

Study of attitude and rotation period of scientific payload using stratospheric small balloon missions

Rupnath Sikdar*, Sandip K. Chakrabarti and Debashis Bhowmick

Indian Centre for Space Physics, Kolkata 700 099, India

The attitude and rotational frequency or period of a payload during a mission are usually measured by the time variation of the azimuth and elevation angles. So far, significant scientific results have been published using stratospheric balloon-borne experimental data of the Indian Centre for Space Physics, Kolkata. Measurements of ground radioactivity, secondary cosmic rays, detection of astronomical sources (Sun, Crab Pulsar, Cygnus X-1, etc.), and weather parameters such as temperature, pressure, wind velocity, etc., have been done. However, the dynamics of the payloads of these 'Dignity missions' have not been studied. In the present study, we analyse data from some of the flights to obtain the payload's attitude and rotational period at each instant of time. We present how to determine the payload attitude from an attitude and heading reference system using micro-electronic modules, and also show the payload's directional stability from the rotational period analysis of the scientific payload in the stratosphere for single balloon (rubber and plastic) missions. Our analysis suggests that though double balloon configurations often float the payloads for a longer duration, the period of rotation of the payload is lower, and as a result, pointing to any object is poorer. In the absence of a pointing device, a single balloon is preferred for receiving useful data.

Keywords: Atmospheric turbulence, inertia measurement unit, meteorological balloon missions, payload attitude, rotation period, stratospheric balloons.

orientation of the detector in the sky to identify the source of the obtained data, the position of sources, and the determination of payload stability under perturbations. An attitude and heading reference system (AHRS) is essential for these missions, and it must be a lightweight and compact device. In our experiment, the AHRS is built using the commercially available inertial measurement units (IMUs) sensor with three measuring instruments: an accelerometer, a magnetometer and a gyroscope, each measuring the respective values in three orthogonal axes. The data obtained from the AHRS during the mission is utilised to calculate Euler's angles. The 3-axis magnetometer provides the components of the Earth's magnetic field along its axes, which is essential in computing the heading angle for the payload. On the other hand, the 3-axis gyroscope provides us with the angular rate around each axis.

The accelerometer readings provide pitch and roll angle information, which are used to correct the magnetometer data. This, in turn, allows for an accurate calculation of the yaw angle. The tilt-compensated device will not operate under free-fall, low-gravity conditions, or high-gravity accelerations. For balloon-borne missions, the payload acceleration is not very extreme except during the time between the balloon burst and the parachute opening. The deviations in the rotational angle calculations by the fixed fields are termed hard-iron effects, and those induced by the geomagnetic field are termed soft-iron effects. Any zero-field offset in the magnetometer during manufacturing is generally included with the hard-iron effects and subtracted simultaneously. The accelerometer values are affected by some gravity offsets, which must be removed before performing tilt compensation during ground testing and