~100 yr Search for Large Amplitude Variables in DASCH Scans Near M44

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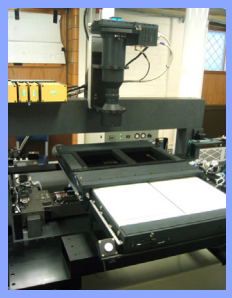
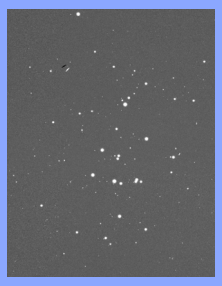


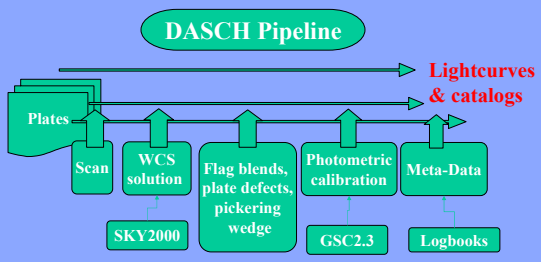
Abstract: Astronomical source variability is poorly explored on ~1-100y timescales, where large scale systematic surveys are generally lacking. The Digital Access to a Sky Century at Harvard (DASCH) project provides unique source of long timescale variability of bright objects (B mag < 15), as well as complement of PanSTARR and LSST. Here we present our search for large amplitude variables (>0.5-1 mag) over ~600 plates which covered a radius~20 deg field (with radially decreasing coverage) centered on the open cluster M44. We found more than 400 new variables, among them there are Algol eclipsing binaries, RR Lyr, Mira, pulsating stars, flare stars, R Coronae Borealis (RCB) candidates, and most interestingly, several very unusual mysterious objects. Three unusual variables are presented with lightcurves and spectra as examples.



I. Introduction to DASCH:

Digital Access to a Sky Century at Harvard

The Harvard College Observatory (HCO) maintains a collection of more than 500,000 glass astrophotographic plates that cover both the northern and southern skies from the 1880s to the 1980s. These 8x10 & 14x17 inch Plates cover 5 - 25 degrees on a side. The DASCH collaboration has developed an ultra-high speed digital plate scanner (*Simcoe et al.* 2006) which will ultimately enable the full Harvard plate collection to be digitized. As demonstration projects for the science case, we have scanned more than 3000 plates in several different fields, including the open cluster M44, Baade's window in Galactic center and several Quasars. Here we present our search results for large amplitude variables in DASCH scans near M44.



- Typical photometry accuracy: 0.1~0.2 mag
- Typical astrometry accuracy: 1~5 arcsec

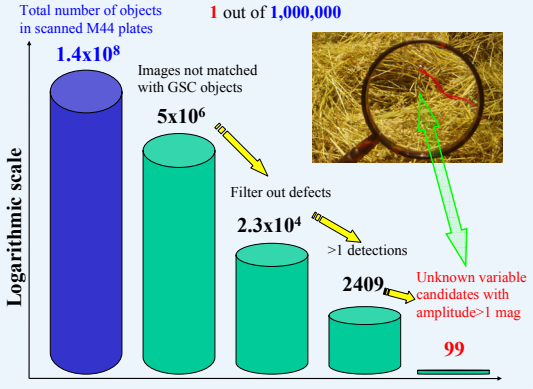
For more details on our pipeline, see *Laycock et al.* 2009 and *http://hea-www.harvard.edu/DASCH/*

II. Search for needles in a haystack

In order to search for new variables, we have to get rid of numerous multiple images and plate defects. We developed filters in both astrometry and photometry, successfully filtered out >95% plate defects. After that, we remove dubious plates with large amount of defects, and require at least 2 detections for any variable candidates.

For non-GSC objects:

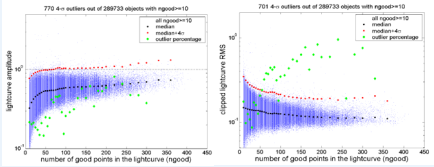
99 new variables found out of 1.4x10^8 measurements



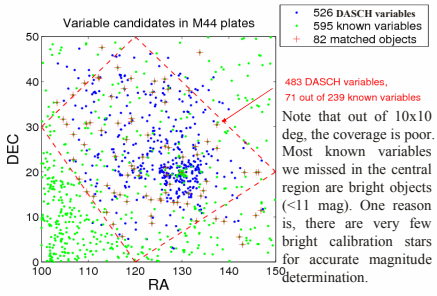
III. Variable search algorithm

- Select 4-sigma outliers of objects with large lightcurve rms or amplitude, only use good measurements passed defect filters.
- Random matches with grain noises show false variability where shallower plates yield brighter points near the flux limit. Galaxies show false variability because more galaxy pixels appear above the noise as plate exposure depth increases. We account for these two effects with a filter that searchs for a correlation between measured magnitude and limiting plate magnitude with correlation coefficient<-0.5 or >0.5.
- We also remove plates with 3-sigma more outbursts than average.

1. Preliminary candidates with large rms or amplitude



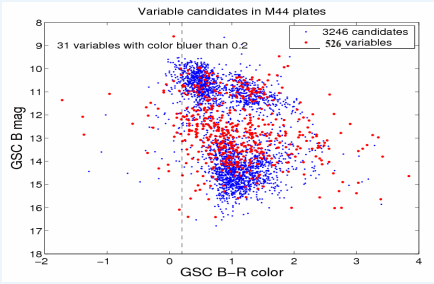
2. Spatial distribution of the variables



483 DASCH variables, 71 out of 239 known variables

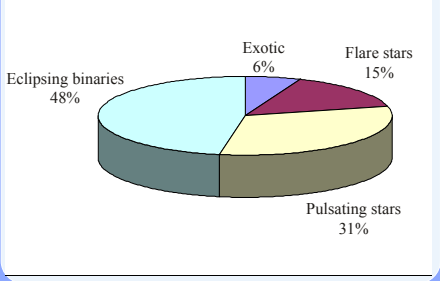
Note that out of 10x10 deg, the coverage is poor. Most known variables we missed in the central region are bright objects (<11 mag). One reason is, there are very few bright calibration stars for accurate magnitude determination.

3. Color distribution of the variables



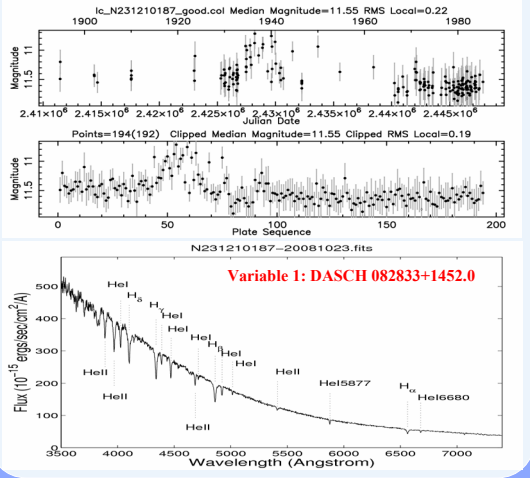
Clustering of candidates at the bright end is due to larger lightcurve rms caused by larger errors at the bright end, and is not real.

Demographics of DASCH Variables

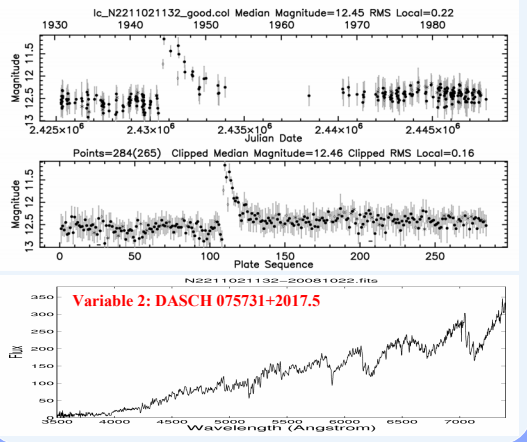


IV. Three unusual long-term variables

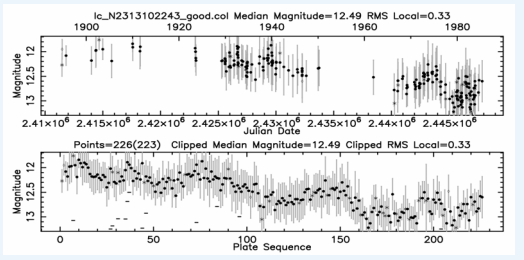
1. A He-rich hot sub-dwarf with a 10 yr flare?

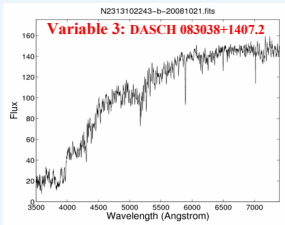


2. An M star with a 10 yr flare?

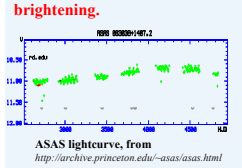


3. A K star with ~100 yr long-term variation?





Only variable 3 is also detected by ASAS, but with ~0.3 mag brightening.



ASAS lightcurve, from *http://archive.princeton.edu/~asas/asas.html*