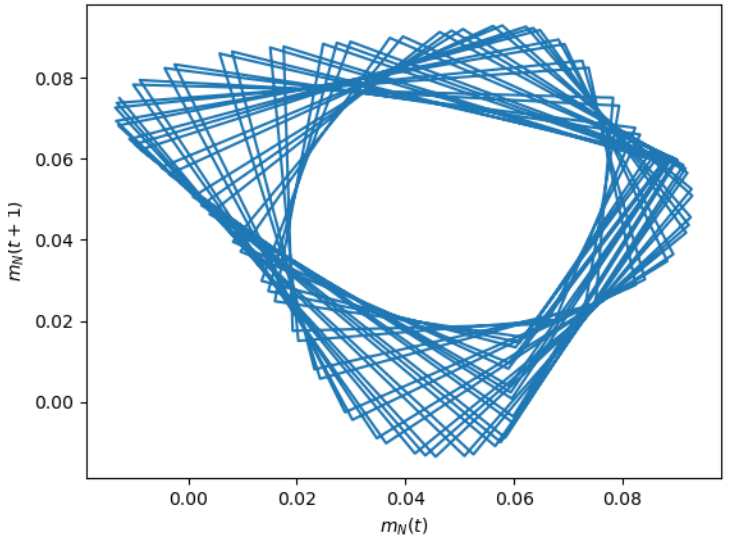
0.02
0.00
−0.02
−0.04
−0.06
−0.06 −0.04 −0.02 0.00 0.02 0.04 0.06
$m_N(t)$
$m_N(t+1)$

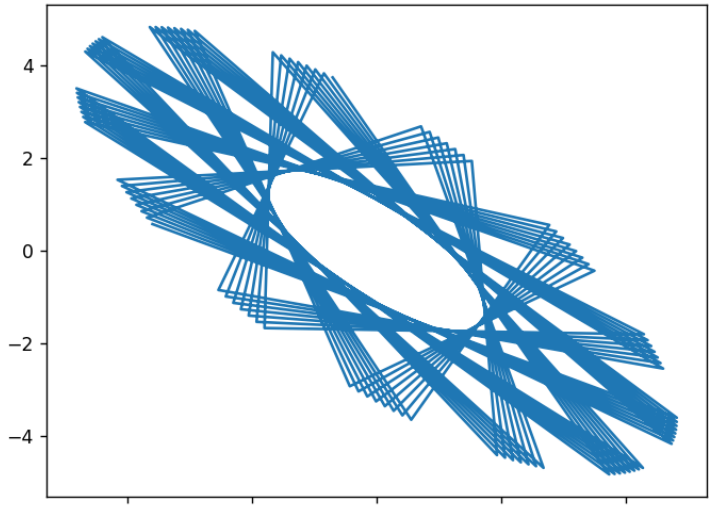

0.075
0.050
0.025
0.000
−0.025
−0.050
−0.075
−0.075 −0.050 −0.025 0.000 0.025 0.050 0.075
$m_N(t)$
$m_N(t+1)$

好图共赏


0.10
0.05
0.00
−0.05
−0.10
$m_N(t+1)$
−0.10
−0.05
0.00
0.05
0.10
$m_N(t)$


0.100
0.075
0.050
0.025
0.000
−0.025
−0.050
−0.075
−0.100
$m_N(t+1)$
−0.100
−0.075
−0.050
−0.025
0.000
0.025
0.050
0.075
0.100
$m_N(t)$


0.08
0.06
0.04
0.02
0.00
$m_N(t+1)$
0.00
0.02
0.04
0.06
0.08
$m_N(t)$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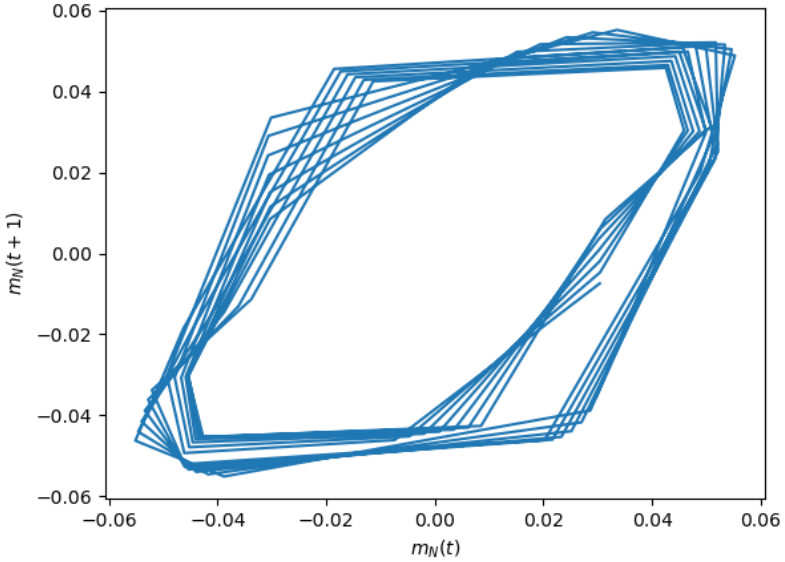
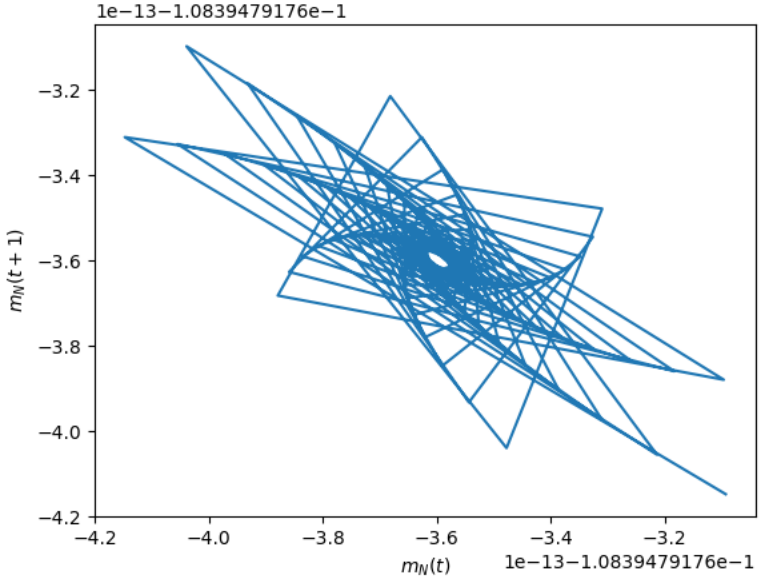
2
0
−2
−4
−4
−2
0
2
4


0.06
0.04
0.02
0.00
−0.02
−0.04
−0.06
$m_N(t+1)$
−0.06
−0.04
−0.02
0.00
0.02
0.04
0.06
$m_N(t)$


1e−13−1.0839479176e−1
−3.2
−3.4
−3.6
−3.8
−4.0
−4.2
$m_N(t+1)$
−4.2
−4.0
−3.8
−3.6
−3.4
−3.2
$m_N(t)$
1e−13−1.0839479176e−1