Selection of InfraRed Variable Objects in the IRAC Dark Calibration Field

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Summary

The Spitzer Space Telescope has devoted 2-3 h of every IRAC instrument campaign to a particularly dark field near the north ecliptic pole since the beginning of the mission in 2003. The IRAC Dark Calibration Field is now the deepest IRAC integration to come out of the Spitzer mission.

Furthermore, the unique temporal information (87 epochs so far) provide a means of closely monitoring the ways in which stars and galaxies vary from 3 to 9.5 microns. We have photometered all 87 IRAC epochs in all four IRAC bands, generating more than 4 x 10000 light curves extending back to 2003 December, a baseline of 1420 days.

Based on these light curves we detect:

- **20 Stars** (Short periods: 30 - 100 days, cross-matched with 2MASS)
  - Long Period Variable stars.
  - Probably halo AGB stars [Marengo et al. AIPC, vol.1001, p.331-338]
- Around **100 AGNs** (Drifting lightcurves)
  - X-ray emission visible on Chandra observations.
  - Confirmation of previous observations [Hund et al 2007, AAS, 209, 149.07]

and we are now engaged in characterizing these objects.

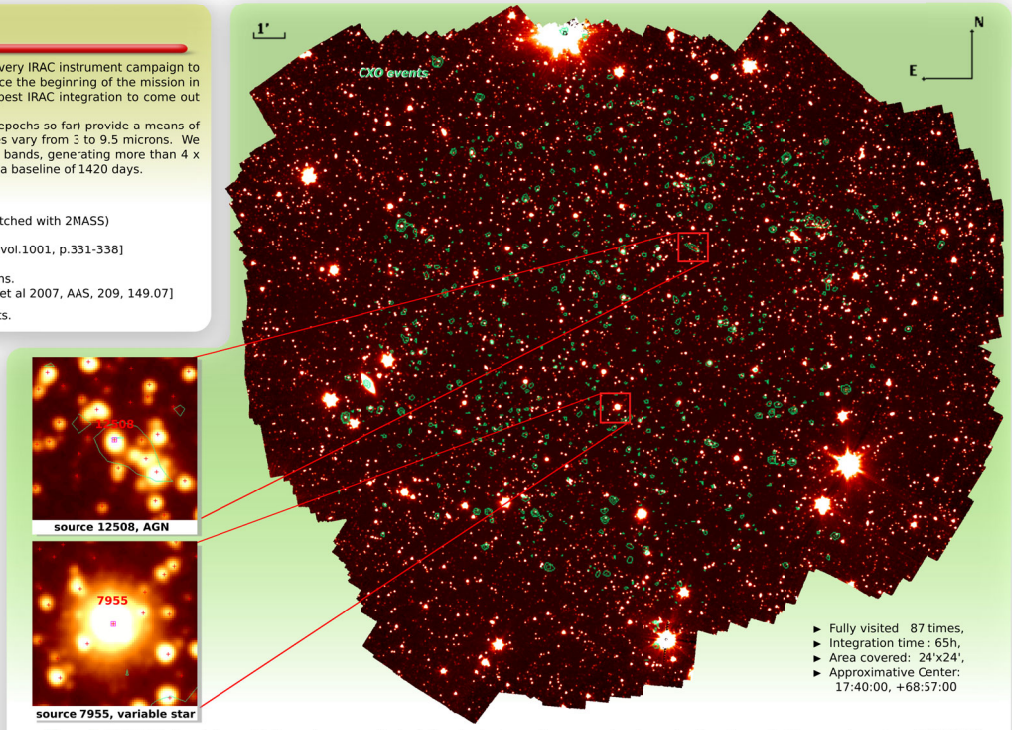

Figure 1: *IRAC-CF 3.6μm full co-added mosaic, cropped to include only single-epoch coverage levels greater than 3, overlaid in green by a recent Chandra X-Ray Observation. Red crosses in the thumbnails represent variable sources identified from the analysis of the IRAC lightcurves.*

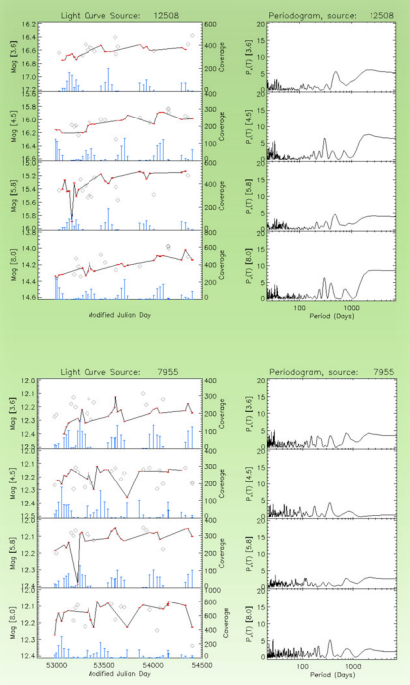

Figure 2: *IRAC photometry of two typical infrared variable sources: an AGN referenced as 12508 and probably a TPAGB star referenced as 7955 in our catalogs. On each Figure from top to bottom, the four left-hand panels show the IRAC photometry in the 3.6, 4.5, 5.8 and 8.0 μm bands, referenced to the left-hand axis. Depth of coverage is represented by the histograms and is referenced to the right-hand axis in units of exposure per visit. Open diamonds indicate measurement errors only and not systematics. The two other four panel series are giving the periodogram of the corresponding IRAC band resulting from our analysis program.*

The Deepest IRAC Integration

A full coadded mosaic for each IRAC band:

- 87 single-epoch images (and counting)
- Different angles, backgrounds, ...
- Non uniform coverage,
- A high S/N, *especially in the center*,
- Deep source detection

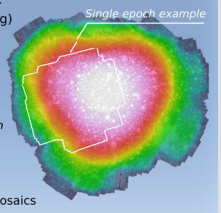

Figure 3: *3.6μm coverage map with arbitrary color scale over the full mosaic.*

Photometry:

- performed on both single and full mosaics
- 4 pixels radius aperture
- filtered for low coverage
- SExtractor in dual mode with 3.6μm full mosaic
  [Bertin & Arnouts 1996, A&AS, vol.117, p.393-404]
- 3.6, 4.5, 5.8, and 8.0 μm **lightcurves for each detected source**,
- Dataset covering a **large timescale**: 6 years

Single epoch mosaics:
Different background levels imply photometry variations
► **Weighted photometry correction** using full mosaic as reference

Full coadded mosaics:
► More than 14000 detections
► Detection count up to 21 Vega Mag.
[Ashby et al. in prep]

Data Analysis

Data Characteristics:

- Data points are **unevenly time distributed**
- Rarely a source is observed in all bands at the same epoch.
- There are gaps in observations
  (due to the spacecraft rotation over the field)

"Classical" Fourier analysis are not applicable because of the unvenly time series.

Analysis Method: a **Lomb-Scargle Modified Periodogram,**

- Complete periodogram estimation
  [Sargle 1982, ApJ, vol.236, p.835-853]
- Main period significance evaluation
  [Press et al. 1989, ApJ, vol.338, p.277-280]

Selection of variable candidates:
foreach object (> 14000)
foreach band (of 4) get the main frequency and its significance
if the **significance average > 0.5 then we have a candidate**

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