

```

1 # Exercise 4.3d
2
3 import numpy as np
4 import matplotlib.pyplot as plt
5 import sys
6
7 title = '4.3d'
8
9 a = 1.4
10 b = 0.3
11
12 cut_tail = 100
13
14 T = 10**4
15 dt = 5*10**-3
16 t = np.arange(0,T,dt)
17
18 x = np.zeros_like(t,dtype=float)
19 y = x.copy()
20
21 x[0] = (np.random.uniform()-0.5)
22 y[0] = (np.random.uniform()-0.5)
23
24 for t in range(len(x)-1):
25     x[t+1] = y[t]+1-a*x[t]**2
26     y[t+1] = b*x[t]
27
28 x = x[cut_tail:]
29 y = y[cut_tail:]
30
31 q_vals = np.linspace(0,4,10)
32 Dq_list = []
33 epsilon_range = np.linspace(10**-3, 2*10**-2, 10)
34 fig, ax = plt.subplots(figsize=(7,7))
35 color = ['tab:blue', 'tab:green', 'tab:red']
36
37 for q_i in range(len(q_vals)):
38
39     q = q_vals[q_i]
40     Iq = np.zeros_like(epsilon_range, dtype=float)
41
42     for epsilon_i in range(len(epsilon_range)):
43
44         epsilon = epsilon_range[epsilon_i]
45         N_points = len(x)
46
47         xmax = 1.3
48         xmin = -xmax
49         ymax = 0.4
50         ymin = -ymax
51
52         x_bins = np.linspace(xmin, xmax, int((xmax-xmin)/epsilon))
53         y_bins = np.linspace(ymin, ymax, int((ymax-ymin)/epsilon))
54
55         plt.figure()
56         histogram = plt.hist2d(x, y, bins=[x_bins, y_bins])
57         boxes = histogram[0].copy()
58         plt.figure().clear()
59         plt.close()
60         plt.cla()
61         plt.clf()
62
63         for i in range(len(boxes[:,0])):
64             for j in range(len(boxes[0,:])):
65                 if boxes[i,j] != 0:
66                     if q == 1:
67                         N_k = boxes[i,j]
68                         Iq[epsilon_i] += ((N_k/N_points)*np.log(1/(N_k/N_points)))
69                     else:
70                         N_k = boxes[i,j]
71                         Iq[epsilon_i] += (N_k/N_points)**q
72
73     x_axis = np.log(1/epsilon_range)
74
75     if q == 1:
76         y_axis = Iq
77     else:
78         y_axis = np.log(Iq)/(1-q)

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79
80     coef = np.polyfit(x_axis, y_axis, 1)
81     Dq = coef[0]
82     Dq_list.append(Dq)
83     print('Dq=', Dq, '    q=', q)
84
85 ax.plot(q_vals, Dq_list, 'o--', color='black')
86 ax.set_title(title)
87 ax.set_box_aspect(1)
88 ax.set_xlabel(r'$q$')
89 ax.set_ylabel(r'$D_{q}$')
90
91 fig.savefig('Dynamical Systems/DS HW4/4.3/'+title+'.png')
92 plt.show()
```