In this project, we follow the popular theory of an early matter-dominated era (EMDE) that takes place after inflation but before the radiation-dominated era. During this time, we derive the final momentum distribution of collisions between relativistic leptons and non-relativistic dark matter particles.

**PARAMETERS**
- Initial and scattering angles: $\theta_i$ ($0, 2\pi$), $\theta_{CM}$ ($0, \pi$), and $\phi_{CM}$ ($0, 2\pi$).
- Masses: $m_X$ and $m_L$.
- Initial momenta: $p$ and $k$.

**DEFINITIONS**
Collision Term: $C$, the distribution, $f_i$, of dark matter particles is determined by the elastic scattering of the particles, $X$.
Collision Rate: $\Gamma$, the rate at which collisions between the dark matter particles and leptons occur.
Momentum Transfer rate: $\gamma$, the rate at which momentum is transferred between the two particles.

**MOTIVATION**
- Within an EMDE, the dominant particle during this time decays into radiation – the relativistic lepton.
- These leptons interact with dark matter particles, resulting in similar temperatures as defined by their momentum distributions.
- Once the interactions between the two particles decrease, a phenomenon called decoupling - the temperatures of the two particles diverge.
- The decoupling processes during an EMDE are complicated due to the presence of the relativistic leptons, which requires us to numerically simulate individual dark matter interactions.
- I am revisiting the scattering rate - derived from previous work - to find their final velocity distribution. This will help predict inhomogeneities within the structure of the Universe.

**CONCLUSION**
Compared to previous work by Charlie Mace in his thesis Simulating the Thermal Evolution of Dark Matter During an Early Matter-Dominated Era, there is a discrepancy of many orders of magnitude. Throughout the process of this work, there were a few inconsistencies. Most of these inconsistencies were different constant factors, however, there was a large disparity in the calculation of the collision operator integral. Further comparison to other studies of similar work must be done to converge on a final value for the collision rate of these interactions.

**FINDINGS**
- Using the final momenta of the particles, the collision rate of the interaction was derived.
- This rate is dependent on all the parameters mentioned earlier.
- Using the final momenta of the particles, the collision rate of the interaction was derived.
- The above value is used as it is in terms of the momentum transfer rate, $\gamma$. Once we have calculated $\gamma$, we can also calculate the time of decoupling between the particles and the resultant final velocity distribution of dark matter.