AKARI results on the Taurus-Auriga star forming region

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Abstract. We present an analysis of AKARI Far-Infrared Surveyor, Spitzer Space Telescope Infrared Array Camera and Mid-Infrared Photometer for Spitzer data as well as various other photometric data of the Taurus-Auriga region. Our aim was to locate and describe young stellar objects (YSO), and to test the potential of AKARI FIS data in the classification of YSOs. We studied 32 YSOs, 7 of those had not been observed by the SST. We successfully modeled 21 YSOs with the SED Fitting Tool of Robitaille. We confirmed the previous models in 20 cases, and corrected the physical parameters for 5 YSOs. This research is part of the AKARI Mission Program "Star Formation".

1. Introduction
Taurus-Auriga is one of the nearest and best-studied regions of low mass star formation (Kenyon et al. 1994), and contains 200 loosely clustered young stars. These stars are associated with long filaments and small clumps of dense gas (Jones & Herbig 1979, Gomez et al. 1993). There are deeply embedded sources in each small clump still accreting material from their own molecular cloud core (Beichman et al. 1986). Luminosities of most of these sources are similar to the Sun’s and their estimated ages are from $10^5$ to a few times $10^6$ years (Myers et al. 1987, Strom et al. 1989, Kenyon et al. 1990, Gomez et al. 1992).

2. Observations
The main objective of the AKARI (Murakami et al. 2007) infrared astronomical mission is to carry out the All-Sky Survey in four photometric bands in the far-infrared wavelengths in 50–180 $\mu$m range with the Far-Infrared Surveyor (FIS; Kawada et al. 2007), and in two mid-infrared bands centered at 9 and 18 $\mu$m with the Infrared Camera (IRC; Onaka et al. 2007) with a sensitivity one order of magnitude better and resolution a few times higher than IRAS. AKARI is the second space mission for infrared astronomy in Japan. AKARI has been developed by members of JAXA/ISAS and collaborators.
2.1. Far-Infrared Surveyor
We used the data of Far-Infrared Surveyor (FIS). It provides four photometric bands between 50 and 180 µm, two broad bands and two narrow bands. The central wavelengths are: 65, 90, 140 and 160 µm. The band widths are about 21.7, 37.9, 52.4 and 34.1 µm.

2.2. Bright Source Catalogue
The Bright Source Catalogue (BSC) is the primary catalogue from the AKARI survey. It contains 63370 sources. 19085 sources have at least two good quality fluxes. There are only 3401 sources which have four good quality fluxes. In this catalogue, Version β-1 (Yamamura, 2008), the average position uncertainty is 8", and the estimated absolute flux uncertainty is 20-25 %. We compared the 2MASS positions with AKARI FIS BSC positions in the Taurus-Auriga region: we got an average 4.36" positional difference with a standard deviation of about 2".

3. Point sources in the Taurus-Auriga region
In the Taurus-Auriga region there are 173 AKARI FIS BSC point sources. There are 46 sources which have at least two good quality fluxes. We examined only these objects. With the use of 2MASS K images and VizieR catalogues, we identified the objects. There are 30 young stellar objects, 2 infrared sources, 11 galaxies. There are 3 objects which we could not identify clearly. In the figure 1 we can see the AKARI FIS BSC sources on the 13CO background (Dame et al. 2001). CO contour level is at 1.5 K km/s. In the left panel we show the point sources which have only 1 good quality flux, and in the right panel, the sources with at least two good quality fluxes.

![Figure 1](image)

**Figure 1.** Left: AKARI FIS BSC point sources in the Taurus-Auriga region with 1 good quality flux. Right: Identified AKARI FIS BSC sources in the Taurus-Auriga region having at least two good quality fluxes on the 13CO background (Dame et al. 2001). CO contour level is at 1.5 K km/s. Pluses are associated young stellar objects (30 objects), triangles indicate associated galaxies (11 objects) and squares are other objects (5 objects).

4. Models
We used the SED Fitting Tool of Robitaille (2006, 2007), which is publicly available on a dedicated web server. These model SEDs were computed using a Monte-Carlo radiation transfer
code, for 20071 different sets of physical parameters (e.g. stellar mass, stellar temperature, disk mass, etc...), and for ten viewing angles, resulting in a total of 200710 SEDs. It’s a grid of radiation transfer models of axisymmetric young stellar objects, covering a wide range of stellar masses and evolutionary stages. The grid consists of 20000 YSO models, with spectral energy distributions (SEDs) and polarization spectra computed at 10 viewing angles for each model, resulting in a total of 200000 SEDs. Since none of the models have physical sizes larger than 100000 AU, the fluxes in the largest aperture correspond to the total fluxes.

We studied in detail only that point sources, which we could classified YSO or IR source. We try to model 32 objects (30 YSO and 2 IR sources). We could fit 21 point sources with the SED Fitting Tool. 13 of them was modeled previously by Robitaille et al. In these cases we use the data for their article and complete them with the AKARI FIS BSC fluxes. Our results are in good correlation with Robitaille’s results. In the other cases we use the AKARI FIS BSC data and archive optical (VizieR) and infrared (SST IRAC and MIPS) data.

4.1. IRAS 04361+2547 and IRAS 04368+2557
IRAS 04368+2557 is the driving source of the molecular outflow in L1527. It is believed to be a single very young protostellar source. IRAS 04361+2547 is a typical Class I protostar (e.g. Tamura et al. 1991).

In figure 2 we can see the spectral energy distribution of IRAS 04361+2547 (left panel) and the SED of IRAS 04368+2557 (right panel). Data and errors are from Robitaille et al. (2006) and figure shows the new AKARI FIS BSC data as well. Upper limits are shown by arrows. Flux errors and FWHM of filters can be found, too. While getting the parameters we took the 10 best fit into account. These fits are shown by the grey zone.

In table 1 we can see the fitted parameters of modeled stars in the Taurus-Auriga region with 4 good quality fluxes.

5. Results
We studied 32 YSOs in the Taurus-Auriga region, 7 of those had not been observed by the SST. We use new AKARI FIS BSC data and we successfully modeled 21 YSOs with the SED Fitting Tool of Robitaille (2006, 2007). We confirmed the previous models in 20 cases, and corrected the physical parameters for 5 YSOs. This research is part of the AKARI Mission Program "Star Formation".
Table 1. Fitted parameters of modeled stars in the Taurus-Auriga region with 4 good quality fluxes

| Name          | $t_\ast$ [10^4 yr] | $M_\ast$ [$M_\odot$] | $R_\ast$ [$R_\odot$] | $T_\ast$ [K] | $M_{disk}$ [$10^{-4}$ [$M_\odot$]] | Type         |
|---------------|-------------------|-----------------------|-----------------------|-------------|---------------------------------|-------------|
| IRAS 04016+2610 | 1.1 ±0.1          | 0.15 ±0.05            | 5.04 ±0.19            | 2847 ±333   | ±295 154±0.95                   | Class I     |
| IRAS 04169+2702 | 193 ±0.3          | 0.43 ±0.30            | 3.39 ±0.29            | 3649 ±923   | 224±1.70                       | Class I     |
| IRAS 04190+1924 | 20.5±44.0         | 0.70±4.33             | 6.60±7.4              | 3889±521    | 657±683                        | Class II    |
| L1551 IRS 5    | 6.3±32.1          | 0.46±7.8              | 6.00±4.5              | 3651±668    | 352±828                        | Class I     |
| HL Tau        | 1.3±65.2          | 0.35±0.2              | 5.78±2.07             | 3454±744    | 143±177                        | Class I     |
| IRAS 04325+2402 | 91.9±4.1          | 0.20±0.10             | 2.80±0.72             | 3034±128    | 1.04±0.11                      | Class I     |
| IRAS 04361+2547 | 1.2±1.4           | 0.25±0.08             | 5.23±0.70             | 3225±787    | 2.45±250                       | Class I     |
| IRAS 04365+2535 | 209±45.0         | 0.87±0.69             | 5.48±1.23             | 4083±207    | 338±57                          | Class I     |
| IRAS 04368+2557 | 237±0.127        | 0.57±0.04             | 4.10±0.27             | 3855±374    | 2.32±1.74                      | Class 0     |

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