Computational Modelling of the Rotamak

Johannes van de Wetering

31st January 2018

Fields Used in the Model

For $z^2 < z_s^2$:

$$\boldsymbol{B} = \left(B\omega\cos(\omega t) - 1/2\, x\pi Bm/zs\, \sin(\pi z/zs)\right)\boldsymbol{i}$$

$$+\left(B\omega\sin(\omega t) - 1/2\, y\pi Bm/zs\, \sin(\pi z/zs)\right)\boldsymbol{j}$$

$$+\left(Bm(1-\cos(\pi z/zs)) + B0\right)\boldsymbol{k}$$

$$\boldsymbol{E} = \omega B\omega(x\cos(\omega t) + y\sin(\omega t)\boldsymbol{k}$$

For $z^2 \geq z_s^2$ (escaped):

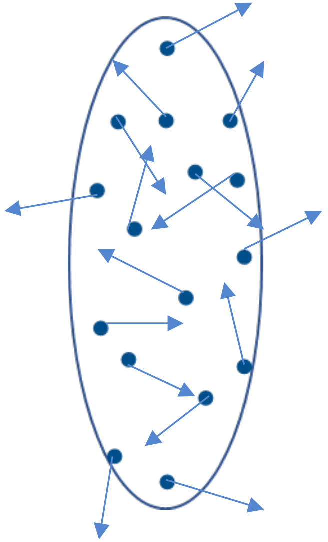
$$\boldsymbol{B} = (2Bm + B0)\boldsymbol{k}$$

$$\boldsymbol{E} = \boldsymbol{0}$$

Simulation Parameters

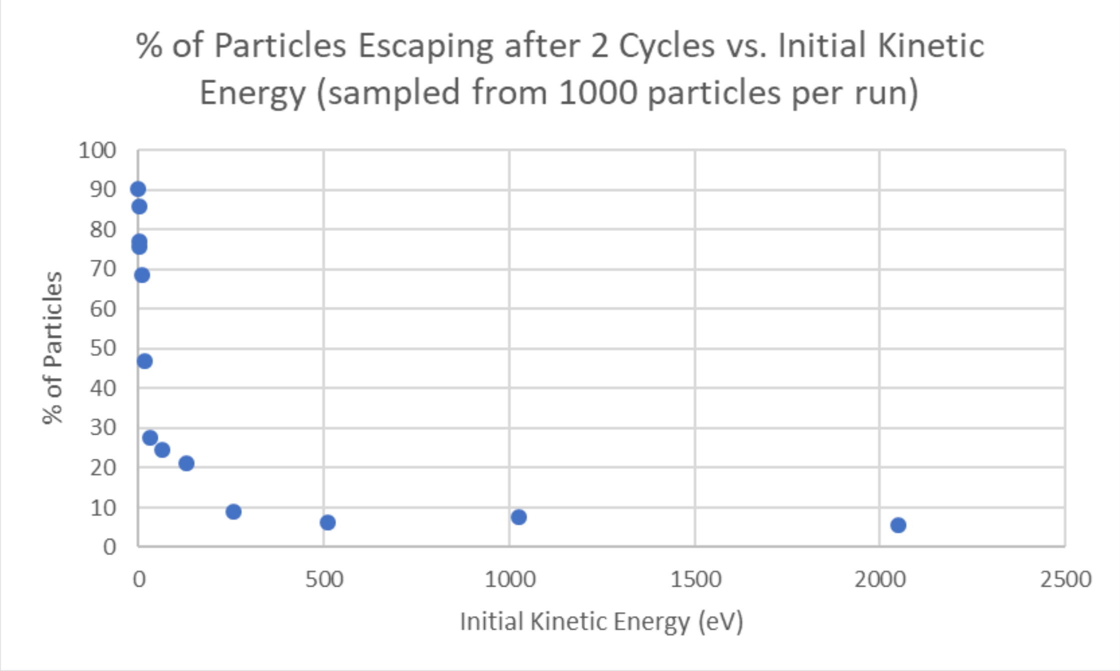
$B_\omega = 10$ Gauss
$B_0 = 200$ Gauss
$R_m = 10$ ($B_m = 900$ Gauss)
$\omega = 5\text{x}10^7$ rad/s
$n = 1\text{x}10^{19}$ m^{-3}
$\ln\Lambda = 10$
$r_s = 5$ cm
$z_s = 45$ cm
$\nu = n\pi e^4 \ln\Lambda / m^2 v^3$ (electron-ion collisions only)

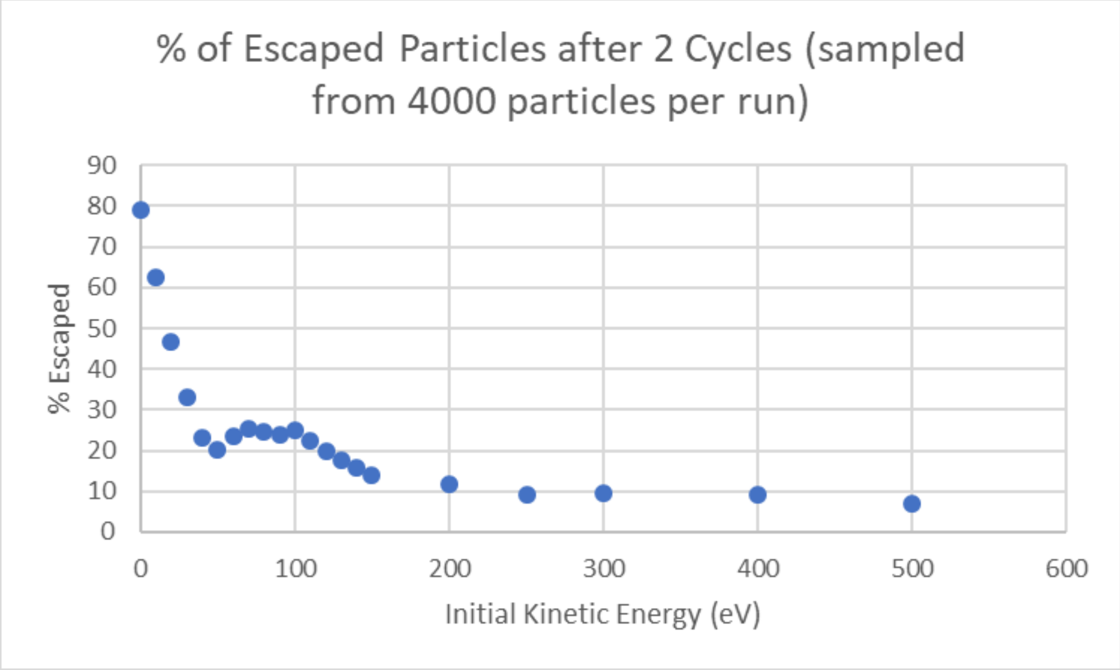
Electrons initialize with random positions on the z=0 disk (with radius r_s), and are given spherically distributed random velocities, all with identical energies.



Escaping Electrons

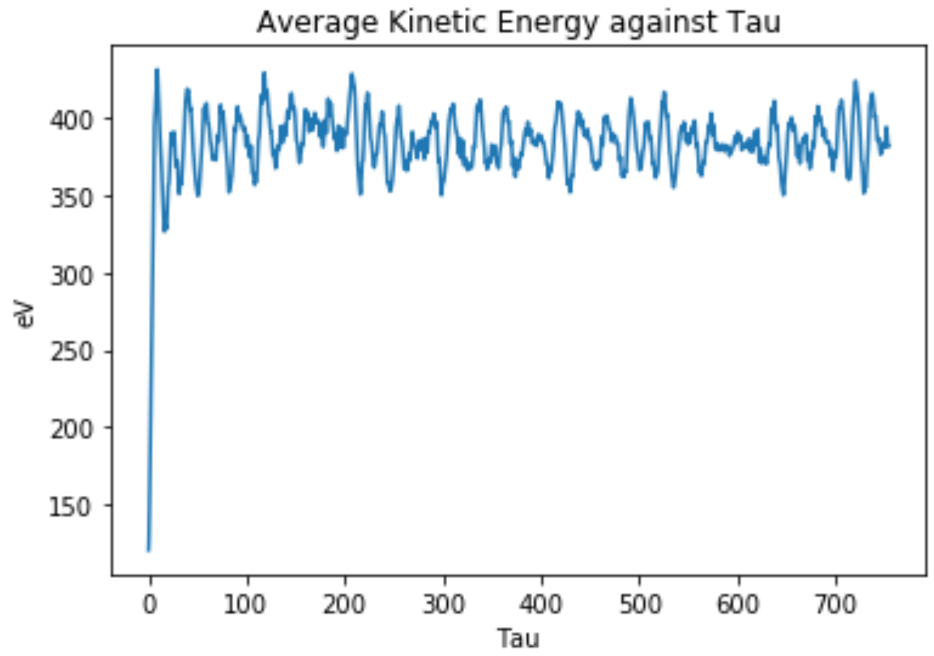
- Electrons starting with higher energies are far more likely to be trapped.
- Most low energy electrons escape only after two cycles of the Rotamak (~250 ns).

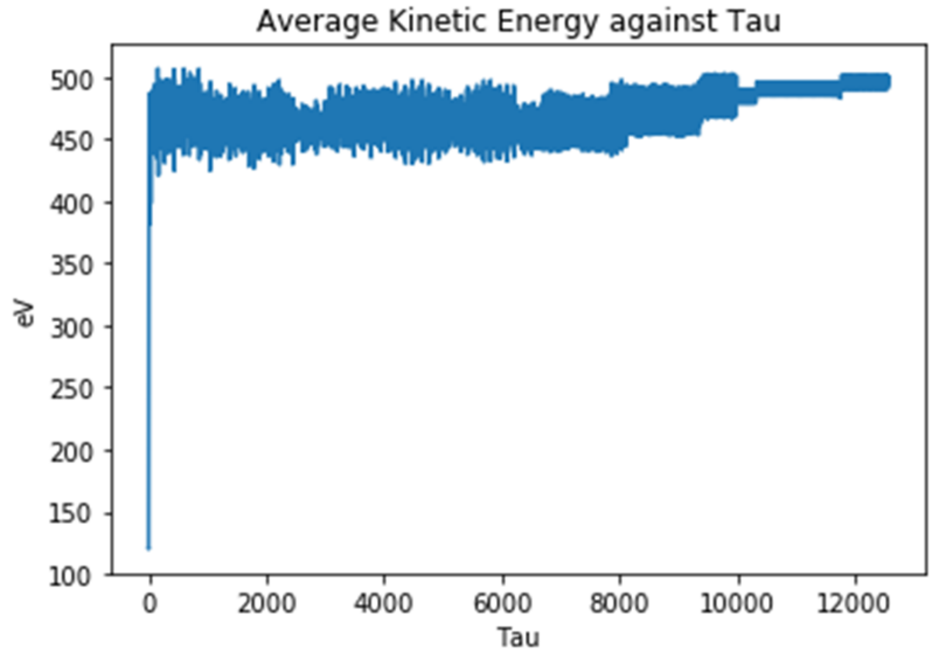




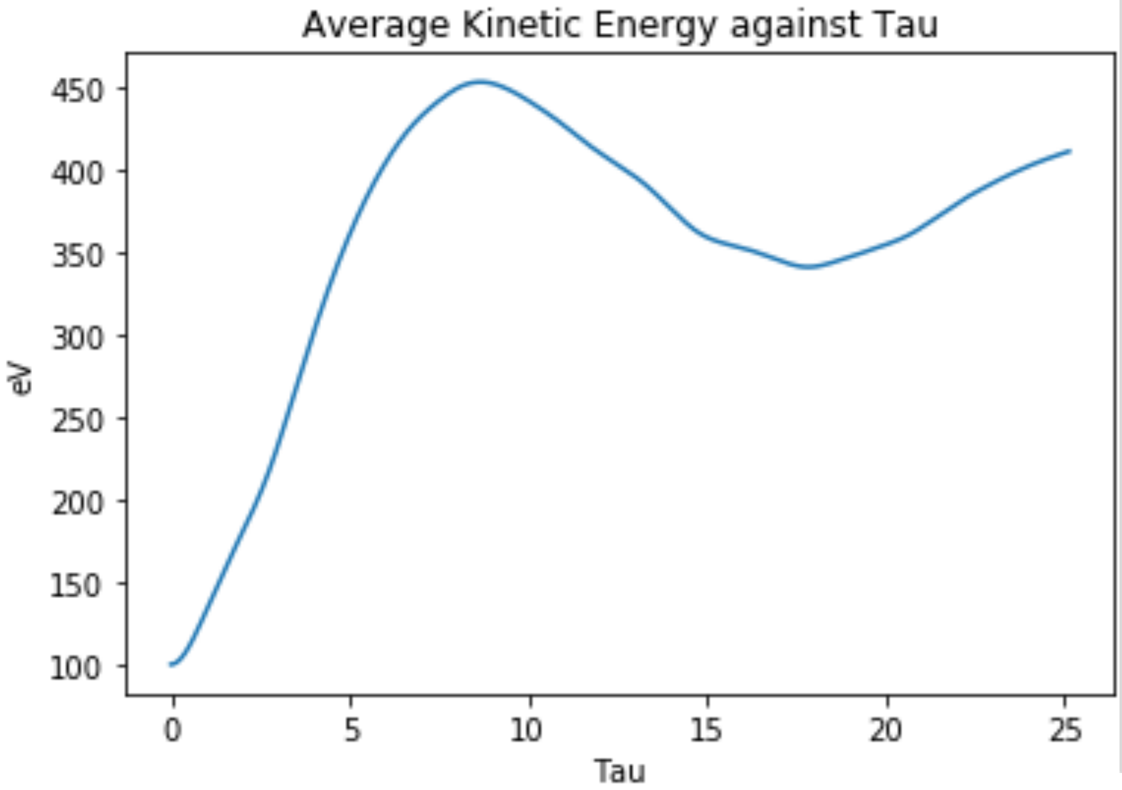
Electron Heating

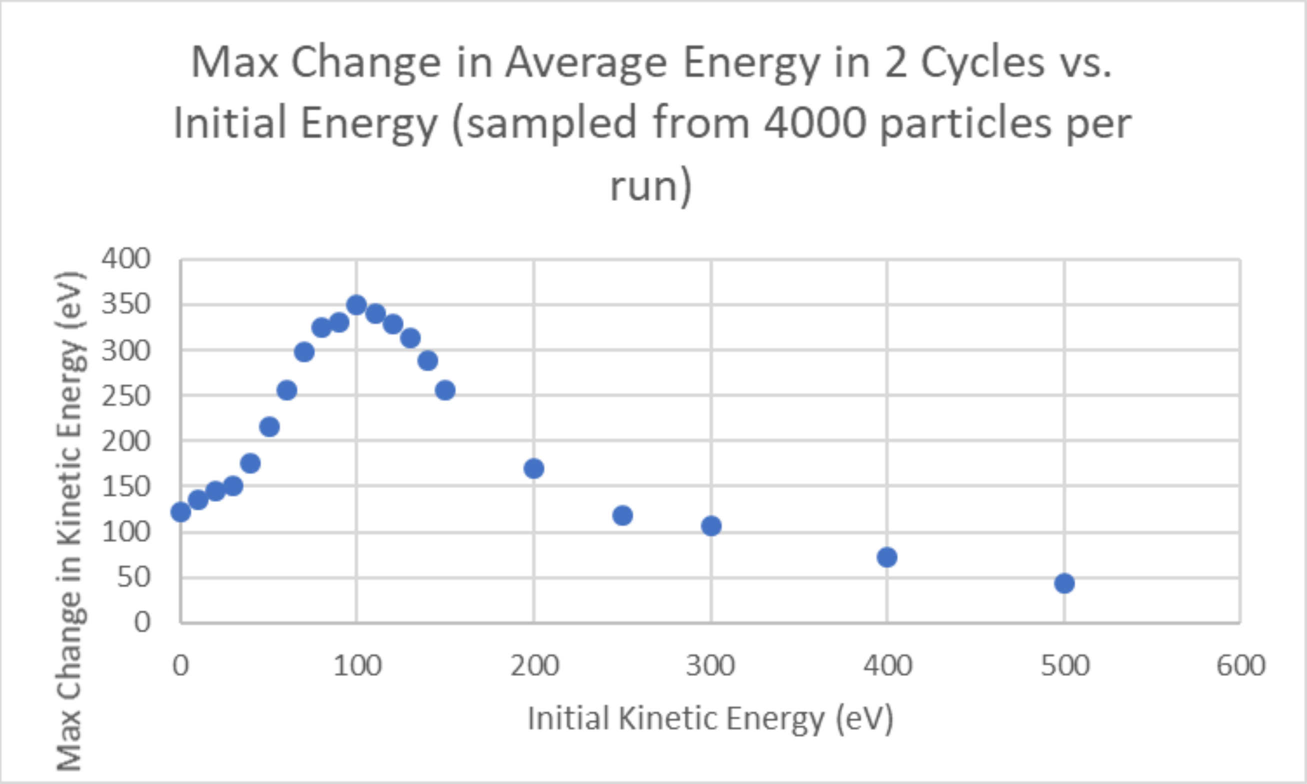
- Electrons initially under ~500eV heat rapidly within two cycles, and then level off.
- Further very gradual heating is due to scattering, taking around a quarter of a millisecond until most of the particles have escaped.





Heating Within the First Two Cycles





Future Work

- Find out how the heating rates change with the simulation parameters, especially with the value of B_{ω}.
- Initialize the particles outside of the bottle like in the machine.
- Find rate of energy dissipation via escaping particles.