* Good morning, my name is Aditya Kendre and this is my 4th year presenting at PJAS
* Over the past few months I have been researching approaches to identify collisional asteroid families in the Kuiper belt
* What is a collisional family?
* Kuiper belt – a disk shape collection of asteroids containing KBOs (or Kuiper Belt Objects)
* 50 AU
* Since the Kuiper Belt is densely populated, many catastrophic collisions occur creating more objects
* This is a collisional family, a group of objects originating from 2 or more common parent bodies
* Most researchers have overlooked this area of the Kuiper belt, and new techniques such as deep neural networks and clustering algorithms have not been applied
* In this research project I will be the Haumea asteroid collisional family and if it can be distinguished from the background objects in the Kuiper belt, and which clustering techniques and/or algorithms are the most efficient in identifying the Haumea family? And can these techniques be used to distinguish other families?
* I think that Collisional families located will be able to be distinguished from background objects in the Kuiper belt, and the Hierarchical Clustering method will be the most efficient way in distinguishing the Haumea asteroid collisional family from the background objects in the Kuiper belt.
* The identification of collisional families are mainly divided into 3 main parts
  + Achieving the data needed to run the algorithms
  + Computation of the algorithms
  + Analysis of the algorithms
* In Proper Orbital Elements Calculations, one uses data from datasets such as the Sloan Digital Sky Survey to calculate universal positional values of an objects orbit
* We then plot the Proper Orbital Elements to understand the dataset and visualize any abnormalities or clustering without doing any analysis
* K-means Clustering Algorithm and Hierarchical Clustering Algorithm are both crusting commonly used in machine learning to identify clusters in large datasets.
* Lastly, Result Analysis requires analysis of the algorithm’s results. Comparing the differences between each algorithm
* There are 2 types of elements that are used to describe KBOs. Orbital elements and Proper elements, I am using Proper elements because they are adjusted for change over time, they are the average movement of orbital elements over a period of time.
* The 3 main proper elements are…
  + ‘a’ which is the semi-major axis of the orbit, this measured in au
  + ‘e’ which is the Eccentricity of the orbit, which are values between 0 and 1 describing the ovelness of the orbit
  + ‘i’ which is the inclination of the orbit, this is measured in degrees
* These calculations of proper elements takes a lot of core computing power, which I do not have aces too
* Therefore, there are datasets online that have already calculated these values
* This is an example of the dataset
* These are plots of the proper elements graphed against each other
* The various clumps that are seen thought each graph are due to the dynamical "sculpting" by Neptune
* Sculpting basically means that they are affected by Neptune’s gravity in specific ways such as resonances
* Resonances are those horizontal lines that can be seen in graphs that have plotted ‘a’
* These lines are caused when the ratio of an object’s orbit and the orbit of Neptune match up, and the object becomes synchronized with Neptune’s gravity.
* The K-means algorithm is a center based algorithm, the number of clusters (k) are predefined. The clusters start out at random positions on the graph, the clusters are then moved to and adjusted until each object’s distance from the cluster’s center is the closest to itself. This iteration is repeated until all objects are located in the cluster closest to their position.
* This method looks promising; however, taking a closer look, many clusters are are just common groupings loosely based on the distance from objects. Hence, most clusters are just created by random chance. This can bee seen as many members of the Haumea family are scatter around in different clusterings.
* The Hierarchical Clustering Algorithm is based on the idea that objects closer in distance are more related than others that are farther in distance. Each point essentially becomes the center of its own cluster and from there, the closest point to if becomes apart of the cluster.
* The top 100 objects with the least dV are displayed to the right. This graph represents how scattered the Kuiper belt is and how difficult it can be to find collisional families. Using this algorithm, no member of the current Haumea family were found. This implies that additional analysis is needed to identify collisional families.
* In the end I found that in the current state of this project, have I rejected my Hypothesis as there has been no clear distinction of the Haumea family. Although some results did look promising, in that they did include some members of the Haumea family, the rest of the cluster had objected which had no relationship with the family.
* In the upcoming months I will be trying to run the Hierarchical clustering algorithm with more objects and more iterations, this will need more computing power.
* Furthermore, more data is need with additional objects to make connections with other objects for a greater chance of finding family member of a collusion.