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A DESCRIPTION OF THIS RESEARCH EFFORT AND ITS NUMERICAL COMPUTATIONS

It has been discovered that planetary perturbations can play an important role in designing interplanetary free-fall trajectories for space vehicles. For example, missions to Mercury normally require very high launch velocities. If instead of going directly to Mercury we have the vehicle pass Venus such that its gravitational influence causes the vehicle to intercept Mercury, the required launch energy can be reduced over 200%. !!!!! negative energy?? Launch opportunities for missions to Mars occur once ever 780 days. These opportunities can be more than doubled by also utilizing the launch opportunities for flights to Venus and having Venus send the vehicle to Mars. Moreover, it has been discovered by previous calculations that a manned Mars landing mission can be accomplished in 1970 or 1972 by employing the Saturn - 5 launch vehicle which is being developed for the Lunar mission. All of these facts were discovered by previous calculations at the U.C.L.A. Computing Facility.

The aims of the new calculations are to numerically analyze the possibility of employing planetary perturbations to reduce required launch energies and flight times for the following three types of missions:

1) solar probes
2) out of ecliptic probes
3) probes to Saturn, Uranus, Neptune and Pluto

The perturbating planets will be either Venus or Jupiter. The numerical analysis will cover all Earth-Venus and Earth-Jupiter launch opportunities from 1967 to 1977. Each launch period will be broken up into ten launch dates with four day intervals. For each launch date several Earth-Venus or Earth-Jupiter transfer trajectories will be calculated having flight times centered about the optimum (least energy) flight time for that particular launch date. For each flight time various distances of closest approach will be given. For each specified distance of closest approach, the approach trajectories yielding extreme values for the post-encounter trajectories

1) eccentricity
2) semi-major axis
3) inclination
4) perihelion distance
5) aphelion distance
6) velocity (just after encounter relative to sun)
7) maximum distance above ecliptic plane
8) maximum distance below ecliptic plane
9) angular momentum

will be calculated.

If $\vec{V_1}$ and $\vec{V_2}$ represents the vehicle's velocity vectors as it enters and leaves the gravitational influence of the planet then $\vec{V_2}-\vec{V_1} = 2\vec{V_p}\cdot(\vec{V_2}-\vec{V_1})$ where $\vec{V_p}$ denotes the planet's velocity vector when the vehicle makes its closest approach. Specifying the transfer trajectory determines $\vec{V_1}$. Thus this necessary equation permits only ~~to~~ two of the three components of $\vec{V_2}=(x,y,z)$ to be independent. Also By specifying the distance of closest approach, only one component can be independent $y=y(x)$, $z=z(x)$. In this case the functions $\frac{de}{dx}, \frac{da}{dx}, \frac{di}{dx}, \frac{dp}{dx}, \frac{dA}{dx}, \frac{dV_2}{dx}, \frac{d(\text{max ht})}{dx}, \frac{dh}{dx}$ can all be determined. By multiplying these functions together we obtain a new function $F(x)$. The zeros of $F(x)$ then yields values for $\vec{V_2}$

which will give extreme values yielding the desired results. The vectors $\vec{V}_1$ and $\vec{V}_2$ then determines the proper approach trajectory. The elements of the post-encounter trajectories are also calculated.

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