**Problem:**

By Monte-Carlo method, calculate the mean distance that the fission neutrons fly till their first collision. Use an infinite system composed of a single fissile nuclide at a reasonable mass density.

Hints:

- Find the formula that gives the distance to the first collision (explained in Topic 4.3: Transition Kernel).

- You will need to locate the total microscopic cross section for specific neutron energy. For this, you need to download a table of cross sections for various neutron energies and program a script that locates the cross-section value for the nearest energy. You can download the cross-section tables e.g., from the JANIS database.

- In a loop, sample the energy of a fission neutron (use your code from Home Assignment 02 to do that), and for each sample locate the corresponding cross section and evaluate the distance to the nearest collision.

- Perform a simple sampling simulation to evaluate the mean distance that fission neutrons fly to the first collision. Collect at least several thousand samples and compute the **mean distance** and the **standard deviation** **of the mean distance**.

**Nuclear Fission:**

Each uranium-235 (U-235) atom has 92 protons and 143 neutrons, for a total of 235. The particle arrangement within uranium-235 is somewhat unstable, and the nucleus can dissolve if energized by an outside source. When a U-235 nucleus absorbs an additional neutron, it swiftly splits into two halves. This is known as fission. When a U-235 nucleus divides, two or three neutrons are released. As a result, the chance of starting a chain reaction exists.

The task at hand is to calculate the mean distance that the fission neutrons fly till their first collision. To accomplish the said task, I took into consideration a particular system mentioned before in the problem i.e., an infinite system composed of a single fissile nuclide at a reasonable mass density.

We know that transition kernel, , is the probability density function of the distance, , traversed by a neutron to next collision. To Perform a simple sampling simulation to evaluate the mean distance that fission neutrons fly to the first collision, I make use of the cumulative density function derived from transformation of the given probability density function.

Where, is the total macroscopic cross-section of a given nuclide. In addition to that, we assumed that the total macroscopic cross section is constant along the flight in between the two collisions.

Knowledge concerning the physics of the fission process is summarized in various nuclear data libraries such as JEFF, ENDF, or ENSDF. JEFF and ENDF list the cross sections of a wide range of nuclear reactions as well as the fission yields. ENSDF, on the other hand, is primarily concerned with nuclear structural data. We can find the distance, , to first collision of neutrons using the microscopic cross-section values collected from ENDF VIII including the incident neutron energies via the JANIS database. These data can be used to simulate the values of distances, , to first collision of neutrons by the help of cumulative density function and inverse transform of it.

Therefore, the cumulative density function of the transition kernel,

(Homogeneous material)

Let the generated random number be, which resides in the interval

From , we get

Therefore, we can make the subject of the equation shown above to obtain

Since the term is also a random number from interval (0, 1). We can rewrite as