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HALLEY'S COMET EXPLORATION

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1. Lift-off

On August 19, 1985, a launch vehicle was launched into space from Kagoshima Space Center at Uchinoura. It lifted off and disappeared into the clouds as many engineers and scientists watched on.

This launching was coordinated by the Institute of Space and Astronautical Science.

2. Target

The target of the vehicle is Halley's Comet, which will enter an orbital pattern close to the earth next March after an interval of 76 years. The comet owes its name to an English scientist, E. Halley, who calculated the orbit and revolution cycle.

The comet is assumed to have the structure schematically shown in Fig. 1. The "head" of the comet is called a coma, whose diameter is several hundred thousand kilometers. The two tails are composed of plasma and dust, both of which originated from the coma.

A comet is said to have two invisible constituent elements. One is a very small nucleus, several kilometers in diameter, at the center of the coma. This nucleus is composed of rock and ice. The other is a gigantic cloud of hydrogen atoms enveloping an area ten to one-hundred times larger than that of the coma.

Comets revolve around the sun and spend most of their time at great distance from the sun, in which state they have neither a coma or trails. It is considered, therefore, that they preserve a state which may go back to the formation of the universe.

Of the many observed comets, Halley's Comet has the most impressive trail, perhaps because much volatile material remains in the nucleus. The orbit has been accurately calculated. It reaches farther than Neptune and the direction of revolution is opposite to that of the earth. These are the reasons Halley's Comet is famous and has received much attention.

3. Mission

The payload of the launch vehicle was a deep space probe called "SUISEI". The external appearance of this spacecraft is shown in Fig. 2. The spacecraft is 1.4 m in diameter and 0.7 m high. It weighs 138 kg and is equipped with an offset parabolic reflector and an ultraviolet camera for taking photographs of the hydrogen cloud in the specific Lyman α spectrum.

SUISEI carries a transmitter with an output of 5.5 W as well as three kinds of antennas for different attitude and gain patterns. The antennas are switched according to the spacecraft's attitude to the earth and the antenna gain required for communications.

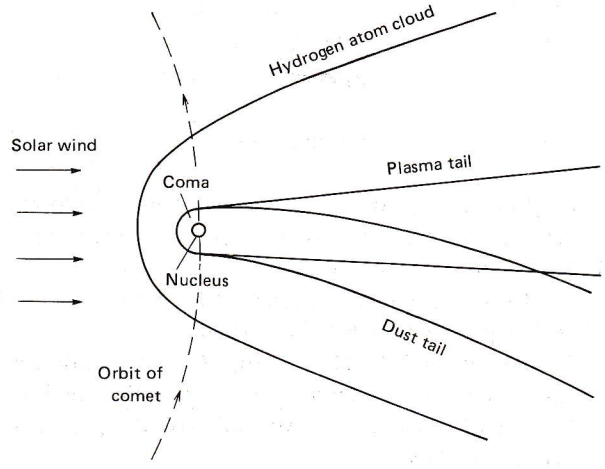

Fig. 1 Schematic view of comet

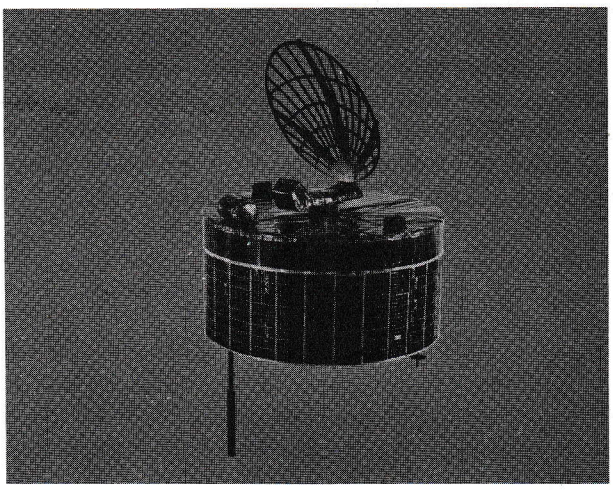

Fig. 2 Spacecraft SUISEI

SUISEI has a sister spacecraft named "SAKIGAKE" which was put into orbit in January, 1985. They are very similar except for the fact that SAKIGAKE carries two 5 m long probe antennas for measuring plasma waves in space instead of an ultraviolet camera.

The two spacecraft follow the trajectories shown in Fig. 3. They will encounter Halley's Comet around March 10, 1986 at a point about 150 million kilometers from the earth. In order to save fuel, two spacecraft revolve on almost the same phase as the eclipse and in the same direction as the earth. Therefore, the spacecraft and the comet travel in opposite directions and their relative velocity at the time of the encounter will exceed 70 km/sec.

The European Space Agency and the U.S.S.R. have also launched space probes called GIOTTO, and VEGA-I and -II, respectively. The American Lagrangean point satellite originally designed for observing solar wind has been converted to the International Cometary Explorer using lunar swing-by techniques. All of these spacecraft are operating favorably, and are expected to gather complementary data on the comet.

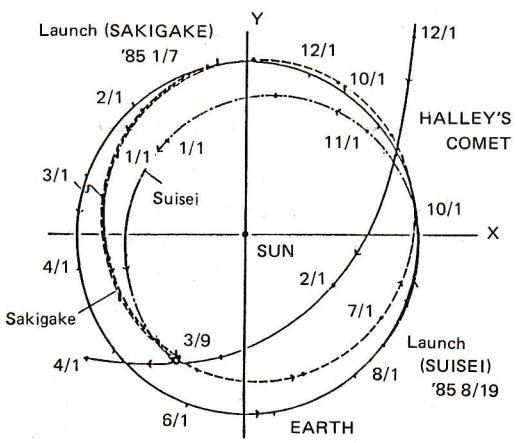

Fig. 3 Helio-centric orbits of SAKIGAKE and SUISEI

4. Ground Support

To achieve the mission objectives, strong command signals are sent from the earth to the spacecraft, and faint telemetry signals are received from the spacecraft. To accomplish this a ground station was constructed at Usuda in Nagano prefecture. This station is shown in Fig. 4.

The huge Cassegrainian antenna has a reflector 64 m in diameter. Since the reflector is distorted by gravity, a homology constitution is adopted to maintain the parabolic surface.

He-gas cooled parametric amplifiers and klystron high-power amplifiers are installed below the antenna. This equipment enables transmission of up to 40 kW power and reception of −165 dBm power in the S-band (2.1 ~ 2.3 GHz)

A three stage heterodyne receiver and a signal modulator are installed in the building on the left-handside

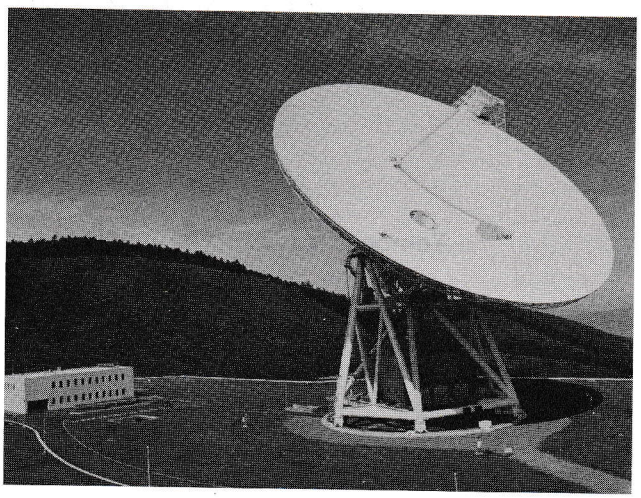

Fig. 4 Panoramic view of the Usuda station

of Fig. 4. The bit rate of the up-link is 16 bit/sec. While the down-link has alternative bit rates of 2 kb/sec and 64 bit/sec. Both the up-link and down-link are established independently, which is different from that in public telephone networks.

These two Japanese missions are also supported by large computers installed at Komaba in Tokyo to determine the orbit from range and range-rate data. A data transmission network connects the Usuda station, the Uchinoura station and the Komaba center.

5. Concluding Remarks

The Japanese spacecraft and the ground facilities are presently operating very well and are providing precious data on space as they approach Halley's Comet. Many riddles related to the comet are expected to be clarified by March, 1986.

Readers who would like further details should refer to the following references.

Acknowledgements

The authors would like to thank the members of this project for their valuable discussions.

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