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# NEWS RELEASE

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## MARINER II DEEP SPACE TELECOMMUNICATIONS

Two major telecommunication activities were in process curing the Venus encounter of 1962. The first, and by far the largest, activity involved the two-way communications and tracking of the Mariner spacecraft from the DSIF stations on the earth. The DSIF includes stations at Goldstone, California; Woomera, Australia; and Johannesburg, South Africa.

The second activity involved an earth-based radar which reflected signals off the planet Venus during the same month that the Mariner spacecraft was traveling toward the planet.

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Communications between the Mariner spacecraft and the DSIF on the earth have resolved several questions of considerable importance of future deep space exploration. It is now known that reliable deep space communication to and from spacecraft is possible within the solar system, certainly to distances of 53 million miles, without significant disturbing effects from space itself. We now know that extremely precise tracking is practical in deep space, particularly the radial velocity of the spacecraft from the earth, and have demonstrated that on the order of one-tenth of an inch per second in radial velocity can be measured to distances of at least 53 million miles. Radial velocity is the velocity of the spacecraft away from the earth.

By the technique of using directional antennas on fully-stabilized spacecraft and extremely sensitive equipment on the earth, it has been proved possible to acquire great quantities of data during the long deep space flights. The Mariner II flight resulted in accumulation of some 65 million bits of information with an accuracy of at least one percent and yet with the use of only three watts of radio frequency power.

A new technique for precise synchronization of telemetry and communication channels using pseudorandom codes successfully demonstrated that precise synchronization is possible using only very low powers.

The Mariner flight also demonstrated the utility of the basic design of the DSIF as a world-wide network of co-operating stations which can keep continuous, 24-hour a day, contact with the spacecraft, transmit the data to California, and have it available to experimenters in a relatively short time. Some 85 percent of the data transmitted from the spacecraft was available to the experimenters within one hour of reception at the earth and some 98 percent of the data was accurately recorded for future use.

The Venus radar experiments were made from a station at Goldstone, California, which used an 85-foot antenna, 13 kilowatts of radiated power, a frequency of 2388 mc/s, a maser receiving system, and several unique detection and data reduction equipments. The 1962 experiment was based upon an earlier experiment in March 1961. The previous experiment had established that the reflection coefficient was remarkably high, nine to eleven percent, making Venus a bright object for a radar.

The surface was shown to be rough at wavelengths of six inches by cross-polarization measurements. The average dielectric constant of the surface material was similar to that of sand or dust.

The earlier experiment had resulted in a determination of the astronomical unit as 92,956,200 miles plus or minus 300 miles. The least certain of the previous experimental results concerned rotational rate, the results indicating a probable slow rotation rate and suggesting that Venus quite possible kept essentially the same face toward the sun at all times.

The Venus radar experiment in 1962 quickly reconfirmed the radar value of the astronomical unit, the reflection coefficient, and the slow rotation rate. Refinement of the astronomical unit will take further measurements over succeeding years because the principal remaining error is caused by limitations in the accuracy of the heliocentric orbits of Venus and of the Earth-Moon system. The distance to Venus and its radial velocity with respect to the Earth were, however, readily checked with accuracies of better than 100 miles and better than three inches per second, respectively.

The 1962 experiment therefore concentrated on the rotation rate which is now given as 230 plus or minus 40 to 50 days, retrograde. (225 days retrograde is defined as non-rotating in Venus-based inertial coordinates.) The fact that the rotation is very slow is now definite and is confirmed by at least four different measurements. The first, doppler smearing of the signal by the rotation of the planet, is the measurement used in 1961 and repeated with improved sensitivity in 1962. The second type of measurement shows that the signal strength varies comparatively slowly with time a characteristic which would be expected if the radar was observing essentially the same face of Venus for long periods.

In 1962, it was also possible to "slice" the planet in 100-mile range increments and then to observe the doppler shifts in each of these range increments. The observed doppler shifts confirmed the slow rotation rate.

Perhaps the most novel measurement involved watching a bright reflecting spot moving across the face of the planet. The motion was observed as a change in the shape of the spectral return from the planet, appearing as a small hump moving from close to the center in early October toward the outside as the months went by.

Converted to angular rotation of the planet, the apparent angular velocity corresponds to a sidereal rotation period of over 1,000 days forward or 230 plus or minus 40 to 50 days retrograde. The 1,000 days forward can be rejected because it leads to spectral bandwidths of about 20 cycles per second for periods of several weeks before and after conjunction, and such a narrow bandwidth was not observed. Also, if the position of the spot is extrapolated back to 1961 and the data from the 1961 experiment is studied, the spot is apparently missing at the location corresponding to synchronous rotation and possibly evident on the side of the planet corresponding to 230 plus or minus 40 days retrograde. Thus, on Venus, a fixed star would not appear to rotate and the sun would rise in the West and set in the East. Studies of the change in spectrum spreading with time, sensitive to the direction of rotation, also appear to confirm the retrograde direction of motion. All conclusions assume that the axis of rotation of Venus is perpendicular to the radar line of sight from the earth.

However, the direction of rotation of the planet Venus is the least definite of the measurements made during 1962. It is conceivable that libration or wobble of the planet could confuse the observed data.

The total period during which Venus was observed in only a fraction of the Venus year. In the near future, with more sensitive equipment, it should be possible to establish the direction of rotation of the planet with the same certainty as the other data.

Measurements were also made on the Faraday rotation of the plane of polarization of the radio wave. Equipment sensitivity resulted in the measurements being fairly noisy, but the general result appeared to be that the Faraday rotation observed due to the signal traveling from the Earth through the Earth's ionosphere to the Venus surface and return was not significantly different from that due to traveling through the Earth's ionosphere.

This suggests that the product of ionization and magnetic field in space and around Venus is relatively low. Such a result is consistent with the Mariner magnetometer observation that the magnetic field of Venus, if any, is very low, and with the radar determination of slow rotation rate implying a low magnetic field.

As has been recently announced, the Goldstone station has also made radar contact with Mars. To do so required the use of a 100,000-watt transmitter and the use of integration times of at least 15 hours. Spectral measurements of the reflected signal from Mars are quite difficult at the signal-to-noise ratios encountered. In contrast to Venus, Mars is a poor reflector and its rotational speed produces a very evident spectrum spreading. In contrast to the spectrum spreading of Venus which is on the order of a few cycles per second, the Mars spectrum spreading is on the order of 400 cycles per second. Such spectrum spreading by a planet known to be rotating helps confirm the experimental technique used to determine the slow rotation of Venus.

Mars thus is several thousand times more difficult to detect and analyze than Venus. Because the characteristics of the Venus reflection are so stable, the experimenters are now using Venus as a calibration target for comparison with Mars.

It is expected that Mercury will be added to the list of targets observed by Goldstone at the next opportunity in a few months.

The results were reported by Dr. E. Rechtin of the Jet Propulsion Laboratory, Director of the NASA JPL Deep Space Instrumentation Facility.

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