Planetary Travel via Hohmann Transfers

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ABSTRACT

Space travel is an event that has evolved over the last half a century, and still has hurdles in the way of future advancement. One of the hurdles is the amount of energy that it takes to maneuver about the Solar System. Hohmann transfers can be used to solve this problem because they are made using the least amount of energy. Looking at traveling in our own Solar System, assumptions have to be made in the orbits of the bodies considered. With these assumptions in place it is possible to calculate the conditions for Hohmann transfers and the orbits or the transfer.

The key to Hohmann transfers is that they use the planetary orbits to propel the spacecraft into an orbit of its own. For the purpose of the program, the assumption of planar, circular planetary orbit were applied to the calculations. This is a big approximation because the planets in the solar system orbit the sun in elliptical orbits instead of circular orbits. The resulting transfer orbit of the spacecraft is an ellipse. Using Kepler's Third Law:

T=pi*m/(2k)*a^1.5

where m/k=7.53E-21 s^2/m^3 and 'a' is the semi-major axis of the ellipse of the spacecraft, we can also calculate the time for a specific transfer to take place. For the program to make these calculations, it uses the distance that the departure planet is from the sun, call it 'd', and the distance the destination planet is from the sun, call it 'D'. The sum of these distances divided by 2 gives 'a'. To calculate the velocity necessary for the transfer is calculated by:

vt=SQRT(2*d/(d+D))*v
v=SQRT(k/(m*d))
del v=vt-v

where del v is the difference between the planet's orbit speed, v, and the spacecraft's transfer speed, vt.If the destination planet is closer to the sun than the departure planet, then the transfer speed will be negative because the spacecraft has to leave the planet the opposite direction of the planet's orbit. The purpose of this thrust is to change to eccentricity of the orbit, but keep the same angular momentum. Using PGplot, graphs of the orbit the spacecraft will take can be generated. In the plot, the dimensions of the transfer ellipse can be seen.

The program created uses an interactive interface to collect the necessary inputs, such as the planets distance from the sun. From these distances, everything else we need to calculate the time needed for transfer and the path taken can be determined. To generate the plot of the orbit the spacecraft would undergo, one hundred and one points are used based as a percentage of the semi-major axis, a. This was done in order to efficiently plot the orbit even though the ranges from plot to plot can vary greatly from one transfer to the next.