A balloon-borne telescope system for optical remote sensing of planetary atmospheres and plasmas

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A planet can not be observed longer than ten hours a day by a ground-based telescope which is mostly located in the mid to low latitudes. However, a telescope floating in the polar stratosphere can continuously monitor planets for more than 24 hours. Thin, clear and stable air of the stratosphere makes it possible to observe planets in a condition free from cloud with fine seeing and high atmospheric transmittance. Moreover, a balloon-borne telescope system is less expensive compared with a huge terrestrial telescope or a direct planetary probe mission.

Targets of a balloon-borne telescope system will extend over various atmospheric and plasma phenomena on almost all the planets, i.e., a sodium tail of Mercury, lightning, airglow and aurora in the atmospheres of Venus, Jupiter and Saturn, escaping atmospheres of the Earth-type planets, satellite-induced luminous events in Jovian atmosphere, etc. The first experiment will be performed in June, 2006 at Sanriku Balloon Center (SBC). The target is global dynamics of the Venusian atmosphere by detecting cloud motion in UV and NIR imagery.

Aluminum space frames form the gondola structure. A decoupling mechanism and a pair of control moment gyros (CMGs) or a torquer mounted at the top of the gondola stabilize the attitude of the gondola at a constant sun azimuthal angle so that a solar cell panel always faces to the sun. A 300 mm F30 Schmidt-Cassegrain telescope is installed at the bottom of the gondola, and it is in the shade of the solar cell panel being kept in constant thermal condition. Important electrical components are contained in a sealed cell, which protects them from severe environment in the stratosphere and on the sea. They are surrounded by polystyrene foam which acts not only as thermal insulator but also as a float and a shock absorber when the gondola is dropped on the water.

The azimuthal angle is detected by a sun-sensor. A PC processes sensor output to control DC motors used in the decoupling mechanism and CMGs with an accuracy in azimuthal attitude of about 0.1 deg. The two-axis gimbal mount of the telescope is controlled by the same PC, guiding an object within a field-of-view of a guide telescope. Tracking error beyond the ability of the gondola attitude and gimbal mount controls is detected by a position sensitive photomultiplier tube and corrected by the two-axis moving mirror installed in an optical system. This mirror corrects tracking error of angle displacement less than 1mrad and frequency less than 100 Hz.

The optical path is divided into three paths with different colors: the first one with wavelengths less than 450 nm, the second one with 550-630 nm, and the last one more than 750 nm. The first and last paths are utilized for imagery of UV and NIR with bandpass filters and CCD video cameras, respectively. The second path is for tracking error detection. The moving mirror mount and the photomultiplier tube are kept in sealed cells to avoid discharge. Another PC controls the moving mirror, high-voltage power supply to the photomultiplier tube, and telescope focus.

Video signals from the CCD cameras are transmitted by analog modulation telemetries to the ground for real-time monitor and at the same time recorded in onboard digital video recorders, which will be recovered after landing on the water. Commands are up-loaded and status and house-keeping data are down-loaded through a PCM code telemetry. During the level-flight a balloon altitude of 32 km and a flight time of 7.5 hours are expected. On the other hand the gondola can be floated in a fixed altitude by an auto-ballast system for as long as several weeks when launched in the polar regions.

The system is under production as of January, 2006, and the first experimental flight is scheduled in June, 2006 at SBC. After confirming the performance of the system by the test experiment it will be put into a full-scale operation in the polar regions.