Considerations for Observing Methods & Analyses Employed for Solar System (Moving) Objects.

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Solar System objects had unique challenges for observing by the Spitzer Space Telescope. Chief among them is the fact that the objects are not stationary with respect to background sky sources, but other specific challenges included:

- Solar System objects, such as comets and dust trails, were often extended, and exceeded the area in the detector's field of view.
- Objects may have had variable flux, such as comets, or may have significantly changed in IR brightness over the course of the viewing window.
- Bright background objects may be encountered along the path of the moving object, and the observations may have been scheduled during these times.
- Ephemerides of new objects, or off-center observations, may have required special ephemerides.
- Peak-up observations (with the IRS) were drawn to the brightest object in the frame, but on occasion were background objects rather than the primary target.

Observing: Common concerns were discussed in the SSC document "SSO Observing with Spitzer" (http://irsa.ipac.caltech.edu/data/SPITZER/docs/files/spitzer/SSO_Observing_With_Spitzer.pdf). Much of the time, the observing plans were vetted for technical complications before cleared for scheduling. A large number of targets were observed by Spitzer during its cold mission (see the observing list and other material provided at: http://irsa.ipac.caltech.edu/data/SPITZER/docs/spitzermission/observingprograms/solarsystemprograms/). Many observations were time-critical, while others were limited only by the object's observability window. Time critical constraints on observations carried additional overhead for the scheduling of the Astronomical Observing Requests (AORs; see Spitzer Observing Manual 5.6.3; http://irsa.ipac.caltech.edu/data/SPITZER/docs/files/spitzer/som8.0.pdf). If the window for the observations extended over several months, however, the object of interest was likely to encounter bright objects along its path. These bright background sources would necessarily be avoided by specifying the exact observing windows in the AORs. Often for spectroscopic observations, but frequently for imaging with the IRS peakup arrays (IRS-PUI), the object was targeted by centroiding the brightest object in the array, but caution had to be employed when the primary target moved through a field of background sources that were on the same order of brightness as the target, owing to the possibility of a "false peak-up" where the telescope would center the FOV on the background source instead. In some cases, the risk of false peak-up prevented the use of the peak-up feature altogether. Observations of sources too faint to peak-up on, or in too confused a region, could be made by offsetting from bright sources near the target.

Spitzer could only view objects when they were between 82.5 – 120 degrees elongation from the Sun. In this region, many solar system objects passed through or near their orbital sky-motion stationary points. At such times, the ephemerides and observations had to be managed with care, since the object's sky motion varied greatly, and linear, fixed rates were used to track moving objects that were set during the start of the AOR's execution. Often, these required that the observing be broken up into smaller AORs, with additional overhead. Extended or slowly-moving objects often employed "shadow observations" to accurately measure the flux from background objects. The sources were frequently combinations of extended sources, such as nebulae, and slowly varying background, such as that caused by the solar system's zodiacal dust. The shadow observations allowed the track across the sky taken during the primary observation of a moving target to be observed again or before, when the target was not present (see SOM 5.6). However, crowded regions, for example near the Galactic plane, were often avoided regardless, to mitigate the possibility of photometric contamination by faint background point-sources, since pointing may not be reconstructed sufficiently to truly eliminate their effects.

Reduction Methods: Of course, every set of observations had its unique demands for data processing and analyses. Most often, Spitzer tracked the sky at the similar sky motion as the observation target. In these cases, many of the specifics of the data reduction were similar to those for stationary sources. Much of the discussion in http://irsa.ipac.caltech.edu/data/SPITZER/docs/dataanalysistools/ pertains to these circumstances. MOPEX can be used to combine images into a single mosaic (cf. Reach et al. 2007). RECIPE 17 (http://irsa.ipac.caltech.edu/data/SPITZER/docs/dataanalysistools/cookbook/1/) shows in detail how to extract a cometary spectrum using the SPICE tool. This a good initial guide to reduction of IRS spectroscopy. It assumes the offset images are not blended, i.e. that strong coma signal from the primary image does not extend to the dithered image. Dithering was used to average out noise or defect characteristics over the detector array, while discrete sampling or shadow observations were usually used to characterize the background. CUBISM could also be used for IRS extractions (see Woodward et al. 2007).

Various examples of observations and reduction methods can be seen in the literature. Some of these are listed below.

Moving Object imaging:

IRAC

Observations of moving sources

Ryan et al. 2009. AJ 137, 5134: http://adsabs.harvard.edu/abs/2009AJ....137.5134R

Extended (moving) source imaging

Kelly et al. 2009. AJ 137,4633: http://adsabs.harvard.edu/abs/2009AJ....137.4633K

Kelly et al. 2006. ApJ 651, 1265: http://adsabs.harvard.edu/abs/2006ApJ...651.1256K
Stansberry et al. 2004. ApJ Supl. 154, 463:
http://adsabs.harvard.edu/abs/2004ApJS..154..463S

MIPS and IRS PUI
Observations of moving sources

Licandro et al. 2009. A&A 507, 1667L:
http://adsabs.harvard.edu/abs/2009A%26A...507.1667L
Lisse et al. 2009. PASP 121, 968: http://adsabs.harvard.edu/abs/2009PASP..121..968L
Fernandez, Jewitt & Ziffer 2009. AJ 138, 240:
http://adsabs.harvard.edu/abs/2009AJ....138..240F

Extended (moving) source imaging

Lamy et al. 2008. A&A 489, 777: http://adsabs.harvard.edu/abs/2008A%26A...489..777L
Bauer et al. 2008 PASP 120, 393: http://adsabs.harvard.edu/abs/2008PASP..120..393B
Kelly, Reach & Lien 2008. Icarus 193, 527:
http://adsabs.harvard.edu/abs/2008Icar..193..572K

Reach, Kelley, & Sykes 2007. Icarus, 191. 298:
http://adsabs.harvard.edu/abs/2007Icar..191..298R

Spectroscopy:

IRS
Observations of moving sources

Mueller et al. 2010. Icarus 205, 505: http://adsabs.harvard.edu/abs/2010Icar..205..505M
Lamy et al. 2010. A&A 516, 74: http://adsabs.harvard.edu/abs/2010A%26A...516A..74L

Observations of extended moving sources.

Reach et al. 2010. Icarus 208, 276: http://adsabs.harvard.edu/abs/2010Icar..208..276R
Bockelee-Morvan et al. 2009. AJ 696, 1075:
http://adsabs.harvard.edu/abs/2009ApJ...696.1075B
Woodward et al. 2007. 671, 1065: http://adsabs.harvard.edu/abs/2007ApJ...671.1065W
Lisse et al. 2006. Science 313, 635: http://adsabs.harvard.edu/abs/2006Sci...313..635L