JX-ISAS-SUZAKU-MEMO-2010-03
Title: Anomaly of XIS1 in Dec 2009
Category: XIS
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Summary

The XIS1 suddenly showed an anomaly some time between Dec 18, 2009 12:50 UT and 14:10 UT. A bright and persistent spot suddenly appeared at an end of the segment C in all images taken during day-earth observations, while none was found during night-earth observations. We speculate that the anomaly stems from optical light leaked from a hole of a size of $\sim$7.5 μm in the optical blocking filter created by a micro-meteorite hit. We present the results of diagnostic operations, discuss the possible cause of the event, and conclude that scientific impact by this anomaly is minimum. The XIS1 has been and will be operated in the same way as before the anomaly.

1 Diagnostics and Results

1.1 Event images

We inspected a number of event images taken at various conditions before and after the anomaly.

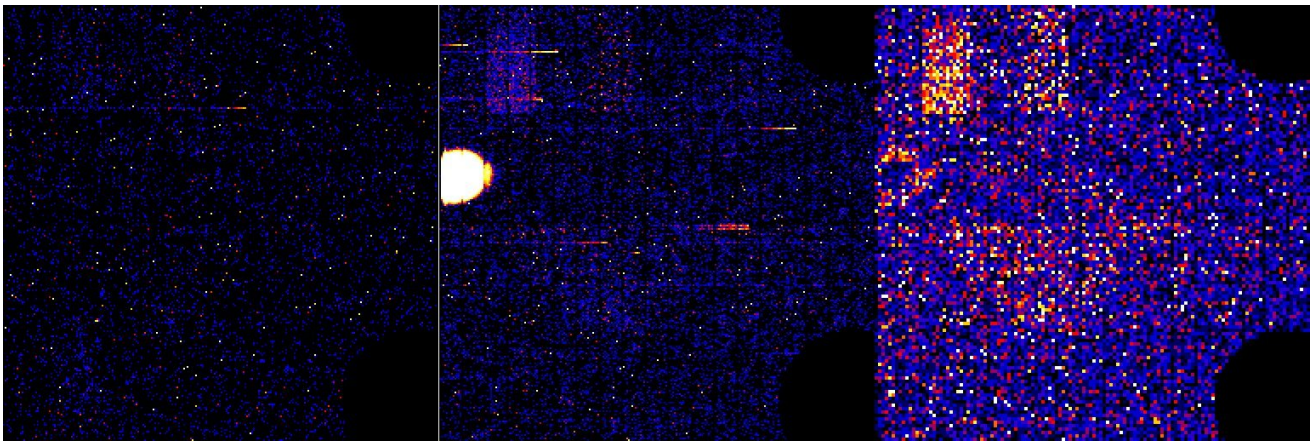

Figure 1: Comparison of three XIS1 event images in the DETX-DETY coordinate during day-earth observations. (a) Event image before the anomaly (Dec 17, 2009) using all grades, (b) Event image after the anomaly (Dec. 18, 2009) using all grades, (c) Event image using X-ray grades only (grades 0, 2, 3, 4, and 6) for the same data with (b). The segment names are shown in (a).

Figures 1 (a) and (b) compare two event images during the day-earth observations before and after the anomaly. Figures 1 (b) and (c) compare two post-anomaly event images constructed by all grades and only the X-ray grades. We see the following symptoms. These symptoms are apparent in all day-earth images taken after the anomaly.

- A bright spot is apparent at the end of the read-out side of the segment C.
- Events in the bright spot are mostly discriminated as non-X-ray events (grade 7).
- The dark level estimated onboard is inappropriate in some parts of the segments B–D (figure 1 c).

1.2 Frame data

After the anomaly, we conducted diagnostic operations to take frame images in various observing conditions. The operations contined for ∼6 months at a frequency of ∼1 per week to minitor possible changes. Figure 2 (a)–(c) and (d) show the comparison of four frame images taken during day-earth observations at different elevation angles from the rim of the day-earth (a–c) and during a night-earth observations (d). We see two trends. The trend continued to be the same during the ∼6 months of the diagnositic operations.

- The symptoms described above are apparent in all the day-earth frame images, but not in the night-earth frame image.
- The brightness of the anomalous features changes as the elevation from the day-earth rim changes.

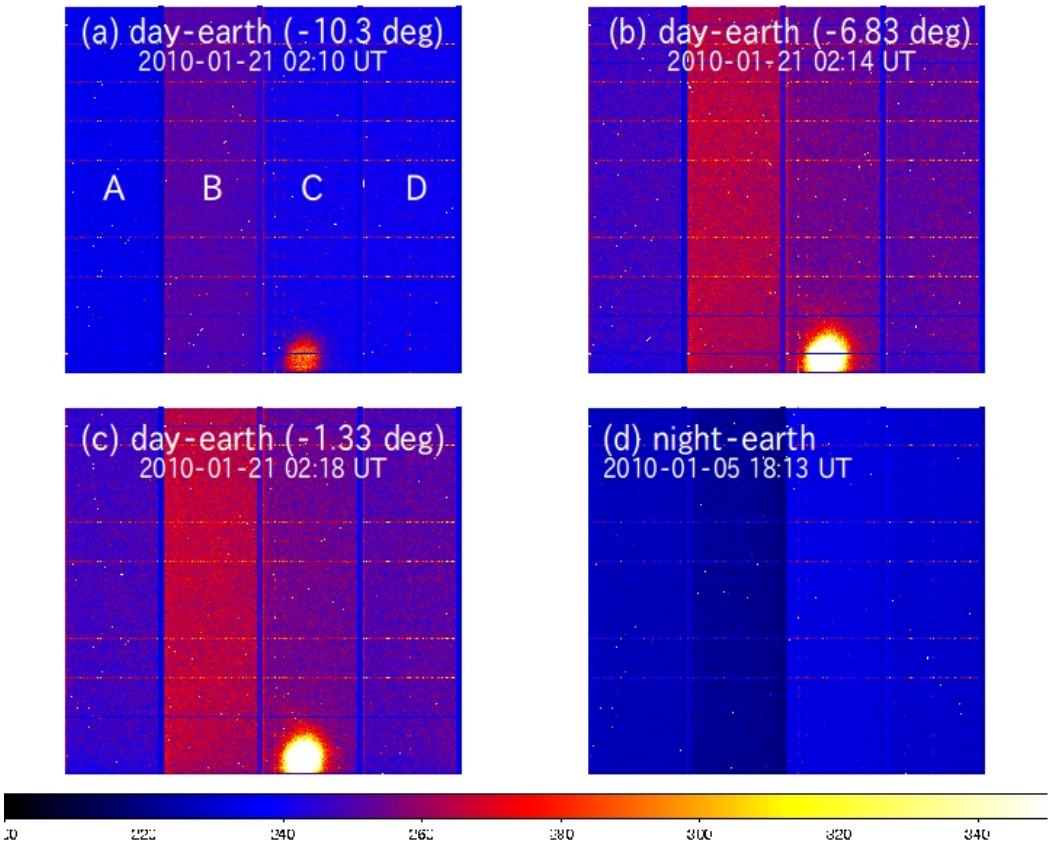

Figure 2: Comparison of frame images in the ACTX-ACTY coordinate taken during day-earth observations at different day-earth elevation angles (shown in parentheses; a–c) and during a night-earth observation (d).

1.3 RX J1856.5−3754

For the purpose of evaluating effects for X-ray observations, we observed RX J1856.5−3754 twice, placing it at the center of the bright spot ole in the first observation and at the XIS nominal position (off the spot of the bright spot) for the second observation. We also retrieved another data set of the object taken ∼2 month before the anomaly. Table 1 lists the data used for the comparison study. The object is an isolated neutron star with a very soft and well-known spectrum (Beuermann et al. 2006).

Figure 3 compares the images taken in data set (a) and (b). In the bottom right of each panel, the enlarged view is shown around the object. There is no significant chnage in the point spread function

Table 1: RX J1856.5−3754 data used to evaulate effects to X-ray observations.

ID	Sequence	Obs. month	Exp. time (ks)	Position of RX J1856.5−3754
(a)	104022010	Oct. 2009	43	XIS nominal position
(b)	104022020	Mar. 2010	40	On the bright spot
(c)	104022030	Mar. 2010	42	XIS nominal position

(PSF) except for the horizontal elongation in the image (b). The PSF elongation has a different cause discussed in anothe Suzaku memo[1].

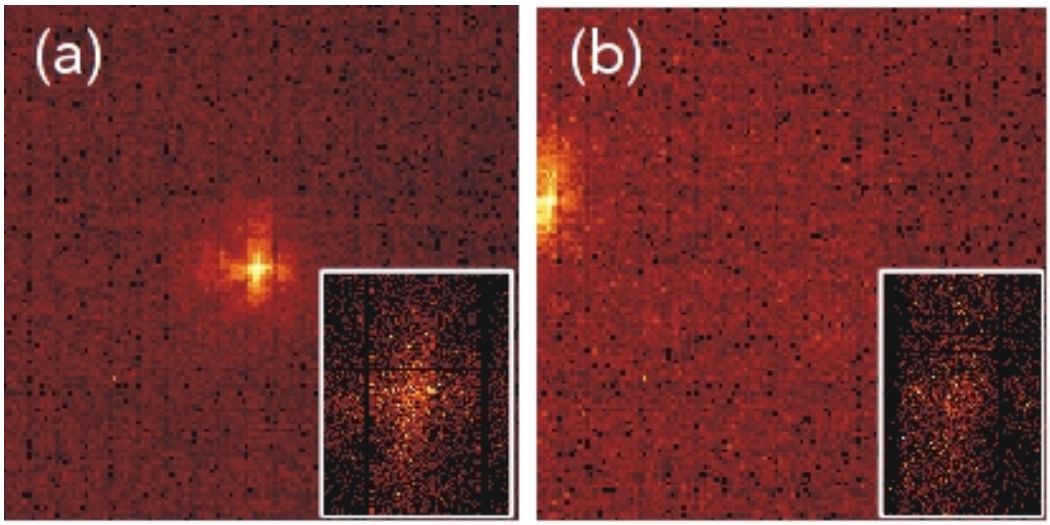

Figure 3: Comparison of X-ray images of RX J1856.5−3754 in data sets (a) and (b) in table 1.

Figure 4 compares the spectra between the data set (a) and (b) and (c) and (b). The spectra are different as is shown in the ratio of the two combinations. However, the difference can be atrributable to changes in the time and position dependent contamination material in the OBF. We conclude that there nos no change both in the X-ray image and spectrum of RX J1856.5−3754 by the anomaly.

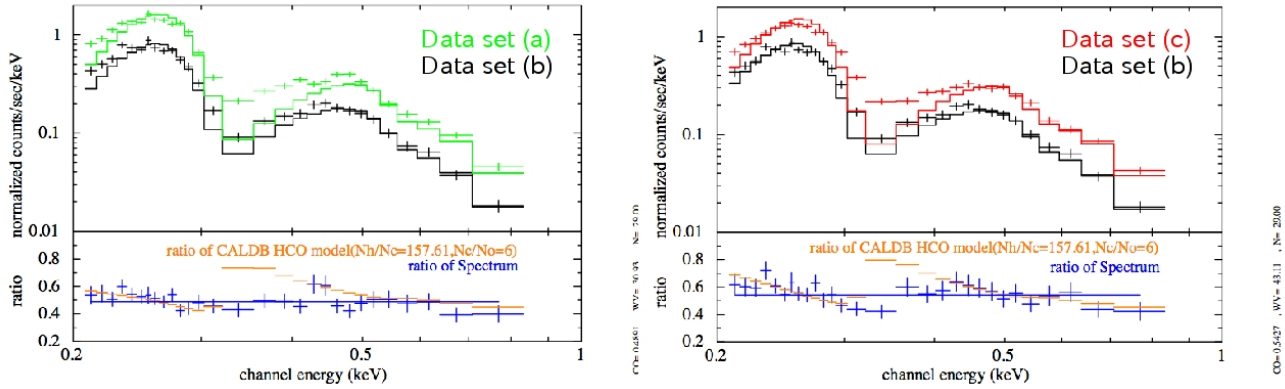

Figure 4: Comparison of X-ray spectra of RX J1856.5−3754 in data sets (a–c) in table 1.

[1]See http://www.astro.isas.ac.jp/suzaku/doc/suzakumemo/suzakumemo-2010-04.pdf for detail.

2 Cause

From all the results presented above, we speculate that the anomaly stems from optical light leaked from a hole in the optical blocking filter (OBF) in the XIS1 created by a micro-meteorite hit.

The OBF is a layer of a 1000 Å polyimide sandwiched by 800 Å and 400 Å Aluminum layers. The distance from the OBF hole to the CCD surface is 20 mm, whereas that to the X-Ray Telescope (XRT) is 4730 mm. Because both layers of the OBF are Aluminum-coated, leaked optical light from the hole reflect between the bottom layer of the OBF and the surface of the CCD, causing increased dark level spreading to the other segments.

From the observed diameter of the bright spot (∼90 pixels in FWHM), we estimated the size of the hole. Both geometric and diffraction effects should be taken into account, which is shown in figure 5. We have two solutions for the size of the OBF hole; ∼7.5 μm (∼0.3 pixel) and ∼2.28 mm (∼95 pixel). We consider that the latter is unlikely. If it is the case, we would have easily observed a distorted PSF in the X-ray image (figure 3).

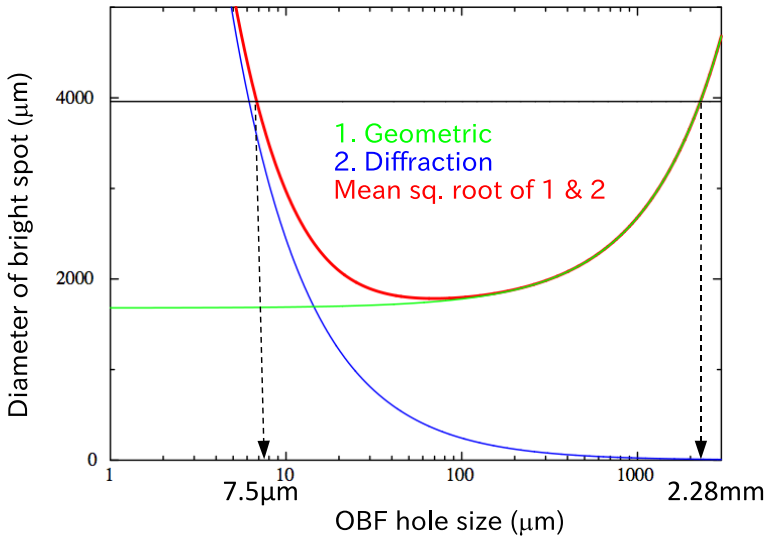

Figure 5: test

3 Concerns

Because of the relatively small size of the OBF hole, we consider that scientific impact by the anomaly is very small. The only possible case that this might be a problem is to have an optically bright source at the center of the hole. See `http://www.astro.isas.jaxa.jp/~tsujimot/pg_xis.pdf` for the position of the hole in the R.A.–Decl. coordinate to examine if your observation will have some impact.