PTFIDE: Palomar Transient Factory Image Differencing & Extraction

F. Masci, 2/2/2016

The Palomar Transient Factory (PTF) and its successor survey currently underway, the *intermediate* Palomar Transient Factory (iPTF) have been advancing our knowledge of the transient, variable, and dynamic sky at optical wavelengths since 2009 (Rau et al. 2009). The PTF Science Data System, which includes the data processing pipelines, archive, and user-interfaces to access the data have been developed at IPAC (Masci et al. 2016).

Flux-transients and moving objects are discovered from the input data stream using image differencing. This is performed by the PTF Image Differencing and Extraction pipeline (PTFIDE). Here, a new incoming image exposure is first astrometrically and instrumentally calibrated, then aligned, PSF-matched, gain-matched, and differenced with a deeper reference image. The reference image is generally a co-add of high-quality historical image exposures and represents a "static" snapshot of the sky. Transient candidates (flux excesses) in the difference image are then detected. A wealth of metrics for each transient source candidate are also computed. This includes for example photometry using both PSF-fitting and concentric apertures; PSF goodness-of-fit; and ellipticity (shape) metrics using their 2D light-profiles. These metrics are then fed to a (prior-trained) machine-learned classifier to assign reliability scores to each transient candidate. Only those candidates with the highest reliability are then retained for further examination and follow-up. Figures 1 and 2 show examples input exposures from the PTF survey and the resulting difference images.

The machine-learned vetted candidates are also used as input to a moving-object detection pipeline. This was also specifically written for PTF and is similar to the classic MOPS software. Here, the transient detections are linked using velocity-matching to first generate moving-object tracklets. These are then merged to generate tracks over longer timespans. Figure 3 compares a color-composite co-add of exposures at three epochs with a composite made from difference images.

References

Rau, A., Kulkarni, S. R., Law, N. M., et al., 2009, PASP, 121, 1334

Masci et al., 2016, PASP (in preparation), preview:
http://web.ipac.caltech.edu/staff/fmasci/home/masci_ptfide.pdf

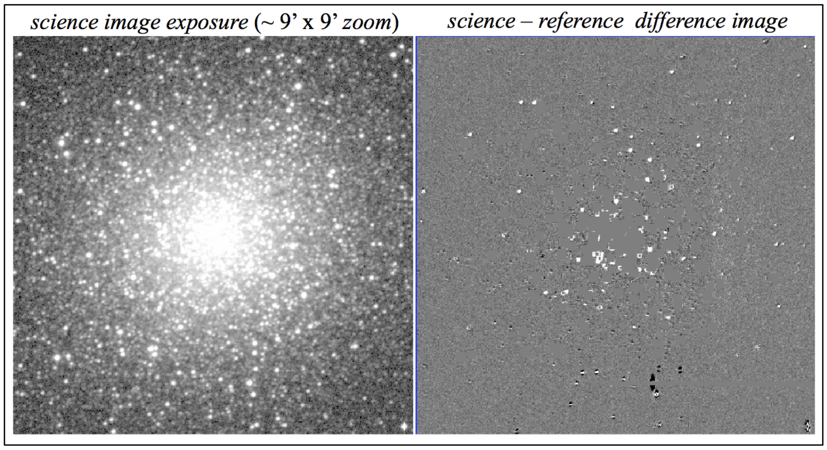

Figure 1: PTF R-band image exposure containing the M13 Globular Cluster (*left*) and the corresponding difference image (*right*). The bright residuals in the difference image are known RR-Lyrae variable stars caught in their high amplitude state.

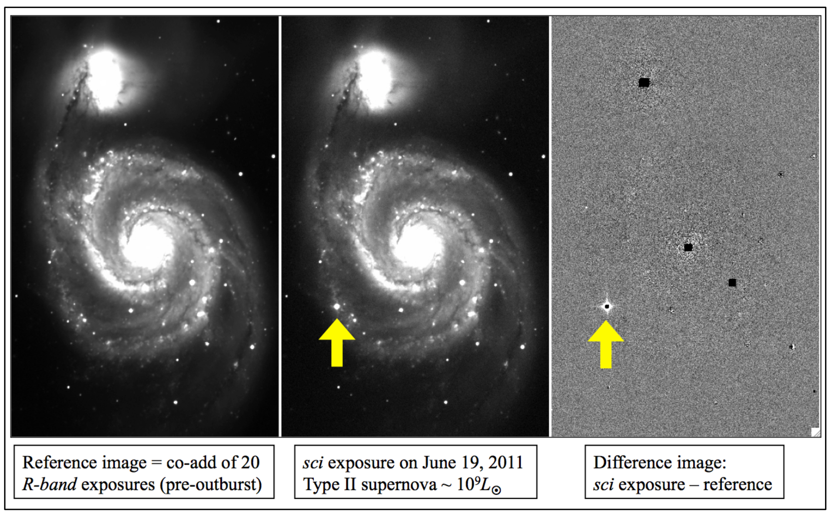

Figure 2: Reference image (*left*), PTF science image exposure (*middle*) and resulting difference image (*right*) on the M51 galaxy at the time of Supernova 2011dh. The core of the supernova is saturated in the difference image.

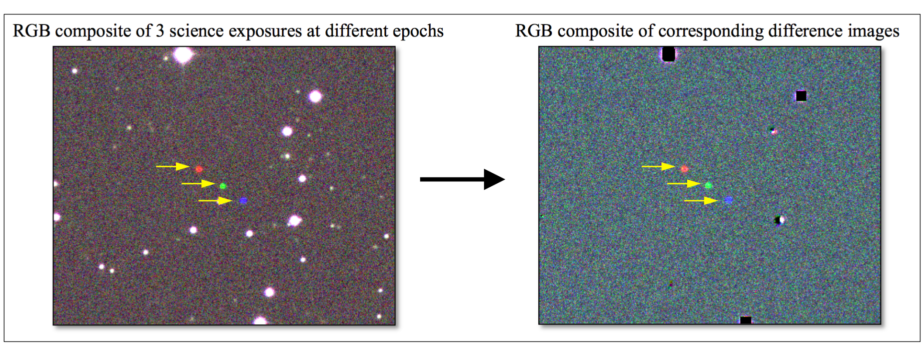

Figure 3: Color-composite of three PTF R-band exposures containing a moving object (*left*) and composite of the corresponding difference images (right). The moving object is more easily discernable in the difference image. Dark regions in the difference-image composite are saturated pixels.