



Infrared Photometry of Asteroids in the Spitzer FLS and SWIRE Programs

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Abstract: We present photometric analysis of asteroids observed in the Spitzer First Look Survey- Ecliptic Plane (FLS, cf., Meadows et al. 2004, ApJS 154, 469) and the Spitzer Wide-area Infrared Extragalactic Survey (SWIRE, cf., Lonsdale et al., 2003, PASP, 115, 897). Initial analysis of the SWIRE data in the XMM-LSS field centered at an ecliptic latitude of -17.5 degrees revealed detections of 39 asteroids which were present in two epochs of data. Of the 39 asteroids detected, only 15 correspond to asteroids detected in ground based surveys. This new result yields a new estimate of 4.23 asteroids per square degree at the ecliptic latitude of -17.5 degrees. The mean flux values for the SWIRE asteroids in IRAC channel 4 (which corresponds to 8.0 microns) are at least 2 times greater than the values for the asteroids found in the FLS field at 0 and + 5 degrees ecliptic latitude. We present photometric results for both programs and also analyze the asteroids position in color space relative to other astronomical objects and will discuss possible future significance for the WISE mission.

SWIRE Data:

The SWIRE survey is a Spitzer Legacy Survey originally designed to probe large scale structure for cosmology, however one of their fields is at sufficiently low ecliptic latitude. In order to reject asteroids from their data, the SWIRE fields are observed in two epochs separated by 3.75 hours. Examples of asteroids found in the fields are presented in Figure 1a and b.

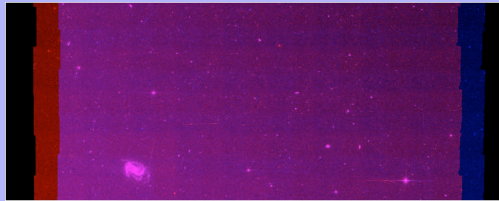


Figure 1a- Two Epoch image of SWIRE data showing two asteroids- one near the spiral galaxy and another near the top of the image near the center.

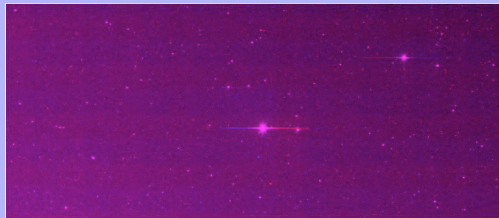


Figure 1b- Two epoch image of SWIRE data with asteroid detected slightly below the bright star in the center of the image

By displaying the two epochs of the SWIRE data in two different color tables in ds9, we found 40 asteroids which are present in both epochs and all fields of view. Because the IRAC instrument has two fields of view (one for Ch2/Ch4 and one for Ch1/Ch3) there are an additional 6 asteroids that were detected, yet we will not present their data here. Of the 40 asteroids seen in both epochs, only 15 of them have ground based asteroid determinations. This leaves an additional 25 asteroids detected by Spitzer, yet currently unknown to ground based surveys.

FLS Photometry:

8.0 micron fluxes for the asteroids found in the FLS survey have been published (Meadows et al., 2004), however fluxes in the other 3 channels of the IRAC instrument have not been reported. We have obtained fluxes in all 4 IRAC channels and report the results for the asteroids with ground based orbit determinations, including the SWIRE asteroids, in Table 2. In the two fields FLS fields, we have a total of 24 asteroids which were detected in all 4 IRAC channels.

Mean and Median fluxes of asteroids in the fields

As we have done photometry on two surveys of data, we present mean and median fluxes for the asteroids at each latitude in Table 1. We note that the fluxes in channels 1 and 2 may be slight overestimates due to crowded fields, however stellar contributions to the measured fluxes should be minimal as a 2 pixel aperture was used in all three fields in all channels. Both the mean and median fluxes for the SWIRE field are significantly higher than the fluxes of asteroids in the FLS fields. This may be significant, however the calculated diameters of the asteroids seen in the SWIRE fields as given in Table 2 are on average larger than those detected in the FLS fields.

Field	mean 3.5 micron flux (microJy)	Mean 4.6 micron flux (microJy)	Mean 5.8 micron flux (microJy)	Mean 8.0 micron flux (microJy)
SWIRE	37.2	66.1	361.7	2448.31
FLS +0 degree	21.0	30.9	154.9	1276.6
FLS +5 degree	95.7	23.5	51.9	315.3

Field	Median ch1 flux	Median ch2 flux	Median ch3 flux	Median ch4 flux
SWIRE	13.0	38.7	201.5	1354.9
FLS +0 degree	10.0	11.9	31.6	198.9
FLS +5 degree	19.7	10.5	43.4	302.2

Table 1- mean and median fluxes in all four IRAC channels for all three fields

Table 2- Fluxes of all detected asteroids with ground based orbits

Asteroid Name	Absolute H Magnitude	Diameter* (km)	3.5 micron flux (microJy)	4.6 micron flux (microJy)	5.8 micron flux (microJy)	8.0 micron flux (microJy)
SWIRE						
2004 TH222	15.2	3.13	14.3	47.4	253.6	1567.5
2005 YV181	15.5	2.73	4.2	13.6	123.5	891.3
2005 YX74	14.8	3.76	13.6	63.7	514.1	4398.5
2005 YV50	16.0	2.17	5.4	9.5	50.7	515.8
1999 WA1	12.7	9.9	38.5	102.3	879.0	7313.6
2004 TO8	14.5	4.32	95.4	241.2	1684.1	10289.4
2006 AP1	15.5	2.73	6.1	30.8	255.0	1739.3
2005 WX162	15.3	2.99	11.1	33.6	286.2	1850.9
1999 VY171	14.0	5.44	74.7	387.1	2800.6	19011.7
1999 JZ7	14.0	5.44	4.6	20.3	181.0	1403.2
2000VP1	15.7	2.49	13.0	25.2	113.3	852.57
2005 YH117	15.3	2.99	6.6	47.2	383.6	3676.5
2002 FE15	14.5	4.32	15.2	56.2	341.5	4976.9
2004 TF243	15.0	3.43	17.6	96.3	743.5	4397.0
2005 YC156	15.4	2.85	4.8	22.4	145.6	871.9
FLS Asteroids:						
2001 QY160	15.0	3.43	8.0	9.2	78.5	766.4
2000 AX136	13.1	8.23	87.8	186.4	946.6	9010.8
2004 BH160	18.4	0.717	2.5	16.8	8.8	82.7
2001 QD49	17.5	1.09	66.6	46.6	14.7	80.3
2002 WL7	15.3	2.99	20.1	44.0	481.5	2429.0
1999 FZ24	13.8	5.96	34.5	38.8	228.3	2250.7
2001 RP137	16.7	1.57	6.1	5.3	40.2	302.1
2004 EU91	18.4	0.717	1.2	3.4	29.7	124.0
2004 CA105	14.8	3.76	15.1	10.6	31.1	455.9
2002 RG160	16.1	2.07	10.1	9.5	23.1	199.0
2004 BU99	17.4	1.14	5.3	9.3	39.8	353.9

* diameters were calculated using the relation $d(\text{km})=(1329/\rho)^{1/3}10^{(0.2+H)}$ and assuming a Bond albedo of $p=0.15$

Asteroid Colors from IRAC photometry

Using the photometric results for the SWIRE and FLS fields, we present their colors in relation to other astronomical objects in Figure 2. This figure is an adaptation of Lacy et al., 2004 (ApJS 154, 166), which reported colors for all astronomical objects observed in the Extragalactic Component of the Spitzer First Look Survey. As one can see by the plot, most asteroids are easily separated in color space from other astronomical objects. However, there are a few which overlap in color space with objects such as low redshift star forming galaxies, so additional tests such as psf fitting will be a deciding factor. The WISE mission is currently slated to launch in 2008 and will have cameras with channels at 3.5 and 4.6 microns. While WISE will be using an observing strategy similar to IRAS, our results show that it should be sensitive to all asteroids (not just those with ground based orbits) by using color selection techniques.

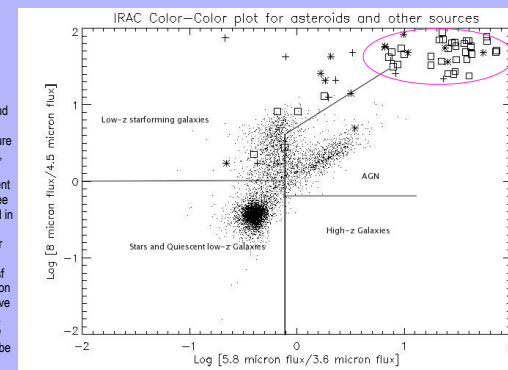


Figure 2- The different data points correspond to the different fields: boxes correspond to the asteroids in the SWIRE fields, + signs correspond to asteroids in the +5 degree FLS field, and * correspond to the asteroids in the 0 degree FLS field. The pink oval marks the asteroid locus in color-color space

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