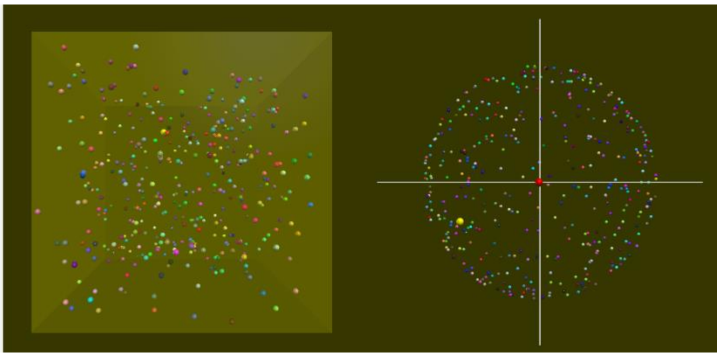
Computer Homework 11 Drift Velocity

In the program, *N*=400 charged particles, each with mass *m* and charge *q*, are in a cubic box of length 2*L*. The velocity of each particle have the same magnitude *vrms*, but with a random direction. With the periodic boundary condition, each particle hitting a wall will appear on the opposite side of wall with the same velocity. The two different displays, the position display (called "real space") and velocity display (called "velocity space"), together form the "phase space" of the entire system. In this "phase space", the states (position and velocity) of all particles are completely represented. In the program, the drift velocity *vd,* which is the velocity averaged over all particles over all time, is found and shown in the velocity display as the larger red ball.

Homework:

(1) Within each time step *dt*, each particle has a probability (*prob*) to encounter a "collision" (Note: not a real collision against any other charged particle, but just a collision against some virtual particles). After the collision, the velocity of the particle has the same magnitude *vrms* but with a new random direction. Find the collision time: *tau* = (total time *t*N*) / (total collision number of all particles of all time).

(2) Follow (1). If there is an electric field *E* to accelerate all particles, find the drift velocity *vd*. Is it close to the theoretical value *q*E*tau/m*?



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from vpython import *
import numpy as np

prob = 0.008
N, L = 400, 10E-9/2.0
E = 1500000
q, m, size = 1.6E-19, 1E-6/6E23, 0.1E-9
t, dt, vrms = 0, 1E-16, 100000.0
atoms, atoms_v = [],[]

#initialization
scene = canvas(width=600, height=600,align = 'left', background=vector(0.2,0.2,0))
scenev = canvas(width=600, height=600, align = 'left', fov = 0.01, background=vector(0.2, 0.2,0))


container = box(canvas=scene, length = 2*L, height = 2*L, width = 2*L,    opacity=0.2, color = color.yellow )

pos_array = -L + 2*L*np.random.rand(N,3)
theta = pi*np.random.rand(N,1).flatten()
phi = 2*pi*np.random.rand(N,1).flatten()
v_array = np.transpose(vrms*np.array([np.sin(theta)*np.cos(phi),np.sin(theta)*np.sin(phi), np.cos(theta)]))

def a_to_v(a):
    return vector(a[0], a[1], a[2])

for i in range(N):
    if i== N-1: atom = sphere(canvas = scene, pos=a_to_v(pos_array[i]), radius = 2*size, color=color.yellow)
    else: atom = sphere(canvas=scene, pos=a_to_v(pos_array[i]), radius = size, color=a_to_v(np.random.rand(3,1)))
    atoms.append(atom)
    atoms_v.append(sphere(canvas=scenev,pos=a_to_v(v_array[i]), radius = vrms/70,
                          color=a_to_v(np.random.rand(3,1))))
atoms_v[N-1].radius = vrms/30
atoms_v[N-1].color = color.yellow

vd_ball = sphere(canvas=scenev,pos=vec(0,0,0),radius = vrms/30, color=color.red)
x_axis = curve(canvas=scenev, pos=[vector(-1.4*vrms,0,0), vector(1.4*vrms,0,0)], radius=vrms/200)
y_axis = curve(canvas=scenev, pos=[vector(0,-1.4*vrms,0), vector(0,1.4*vrms,0)], radius=vrms/200)

vv = vector(0, 0, 0)
total_c=0
while True:
    t += dt
    rate(10000)
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pos_array += v_array*dt
outside = abs(pos_array) >= L
pos_array[outside] = - pos_array[outside]
vv += a_to_v(np.sum(v_array,axis = 0)/N)
#handle collision here

if int(t/dt)%2000 == 0:
        tau = 0                                   #find tau
        print(tau, vv/(t/dt), q*E*tau/m)
vd_ball.pos = vv/(t/dt)

for i in range(N): atoms_v[i].pos, atoms[i].pos = a_to_v(v_array[i]), a_to_v(pos_array[i])
```