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"""
Registration : xxxx
Description  : Nuclear Decay Monte Carlo
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"""

import numpy as np
import matplotlib.pyplot as plt
from scipy.interpolate import interp1d
from scipy.optimize import brentq

tau, dt, tmax, n0 = 500, 20, 1000, 20000;  # Half-life, Time-step, Maximum Time, Initial
number of nuclei
p, d = n0, 0           # Initial Number of Parent and Daughter Nuclei
count = np.array([p])  # Initial Counter for Parent
dcount = np.array([0]) # Initial Counter for Daughter
alpha = np.log(2)/tau  # Decay constant
decay_prob = alpha*dt  # Decay probability
nsteps = tmax/dt
times = np.arange(nsteps)*dt

# Monte Carlo Estimate
for t in times[1:]:
    decay_rand = np.random.random(p)
    dec = np.sum(decay_rand < decay_prob)
    d += dec;    p -= dec;
    count = np.append(count,p)
    dcount = np.append(dcount,d)

#Half-life estimation
I = np.where(count > n0/4)
func = interp1d(times[I], count[I], kind='cubic')
tau_estim = brentq(lambda x: func(x) - n0/2, times[I][0], times[I][-1])
print ('Estimated half-life is: ', tau_estim, ' with given value ', tau)

#Plot
plt.figure(1)
plt.subplot(2,1,1)
plt.plot(times, count, '.', lw='4', ms='12', color="teal",    label='Parent')
plt.plot(times, dcount,'+', lw='4', ms='6', color="magenta", label='Daughter')
plt.plot(times, n0*np.exp(-alpha*times), '-',  lw='2', color="red", label=r'$N_0e^{-
\lambda t}$')
plt.title(r'$\lambda =$'+str(np.around(alpha,8))+', dt ='+str(dt)+r', $\tau_{1/2}$
='+str(int(tau_estim)), size=12)
plt.ylabel('Nuclei', size=16); plt.yticks(size=12)
plt.xlabel('Time', size=16); plt.xticks(size=12)
plt.legend(loc='best',prop={'size':12})
plt.title('Decay Probability (P) = '+str(decay_prob))
plt.grid(); plt.tight_layout();

#Semilog Plot
plt.subplot(2,1,2)
plt.semilogy(times, count, '.', lw='4', ms='12', color="teal",    label='Parent')
plt.plot(times, n0*np.exp(-alpha*times), '-',  lw='2', color="red", label=r'$N_0e^{-
\lambda t}$')
plt.xlabel('Time', size=12); plt.xticks(size=12)
plt.ylabel('$log(Nuclei)$', size=12); plt.yticks(size=12)
plt.legend(loc='best',prop={'size':12})
plt.grid(); plt.tight_layout(); plt.show()

#Results:
"""
tau, dt, tmax, n0 = 1000, 20, 5000, 100;
Estimated half-life is:  820.0  with given value  1000

tau, dt, tmax, n0 = 1000, 20, 5000, 100000;
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Estimated half-life is:  991.367172421  with given value  1000
"""
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