EPSC Abstracts
Vol. 6, EPSC-DPS2011-965-1, 2011
EPSC-DPS Joint Meeting 2011

In-flight observations performed by Akatsuki/IR2

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Abstract

Since the successful launch of "Akatsuki" (21 May 2010), IR2 (2-μm camera) carried out important observation programs in the space. This paper reports the preliminary results from the zodiacal-light observation and imaging of the Earth (October 2010), plus the photometric observations of Venus (March 2011).

1. Introduction

Akatsuki (Venus Climate Orbiter of Japan) was successfully launched in the morning of 21 May 2010 by a H-IIA launch vehicle from Tanegashima Space Center. Science targets of IR2 are:

1. Venus middle to lower atmosphere as probed through the near-IR "windows"of the CO_2 atmosphere, one at 1.74 μm and another near 2.3 μm.
2. Mapping CO in the lower atmosphere by differentiating images at 2.32 μm (CO absorption band) from simultaneous images at 2.26 μm.
3. Study "relative" cloud-top variation by examining contrast features in reflected sunlight at 2.02 μm (strong CO_2 absorption band).
4. Characterize the distribution of interplanetary dust between 1.0 and 0.7 AU heliocentric distances by imaging the zodiacal light at 1.65 μm (astronomical H band) en route Venus.

2. Instrumentation

2.1. Detector and thermal control

A platinum silicide (PtSi, 1024×1024 pixels) array detector on IR2 has the following merits:

1. Superb uniformity over the array. For applications where the primary noise source is statistical fluctuation of signal, advantage of uniformity overcomes disadvantage (PtSi's low Q.E.).
2. As PtSi detectors can be manufactured with today's mature LSI technology, large format arrays (1M pixels) can be domestically produced.
3. CSD (charge sweep device) technique used in the vertical transfer of electrons requires only narrow transfer channels. This results in a large filling factor of the device, ∼59 percent.

The PtSi detector needs to be cooled down to ∼65 K with stability, and the optical elements $T < 190$ K. Appropriate thermal control is achieved by means of a one-stage Stirling-cycle cooler (nominal driving power is 50 W).

2.2. Optics and mechanical structure

By considering many factors, such as trade-offs between faster and slower optics, available glass materials, etc., we have optimized the IR2 optics to a focal length $f = 84.2$mm with $F = 4$. A simple triplet design (ZnS and quartz) is used with slight remaining chromatic aberration over different filters (Table 1). The 2.02-μm filter is, therefore, made slightly thinner so that a small focus shift is compensated for.

Table 1: IR2 filter passbands.

Center [μm]	Width [μm]	targets
1.735	0.043	dynamics and clouds
2.260	0.058	dynamics and clouds
2.320	0.038	CO distribution
2.020	0.040	cloud-top altimetry
1.650	0.300	zodiacal light

To effectively dispose the removed heat to the space, a radiator plate of high-tech material (AlBeMet) is used. Because this plate is so large (500 mm W × 735 mm D), this also works as part of the spacecraft body. The entire system of IR2, including this plate and the cooler-driver electronics, weighs 10.47 kg.

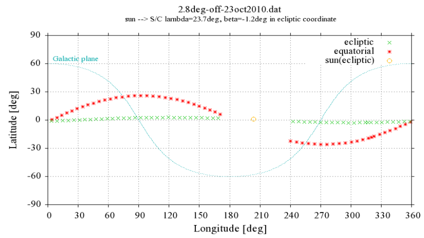

Figure 1: Scan plane for the zodiacal-light observation. Green and red symbols are the same but with different (ecliptic or equatorial) projection.

3. Observations

3.1. Zodiacal-light observation

We turned on the IR2 cooler on 11 October 2010 and adjusted the power until desired cooling was achieved. The observation was carried out from 22 October (06:08 UT) through 23 October (06:19 UT). A plane tilted $\sim 3^o$ from the ecliptic was scanned, from 37^o W of the Sun to 37^o E of the Sun, by twisting the spacecraft every 5.5^o around its Y axis (Fig. 1).

Upon data downlink, it was found that the exposure of a certain portion of the spacecraft to the Sun disturbed the thermal balance. Saturation due to execessive dark current was found and it continued until $\sim$20th image after the beginning. Because of this problem, it may be hard to detect the zodiacal light signals although the work is in progress. One nice 1.65-μm star field image is shown in Figure 2.

3.2. Imaging the Earth and the Moon

IR2 acquired the Earth and the Moon images (2.02 μm) from a great distance on 26 October 2010. Bacause IR2 was off, to avoid unwanted contamination, after the lauch, this was the first time that IR2 imaged its home. Although mere a point object, this Earth-Moon image made the team extremely happy.

3.3. Photometry of “Full-Moon” Venus

Since the failure of Venus orbit insertion (VOI-1, 7 December 2010), Akatsuki is orbiting around the Sun with the perihelion $\sim$0.62 AU. Because of this orbit, in March 2011, Venus appeared just as “full-moon” phase as viewed from Akatsuki. We had a campaign of multi-color photometric observation:

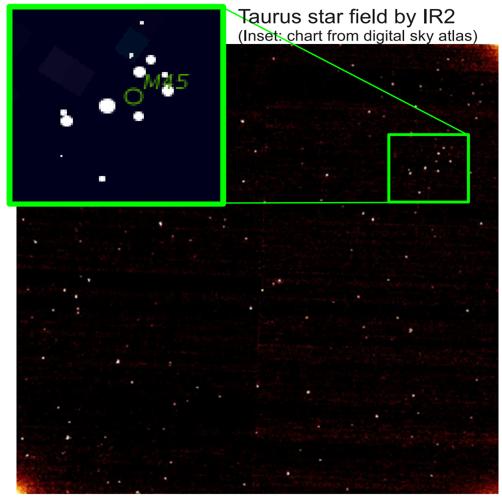

Figure 2: An example star-field image by IR2.

1. To detect modulation of the light curves possibly caused by planetary-scale waves, and
2. To characterise the phase curve (from UV to IR) around the “full moon” phase which is hard to access from the Earth.

The data are, as of this writing, to be received soon.

4. Concluding remarks

Despite the failed VOI-1, Akatsuki is still healthy and we hope to retry the VOI. Until then, IR2 will perform the zodiacal-light observations so that the scientific return from this mission will be of significance.

Acknowledgements

Special thanks go to those who worked hard during development and initial operation. The primary contractor of IR2 is the Sumitomo Heavy Industries, Ltd.

References

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