Definition of science coordinate systems for the Arase satellite

1. **Spinning satellite Geometry Axis (SGA) coordinate system**

A satellite coordinate system fixed to the satellite body (rotating in an inertial frame of reference as the satellite spins) whose axes are defined as described below:

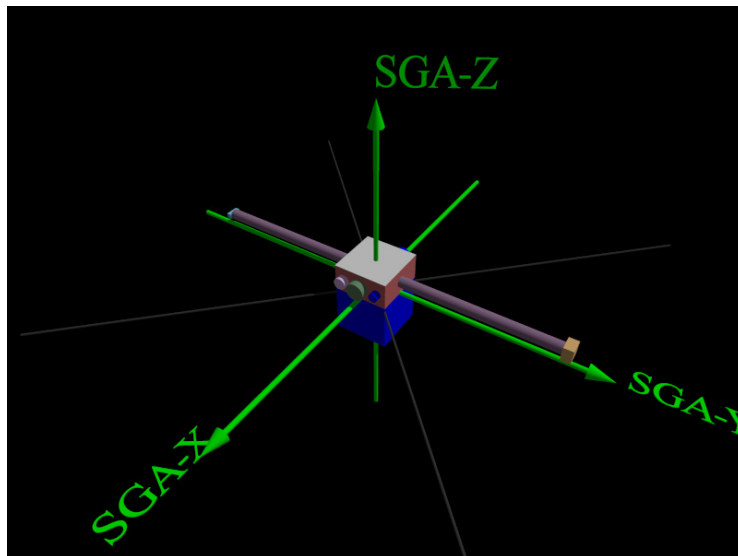Z-axis: The z-axis of the satellite mechanical coordinate system.
　　　　Its positive direction is roughly anti-sunward.
X-axis: The x-axis of the satellite mechanical coordinate system.
　　　　LEP-i, MEP-e, HEP are mounted on the +X-plane.
Y-axis: The y-axis of the satellite mechanical coordinate system.
　　　　SSC, MAST-MSC are mounted on the +Y-plane.

The satellite's spin direction is counter-clockwise about the z-axis, in the direction from SGA-X to SGA-Y.

2. **Spinning satellite Geometry Inertia (SGI) coordinate system**

Almost same as SGA, but the z-axis is the instantaneous spin axis of the satellite, which is defined as the principal axis of inertia with the largest inertia moment for the satellite's spin motion (referred to as just the spin axis in the following description).
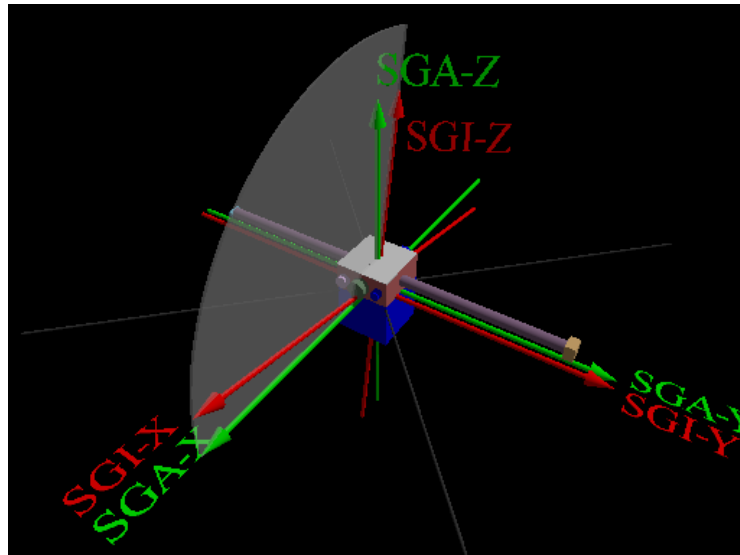Difference between the z-axis of SGA and SGI is less than ~1.0 deg.

Z-axis: The direction parallel to the spin axis.

X-axis: The normal direction to the z-axis in the plane defined by the z-axis and the SGA-X axis. The sign should be the same as that of SGA-X.

Y-axis: The direction of the cross product of the z- and x-axis.

CAUTION1: This schematic shows an example in which the SGI-Z axis has an offset angle from SGA-Z about the SGA-Y axis. But SGI-Z could point in any direction, not necessarily confined in the SGA-ZX plane.

CAUTION2: Precisely speaking, the spin axis is not necessarily fixed to the satellite body. But if the period of the satellite nutation is much longer than that of the satellite spin and the nutation angle is negligibly small, the spin axis can be considered to be approximately tied up to the satellite body.

For simplification, the following illustrations for satellite coordinate systems draw the SGI-Z axis as the one identical to SGA-Z.
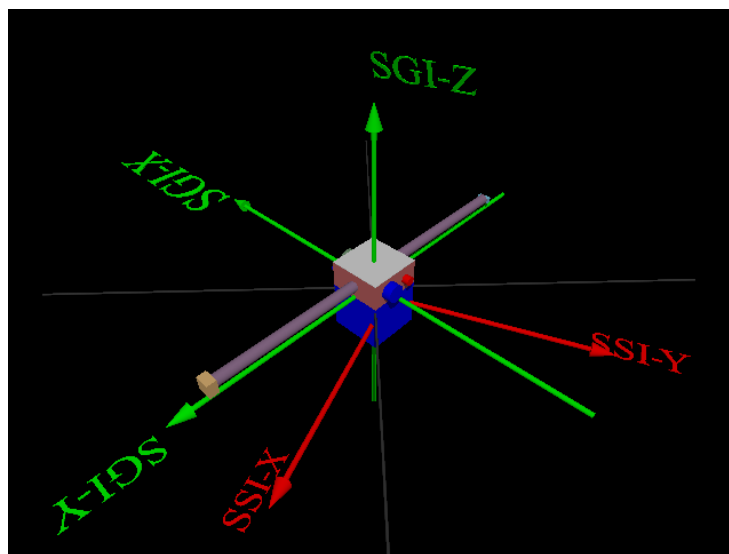
3. Spinning Sun sensor Inertia (SSI) coordinate system

Z-axis: The same as SGI-Z.

Y-axis: The direction of the cross product of the z-axis and a unit vector normal to the z-axis along the azimuthally collimated field of view of the SSAS-H1 (SSAS-H1 is an onboard sun sensor used for the nominal operation).

X-axis: The cross product of the y-axis and z-axis.

The angle between SGA-Y and the SSAS-H1 direction in the SGA-XY plane is ~21.6 deg. Although the SGA-XY plane and the SGI-XY plane are not identical, the SSI system is close to the SGI system rotated counter-clockwise (the spin direction) by roughly 90 + 21.6 deg around the z-axis .

### 4. Despun Sun sector Inertia (DSI) coordinate system

This coordinate system is considered as a despun SGI/SSI system referring to the timing of a sun pulse detected by the SSAS-H1.

Z-axis: The same as SGI/SSI-Z

X-axis: The (instantaneous) SSI-X axis direction in an inertial frame of reference at the

timing of a sun pulse detected by the SSAS-H1. This direction is defined per spin.
Y-axis: The cross product of the z-axis and x-axis.
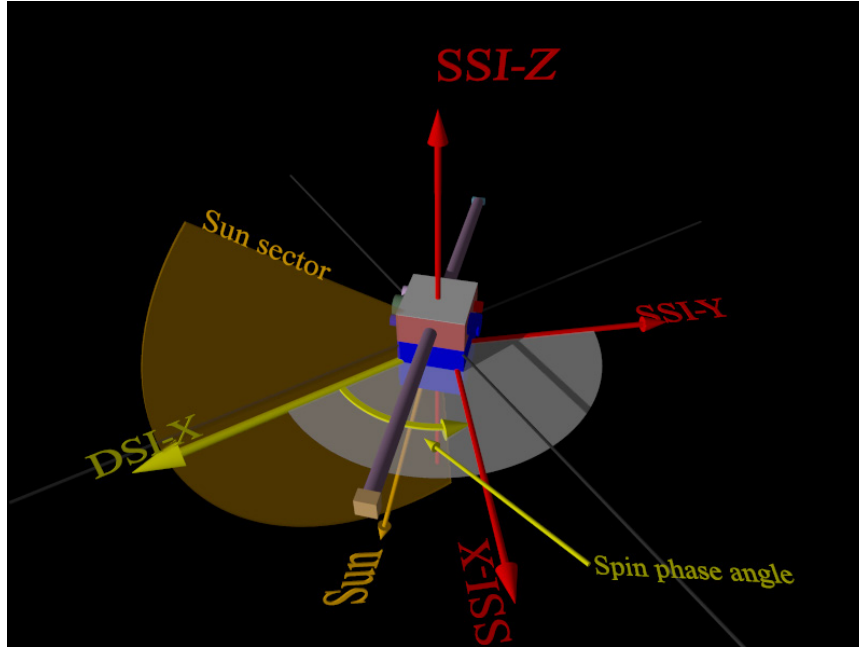
A spin period of the satellite starts when a sun pulse is detected by the SSAS-H1 (spin phase angle = 0 deg) and lasts through the next sun pulse.

4. Geocentric Equatorial Inertial coordinate (GEI)

This is an equatorial coordinate system referring to the mean vernal equinox, so called the Earth-Centered Inertial – Mean of Date (ECI-MOD) coordinate system.

Z-axis: Northward parallel to the rotation axis of the Earth.
X-axis: The direction of the mean vernal equinox.
Y-axis: The cross product of the z-axis and x-axis.

IDL/SPEDAS procedures for the coordinate transformation

1. **erg_cotrans.pro**

   The program transforms time series data from one coordinate to another. The supported coordinate systems are the ERG satellite coordinate systems (SGA, SGI, DSI) and an inertial coordinate system (J2000).

2. **spd_cotrans.pro**

   The program transforms time series data from J2000 to the geophysical coordinates (GEI, GSE, GSM, SM).