Project Proposal: Analyzing the Redshift of Type Ia Supernovae in Distant Galaxies to Calculate Hubble's Constant

Katherine Mora

1. **Introduction:**

In the following proposal, methods used to collect and analyze data to calculate the rate of expansion of the universe will be overviewed. This project will involve generating data for significantly redshifted spiral galaxies at varying distances, comparing the redshifted hydrogen spectra of galaxies with known unshifted spectra of hydrogen and, and calculating the current Hubble's constant, H_0, from the observed data. In addition to data analysis, systematic error will be discussed as well.

2. **Chosen phenomenon and Data Source:**

For the purpose of this project, the rate at which the distant galaxies are receding due to the expansion of space, otherwise known as Hubble's Constant, will be measured. To calculate Hubble's constant, the redshifts of type Ia supernovae in distant galaxies will be analyzed in comparison to known spectra of elements like hydrogen. Data on distant galaxies will be collected from NASA/IPAC Extragalactic Database and IRSA: Finder Chart (caltech.edu).

3. **Equations to Fit Data:**

The Hubble-Lemaitre Law will be used to calculate Hubble's constant from the observed redshift and distance of the galaxy. The Hubble-Lemaitre Law is as follows: $v = H_0 d$. v being the observed velocity at which a galaxy is receding at; it can be found by taking the difference in hydrogen wavelengths (redshift) divided by the control wavelength of hydrogen, and all multiplied by the speed of light. If the distance is unknown or not given by the data source, it can be calculated if the size of the galaxy is known. The distance is simply the size of the galaxy divided by the angular size that the galaxy appears to be in the data. The measurement of galaxies will be performed using a consistent method of measurement.

4. **Data Generation for Testing:**

In addition to the data that will be used from the sources mentioned above, mock data will be generated to test the filtering and overall performance of the model. This will ensure that there are absolutely no outliers that are too close to the location of observation to skew the results. The test data may be generated from Python's NumPy library, where different spectra for mock type Ia supernovae can be analyzed with different redshifts.

5. **Data Filtering:**

Only type Ia supernovae in spiral galaxies with sufficient distance between the observation points will be considered useful for the purpose of this project. The objects used must fit the following criteria:

a. Galaxies considered to be too close will be removed from relevant data.
b. Type Ia supernovae in elliptical galaxies will also be removed from usable data.
c. Supernovae must be type Ia since they are considered to be standardizable.

Any data that fits within these categories but is still considered an outlier for any multitude of reasons will thus be removed from any usable data.

6. **Data Fitting with Error:**

The model to fit the data depends on the range of objects that are chosen. The model will take in data and determine the distance in megaparsecs (Mpc) and recession velocity (km/s) (calculated from redshift). Ultimately the final result from the model should have a linear relationship between the distance (Mpc) and recession velocity (km/s) which gives a slope with the magnitude of Hubble's constant. Statistical error analysis methods will be used to provide confidence intervals and the maximum and minimum error values of the derived value of Hubble's constant.

7. **Explanation of Model Fit:**

Once the data has been fitted with the model, an explanation about the implication of the value of Hubble's constant in relation to the age and shape of the universe given only the information from this project will be provided. Hubble's constant is inversely proportional to time, which means that the age of the universe could be derived knowing this correlation. Additionally, if the rate of expansion of the universe is increasing then some predictions about the universe on a large scale could be considered.