UNIQUE ASPECTS OF THE ULYSSES MISSION*

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Abstract

The primary goal of the Ulysses mission is exploration of the polar regions of the sun. This mission is a joint project between NASA'S Jet l'repulsion laboratory and the European Space Agency. The Ulysses spacecraft is now traveling south out of the ecliptic plane, the plane in which the planets orbit the sun. As of September 28, 1993, its latitude with respect to the equatorial plane of the sun is -40.16 degrees and with respect 10 the ecliptic plane -33.01 degrees. In 270 days the space.craft will reach -70 degrees solar latitude, when it will begin the south solar pass. Ulysses observations will focus on the sun's magnetic field, solar wind, cosmic rays and energetic charged particles.

Some aspects of the Ulysses mission arc. unique. This paper provides a mission chronology and talks about unique aspects of both the trajectory design and Ulysses flight events.

The Ulysses spacecraft was injected into a direct Earth-Jupiter transfer orbit on October 6, 1990. A diagram of its resulting interplanetary trajectory is shown on Fig. 1. This is a view from ?0 de grees above the ecliptic plane. The first leg of Ulysses' trajectory took the spacecraft to Jupiter. The closest approach to Jupiter occured at 12:02 universal time (11'1') 011 February 8, 1992, 16 months after launch. Jupiter's gravity c.hanged the Ulysses trajectory so that, when the spacecraft left Jupiter, it was descending south of ecliptic and setting its course below the sun'ssouthern pole'.

Nominally the first high latitude solar pass will begin when Ulysses reaches 70 degrees south solar latitude on June 26, 1994. Ulysses will spend about four months, 132 days, above that latitude, climing to its maximum at 80.2 degrees on September 13, 1994. At this point the spacecraft is 2.3 AU, 344×10^6 kilometers (21 5 x 106 miles) from the sun. The south solar pass ends when the spacecraft again reaches '70 degrees south solar latitude, which is on November 5, 1994.

Ulysses will then continue its course, climbing to the sun's equatorial plane to reach perihilion at the distance of 1.3 AU on March 12., 1995. This distance is the minimum distance to the sun on the post-Jupiter trajectory leg. Ulysses was actually closer yet to the. sun (1 AU) while sitting on Earth prior to launch.

The three-month-long pass over the sun's north pole begins on June 19, 1995, and ends on September 29, 1995. Ulysses will spend 102 days in this region at the. distance of 2 AU, 299×10^6 kilometers (187 $\times 10^6$ miles) from the sun. It will reach the maximum latitude of 80.2 degrees on July 31, 1995. Plots and tables of Ulysses' post-Jupiter primary mission characteristics arc documented in Ref. 3.

In order to obtain sufficient energy to reach high solar latitudes the design of Ulysses' trajectory depended on a gravity-assist from Jupiter. The immensly powerful gravity of this planet was used to rotate Ulysses's orbit nearly 80

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degrees with respect to the ecliptic plane. Such a large change in orbit inclination, achieving an orbit almost perpendicular to the ecliptic plane, is certainly unique and places this Jupiter flyby among the most impresive gravity-assist applications in the history of the, space program.

The Jovian flyby provided not only a way 10 get the desired trajectory, but also an additional opportunity to obtain valuable scientific results that confirm alld complement earlier observations of complex and dynamic phenomena in Jupiter's magnetosphere. Changes in size of the magnetosphere were confirmed. Also, it was revealed that the solar wind has a much stronger impact on Jupiter's magnetic field than was previously thought. Magnetic field lines arc being peeled away from the. Jovian magnetosphere by the solar wind, causing high-latitude components to flow out into interplanetary spat.c, rather than return to Jupiter.

in the Jovian vicinity, the Ulysses spacecraft penetrated and probed the density of the 10 plasma torus, which was found much less homogeneous than anticipated. The spacecraft observed variations in density al diffc.rent latitudes and found five bright radio sources that were distributed along and rotating with the torus.

Ulysses is the first spacecraft that probed the dusk side of Jupiter. During measurements taken in the dusk sector of the Jupiter's magnetosphere, a Jovian aurora was observed as beams of particles strc aming along the magnetic field.

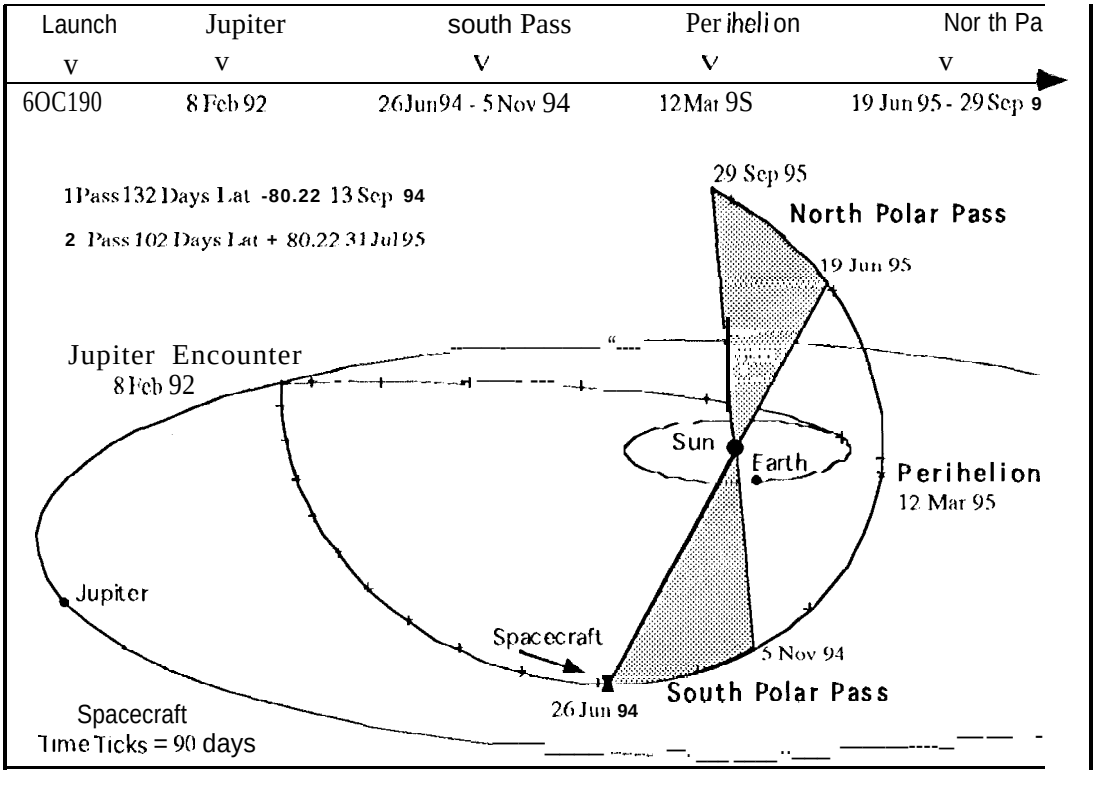

Fig. 1. Ulysses' Primary Mission Plan

A ri experiment involving two other spacecraft, Galileo and Mars Observer, was conducted in search for gravitv waves. Scientists decided to beam radio signals of precisely controled frequencies toward three spacecraft from a network of ten ante.nnas situated all over the globe. Each spacecraft then amplified the signal received and sent it back to Earth for comparison and analysis. Results of this experiment are expected 10 be known at the end of this year.

Presently, a healthy Ulysses spacecraft is climbing in latitude and gradually approaching the south pole of the sun. While the spacecraft is zipping through the previously unexplored regions of our south solar hemisphere, instruments on board arc continuously taking unique measurements that will certainly prove to be valuable scientific contributions. Discoveries made 10 dale include: first detection of neutral helium atoms arriving from interstellar space; measurement of micrometer-sized dust grains arriving from interstellar space; first measurement of singly charged hydrogen, nitrogen, oxygen and neon ions, entering the heliosphere as interstellar neutral atoms and then becoming ionized; and the highest resolution measurements of the isotropic composition of cosmic-ray nuclei.

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