

MARINER MARS '69 CELESTIAL MECHANICS EXPERIMENT

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Abstract. Spacecraft tracking data can be used to determine some parameters of importance to recent developments in celestial mechanics. Integrated Doppler data are available from both Mariner VI and VII. These data are phase coherent and are accurate to two one thousandths of a cycle at S-band over a 10 min integration time. In terms of a range rate error this is better than 0.2 mm/sec. Round trip range data are also available. They are accurate to 100 nsec in absolute accuracy and have a random error component of about 30 nsec, or about 4.5 m in one-way range.

Only data near the closest approach of the spacecraft to Mars are capable of yielding information on that planet, but other data are useful for investigations into the ratio of the masses of the Earth and Moon, the ephemeris of the Earth, and both orbital and propagation effects of general relativity. For purposes of this conference, however, the only results reported are those which pertain directly to Mars.

The problem in using the Mariner VI and VII encounter data is that significant non-gravitational forces were acting on the spacecraft.

On Mariner VI, the trajectory was essentially a gravitational one until about 35 minutes before closest approach when the system to cool the infrared spectrometer was turned on. This system expelled hydrogen and nitrogen gas through a Joule Thompson cryostat and as a result imparted a thrust on the spacecraft of something on the order of 100 dyne, or a total velocity change in the trajectory of about 0.2 m/sec. Unfortunately the system did not operate properly on Mariner VI; it is known that the thrusting from the infrared system occurred over a period of about six days after encounter. In normal operation, the thrust level would decrease to an insignificant level after a few hours.

On Mariner VII, the infrared cooling system worked properly but an unknown event which occurred some 5 days before encounter imparted a thrust to the spacecraft for at least several days prior to closest approach.

There is a possibility, in fact, that a thrust was applied to the spacecraft for several weeks after encounter. Combining this effect with the normal thrusting from the infrared system, makes the scientific analysis of the Mariner VII tracking data a near impossibility.

Despite these difficulties with Mariner VII, some interesting results have been obtained with Mariner VI. For example, the universal gravitational constant times the mass of Mars GM_{Mars} has been determined from the acceleration on the spacecraft as it approached the planet. The best value of GM_{Mars} is $42\,828.3 \pm 1.0$. Also, by combining the range data from Mariner VI with data from the radar range measurements of Mars obtained by R. Goldstein this year at Goldstone, California, it has been possible to prepare a topographical map of Mars between 3° and 12° north latitudes. This map predicts that the immersion of Mariner VI into earth occultation should occur at a point on Mars which is 3393.6 km from the center of the planet. An independent calculation of this distance by A. Kliore, who used the Mariner VI occultation data, is in excellent agreement with the calibrated radar topography.