The first experiment of a balloon-borne telescope system for planetary atmosphere and plasma studies

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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 was scheduled in June, 2006 at Sanriku Balloon Center (SBC), but it was postponed until late August because of delay in final testing of the system. 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 are mounted at the top of the gondola. The decoupling mechanism isolates the gondola from a balloon which may generate a large twisting moment and also transfers an excess angular momentum of the CMGs to the balloon. The attitude of the gondola is stabilized at a constant sun azimuthal angle so that a solar cell panel faces to the sun. A 300 mm F30 Schmidt-Cassegrain telescope is installed at the bottom of the gondola. DC/DC converters, a PC, a high voltage power supply for a piezo-electrically moving mirror and digital video recorders are contained in a sealed cell, which protects the electrical equipments inside from severe environment in the stratosphere. The gondola is 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 0.5 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. The field-of-view of the telescope covers elevation angles from 0 deg to 70 deg. Residual tracking error 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 analog and digital 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. The PC also controls the moving mirror, high-voltage power supply to the photomultiplier tube, and telescope focus.

A video signal from the analog CCD camera is transmitted by analog modulation telemetry to the ground for real-time monitor and at the same time recorded in an onboard digital video recorder, which will be recovered after landing. Commands are up-loaded and status and house-keeping data are down-loaded through a PCM code telemetry.