PHY 494: Final Project Proposal

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Problem

The extrasolar object "Rama" is entering the inner solar system. Its trajectory appears to be hyperbolic as it is using the Sun as a gravity assist to be redirected out of the solar system along a new trajectory. While on its way to encountering the Sun, it has the potential to collide with Earth and cause devastating havoc and destruction. Being provided its current position and velocity we need to determine what kind of threat Rama poses to the planet Earth and if action should be taken to try and redirect the object during its approach. The math of Newtonian mechanics and Keplerian orbits will be used to model what scenarios could play out as the object draws near. Specific equations include:

$$\theta = cos^{-1}(-1/e) \text{ and } e = -1/cos\theta$$

to determine the angle of approach and departure of Rama about the Sun.
Newton's law of gravitation will be used in modeling Earth's orbit around the Sun.

$$F = \frac{GMm}{r^2}$$

Angular velocities of the object and Earth will have to be considered as well.

$$v(r) = \sqrt{\frac{GM}{r}}, \ \Omega(r) = \frac{v(r)}{r}$$

A final consideration will be the orientation of the solar system during this time in its history, the "epoch time." This will be done to analyze where planets (such as Earth) will be in relation to each other. There are many epoch reference times to work with, we will be using data provided by NASA for our reference frame. We find this analysis1 important for being able to study any kind of Near Earth Objects (NEOs) and because "Ramans always do things in threes."

Approach

Being provided observations of Rama, its mass and velocity are initially known (via Arthur C. Clarke). Using the equation listed for the angle of approach and departure of Rama, the object's hyperbolic orbit will be determined. Knowing this orbit the consideration of the Earth's position in the Solar System during this time will be taken into account to assess what threat Rama poses (for this scenario, a VERY likely threat). Velocity verlet algorithms will be used to map out the position of Rama and Earth and will be used with force calculation on each object from the Sun. The initial position of the inner solar system will be provided by NASA: http://ssd.jpl.nasa.gov/?ss_inner to orient the Earth in the correct position at the beginning of this scenario. Input parameters will include the mass and velocity of Rama (mentioned above), as well as the mass and velocity of the Earth and Sun. Also gotten from NASA:
Earth: http://nssdc.gsfc.nasa.gov/planetary/factsheet/earthfact.html
Sun: http://nssdc.gsfc.nasa.gov/planetary/factsheet/sunfact.html
The parameter most important will be the initial velocity and position of Rama. The initial parameters of the Earth and Sun will be known but not as much can be done in regards to altering their trajectory. An additional consideration to this scenario is listed under "Objectives" that considers a retaliation plan to alter Rama's hazardous trajectory.

Objectives

1. Initialize and propagate a simple model of the inner solar system, specifically considering the Earth and its position relative to the Sun.
2. Use observations of Rama to predict an accurate trajectory (entry and exit) through the inner Solar System.
3. Plot out relative position of both Earth and Rama over time to analyze the potential collision.
4. Calculate the relative distance between Earth and Rama over time.
5. *Potentially Extra* Finding that Rama will collide with Earth, send a ship to apply an opposite force to Rama, slowing it down. This will give vital time for Earth to pass out of the… Danger Zone.
6. *Potentially Extra* If only considering Earth, Sun, Rama is too simple, include Mars, Venus, Mercury in scenario for analyzation.