DASCH on KU Cyg: a 5 year dust accretion event in ~1900

Sumin Tang

Jonathan Grindlay, Edward Los, Mathieu Servillat

Harvard-Smithsonian Center for Astrophysics

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Introduction to DASCH

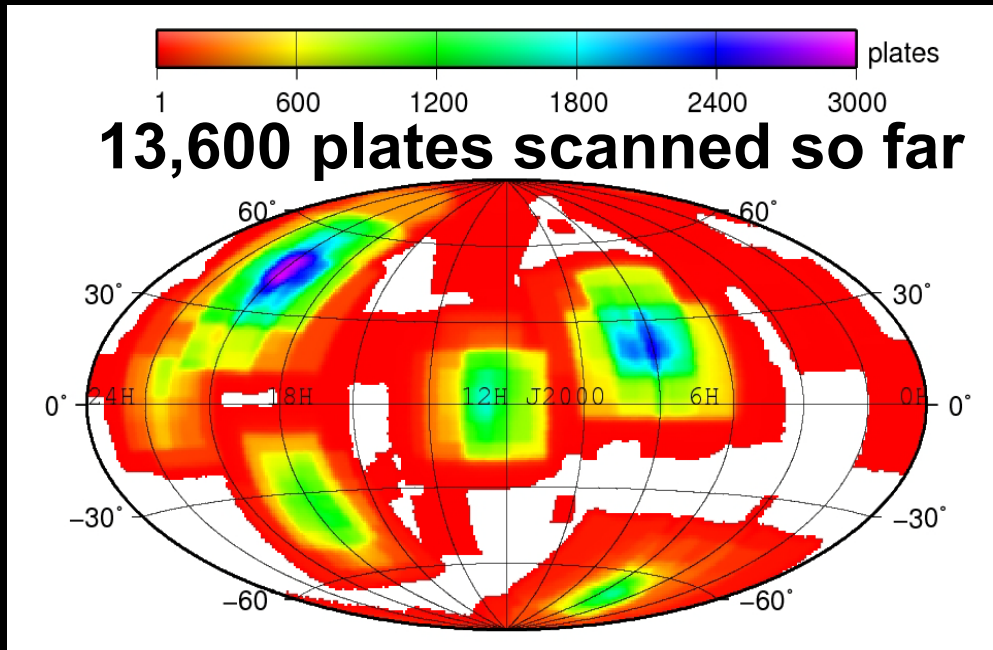
Digital Access to a Sky Century@Harvard

Digitize and Measure the Harvard Plates
to open the ~100yr TD Window

- ~530,000 photographic plates between 1880s-1980s covering the whole sky (*Grindlay et al. 2009*).
- ~500-1500 measurements for each object with B~10-14 (up to 18 mag in some regions)
- Study temporal variations of a wide variety of objects (stars to AGNs)
- Astrometry: 0.8-3 arcsec

  Photometry: 0.1-0.15 mag (*Laycock et al. 2010*).

RA-Dec map of scanned plates:



KU Cyg

Popper 1964, 1965; Olson 1988; Olson et al. 1995; Smak & Plavec 1997

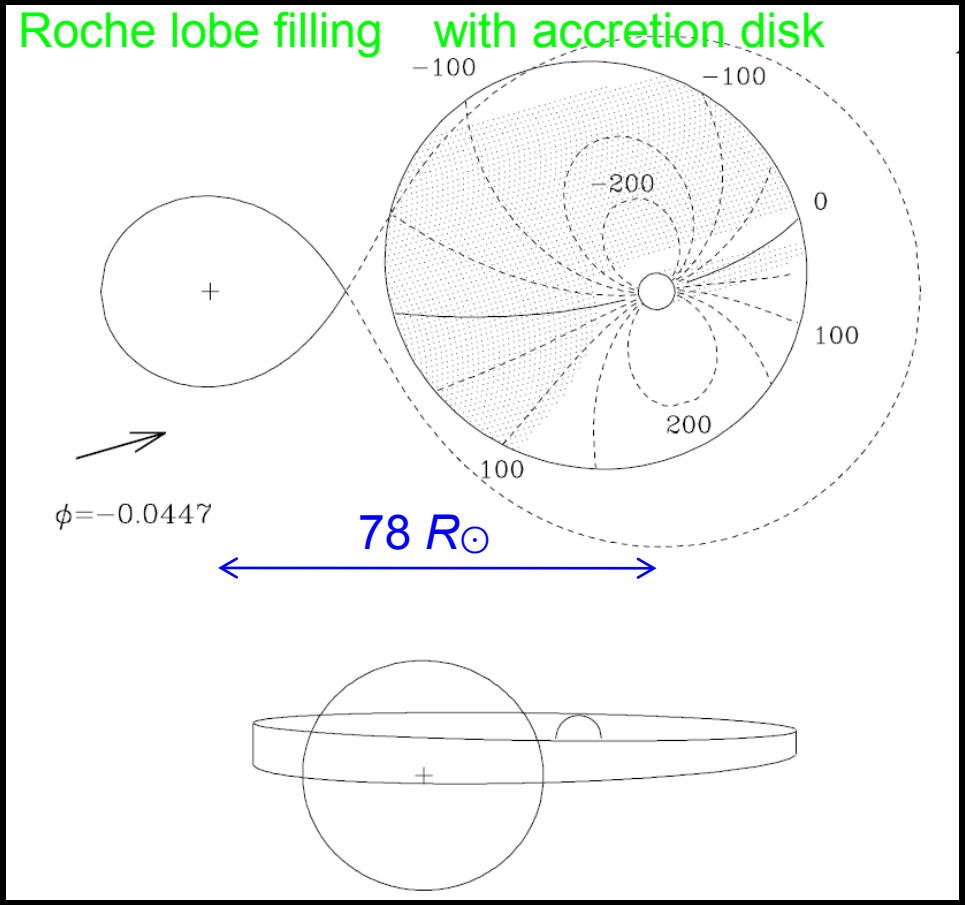
- Algol-type eclipsing binary

3.85 $M_\odot$ F MS star + 0.48 $M_\odot$ K5III

- Large, thick and dusty accretion disk around the F star: ~10^{-8}-10^{-5} $M_\odot$
- Peak accretion rate: ~10^{-6} $M_\odot$/yr
- Accretion timescale: a few years
- P=38.439484 days, i=86-86.5 deg
- Extinction of the F star due to the disk: ~1.3 mag (*Smak & Plavec 1997*)

0.48 $M_\odot$ K5III Roche lobe filling

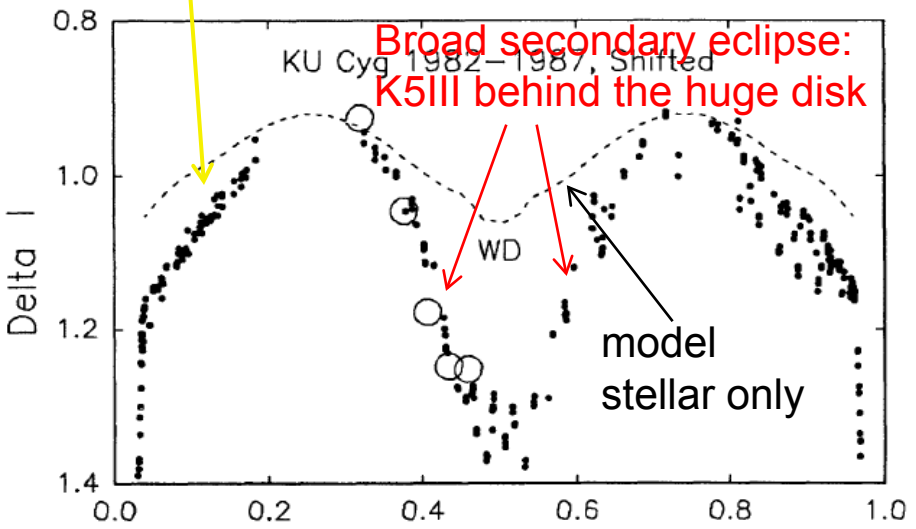
3.85 $M_\odot$ F MS star with accretion disk



Smak & Plavec 1997

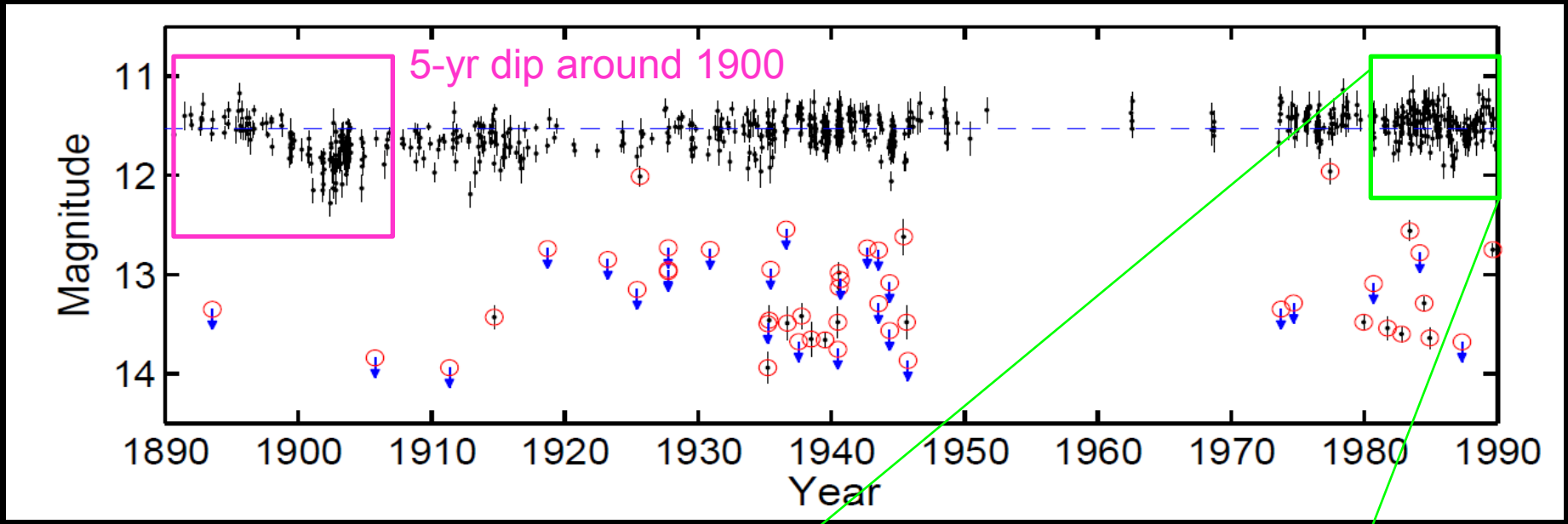
Broad wing in primary eclipse: disk behind the K5III

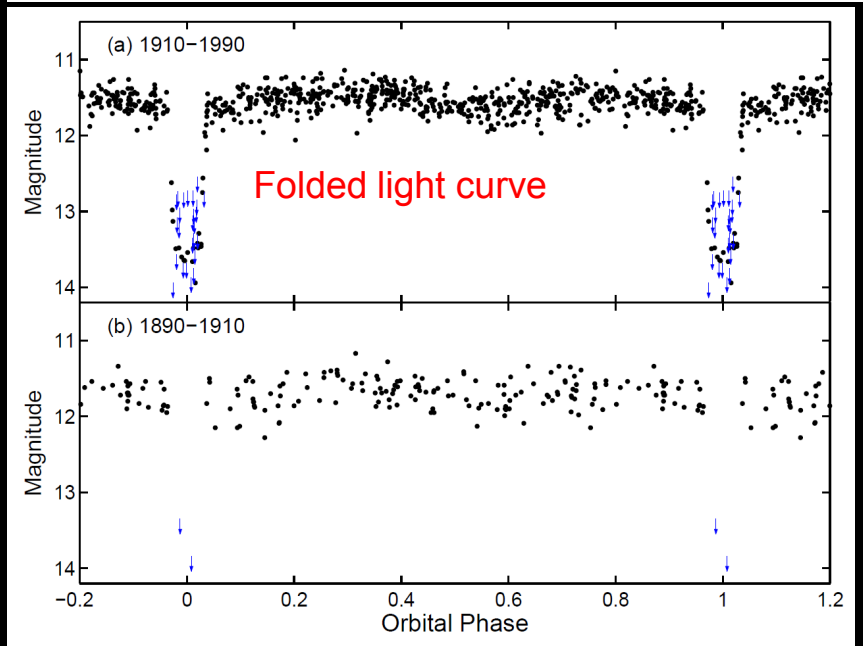
Broad secondary eclipse: K5III behind the huge disk

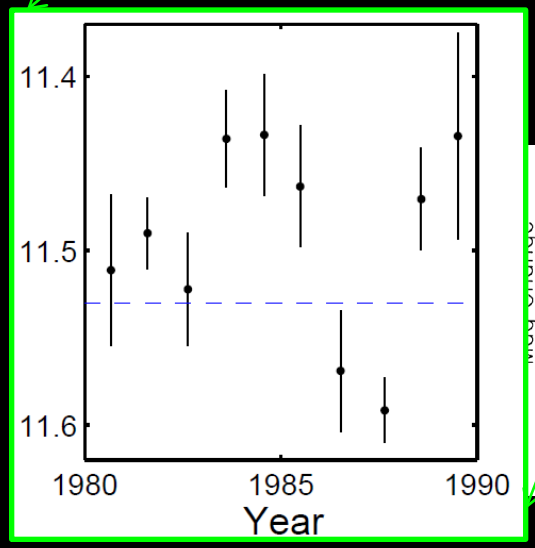


Olson 1988

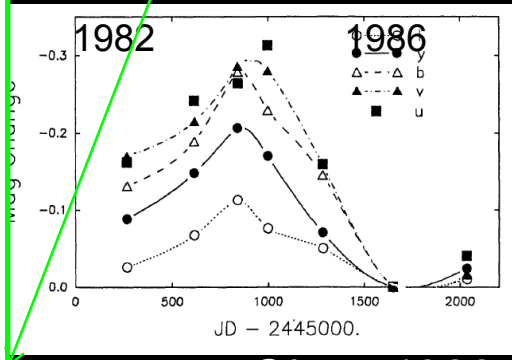
DASCH light curve of KU Cyg





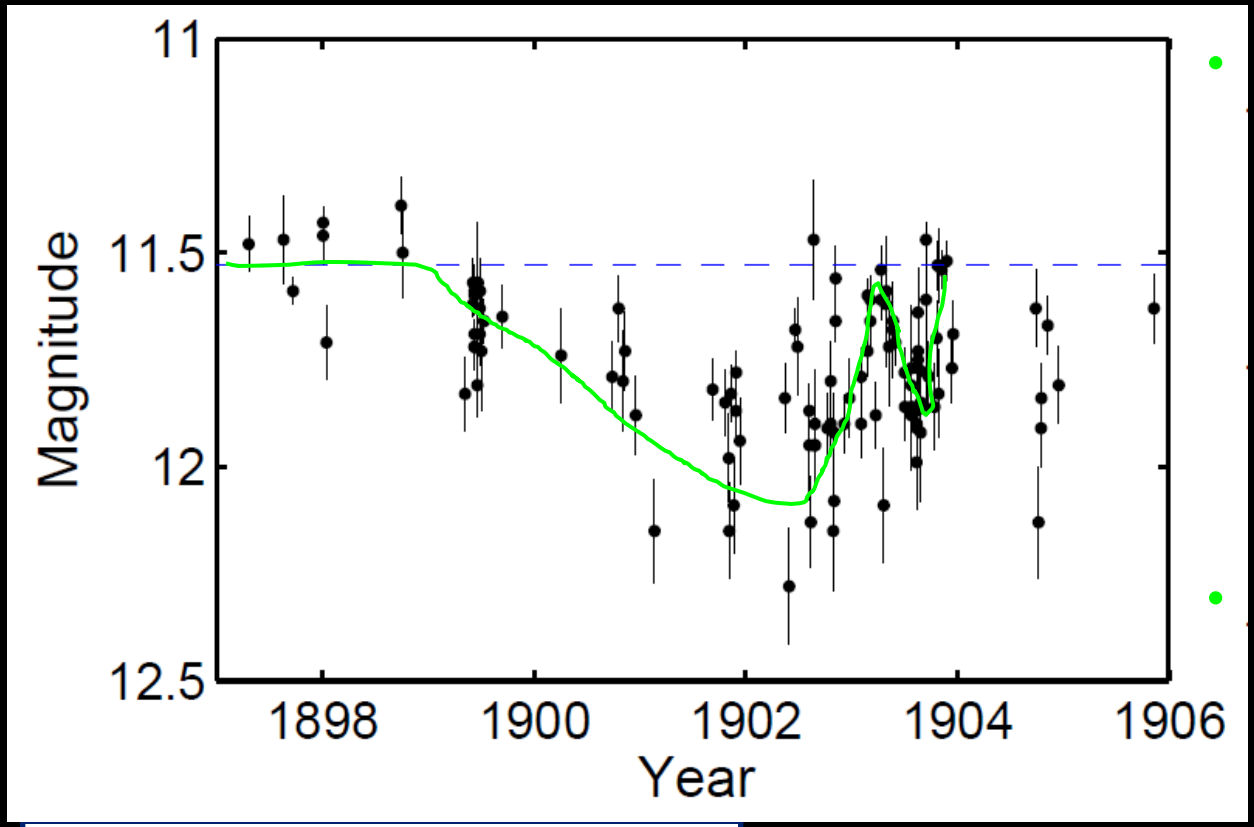


~0.1 mag variation on year timescales



Olson 1988

5-yr dip around 1900

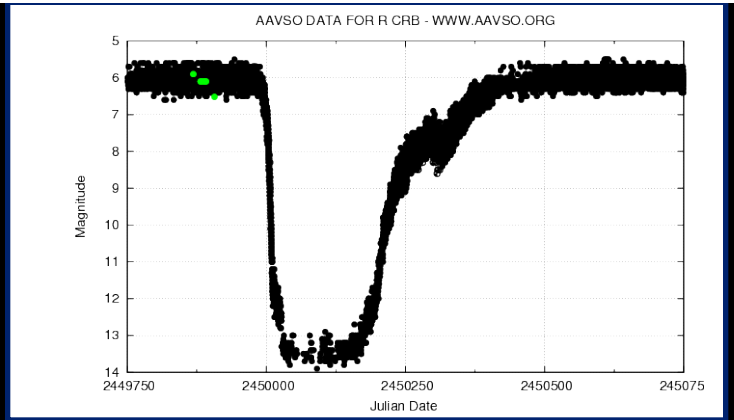


- Faded slowly and brightened back relatively fast with oscillations

Different from dust production & dispersion process as observed in RCB stars

- P=38.4 days + K5III contributes <10% L:

must be related to the F star and its accretion disk



RCB@AAVSO:

faster fading, slower recovery

b/c it usually takes short time to produce dust, and longer time for the dust to get dispersed

Possible explanation of the 5-yr dip:

increasing disk extinction of the F star arising from increasing mass transfer rate and thus higher disk mass

Fading:

- Increased disk mass and consequently increased optical depth, leading to increased attenuation
- Given the 1.3 mag extinction (0.7 mag blocking + 0.6 mag absorption by disk atmosphere) by the disk in normal state (Smack & Plavec 1997), double the original disk mass could yield a ~0.5-0.6 mag dimming

Brightening and fluctuations:

- Dust evaporates when moves closer to the F star -> brightening
- Some evaporated dust transported outwards, cool down to condensate (~1500 K), more extinction -> fading
- Energy release on the boundary layer when accreted on the F star -> brightening

Or higher dust to gas ratio?

- Dust clumps are ejected from K giants (*Tang et al. 2010*), so the dimming could be simply due to such an ejection from the K giant in this binary

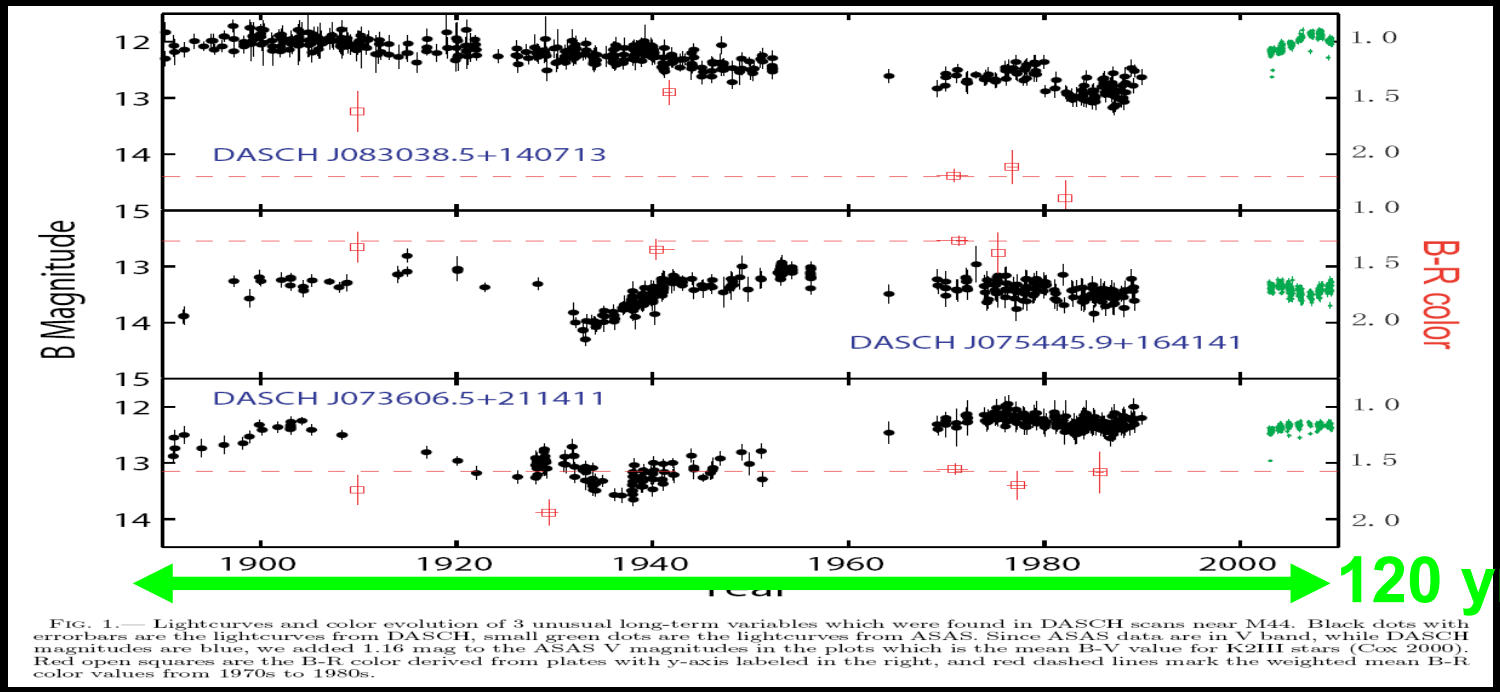


FIG. 1.— Lightcurves and color evolution of 3 unusual long-term variables which were found in DASCH scans near M44. Black dots with errorbars are the lightcurves from DASCH, small green dots are the lightcurves from ASAS. Since ASAS data are in V band, while DASCH magnitudes are blue, we added 1.16 mag to the ASAS V magnitudes in the plots which is the mean B-V value for K2III stars (Cox 2000). Red open squares are the B-R color derived from plates with y-axis labeled in the right, and red dashed lines mark the weighted mean B-R color values from 1970s to 1980s.

- Disruption of a 20 km-size comet

  Very unlikely origin but cannot be ruled out

- Rapid rise: dust moves in through the disk and is evaporated as it approaches the hot star

Summary

- We discovered a 5 year dip of KU Cyg around 1900, which is unique in the way that it faded slowly and brightened back relatively fast
- This fading-brightening event in KU Cyg is probably related to the accretion disk surrounding the F star, which provides interesting clue for the study of dust confinement, levitation and evaporation in an accretion disk.

The power of DASCH: 100 yr light curves of B<15 objects

- Explore long-term variability for known variables
- Discovery of exciting new types of variables