NEW VIEWS OF SU UMA-TYPE DWARF NOVAE FROM SIMULTANEOUS OPTICAL AND NEAR-INFRARED OBSERVATIONS

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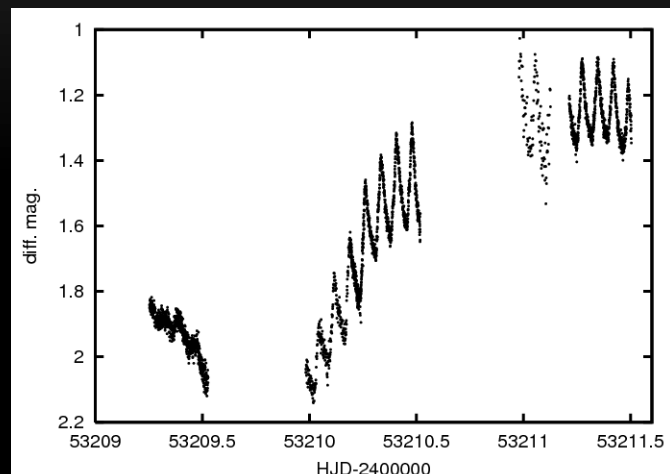
OUTLINE

- Superhump
  - with time-series photometry
  - with simultaneous optical & NIR time-series photometry
- Early superhump
  - with simultaneous optical & NIR multi-band time-series photometry

SUPERHUMPS AND EARLY SUPERHUMPS

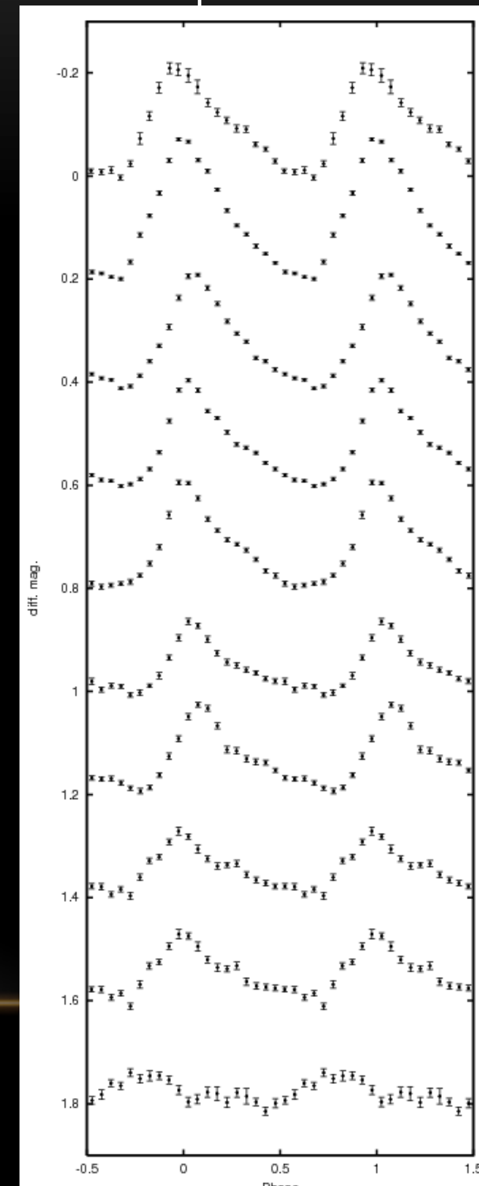
BASIC OBSERVATIONAL PROPERTIES

- Characterize superoutbursts
  - SU UMa-type dwarf nova
  - Late phase of superoutbursts in WZ Sge-type stars
- Having a period 1-4% longer than the orbital period.
- The superhump period is varaible through a superoutburst
  - Decreasing in most cases
  - Sometimes increasing



A growing phase of superhumps detected in V2527 Oph

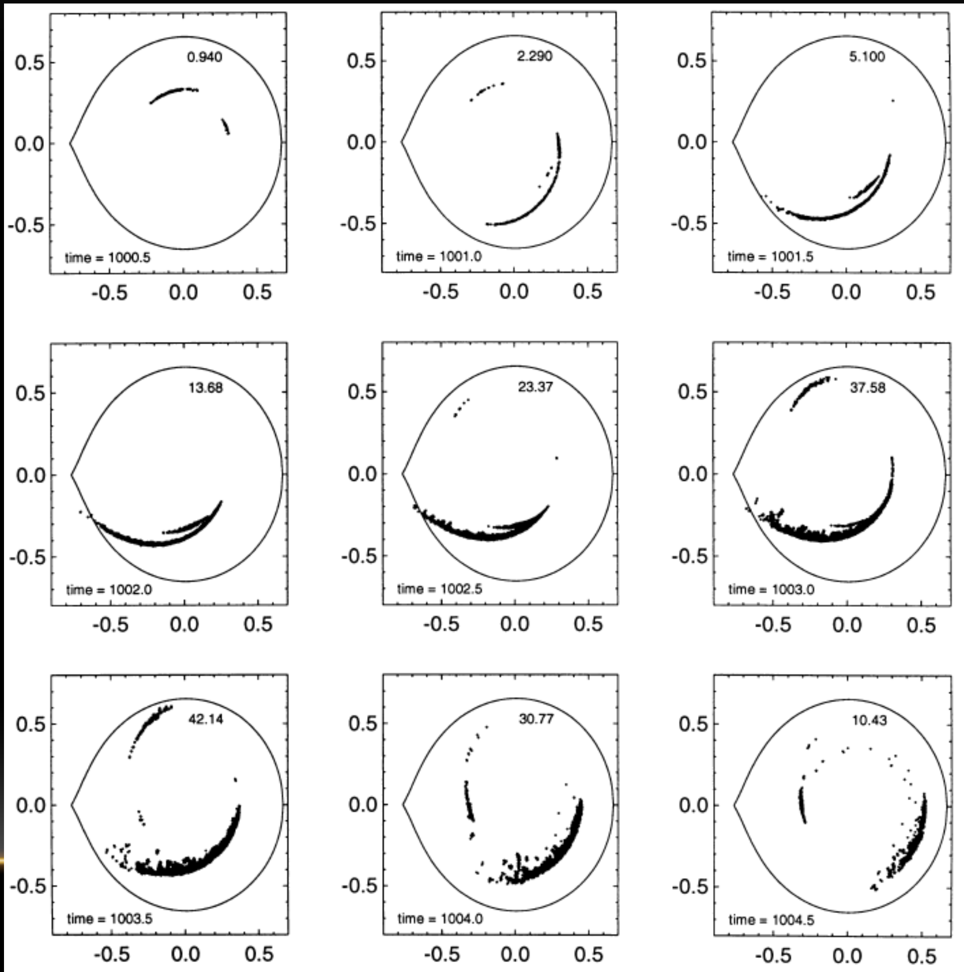
Superhump evolution during superoutburst in V2527 Oph



TIDAL INSTABILITY OF ACCRETION DISKS

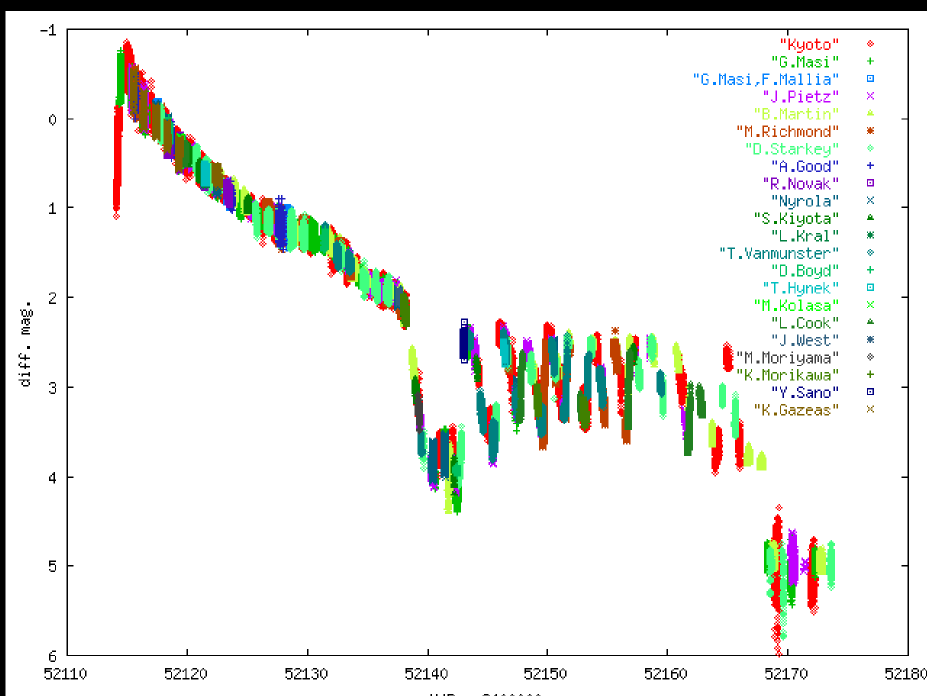
- Tidal instability in the disk
  - A resonance around the 3:1 radius of the disk
  - Eccentric disk
  - can explain the appearance and period of superhumps

Simulated superhump light sources (Murray 1998)



THE GOLDEN DAYS OF TIME-SERIES PHOTOMETRY WITH SMALL TELESCOPES

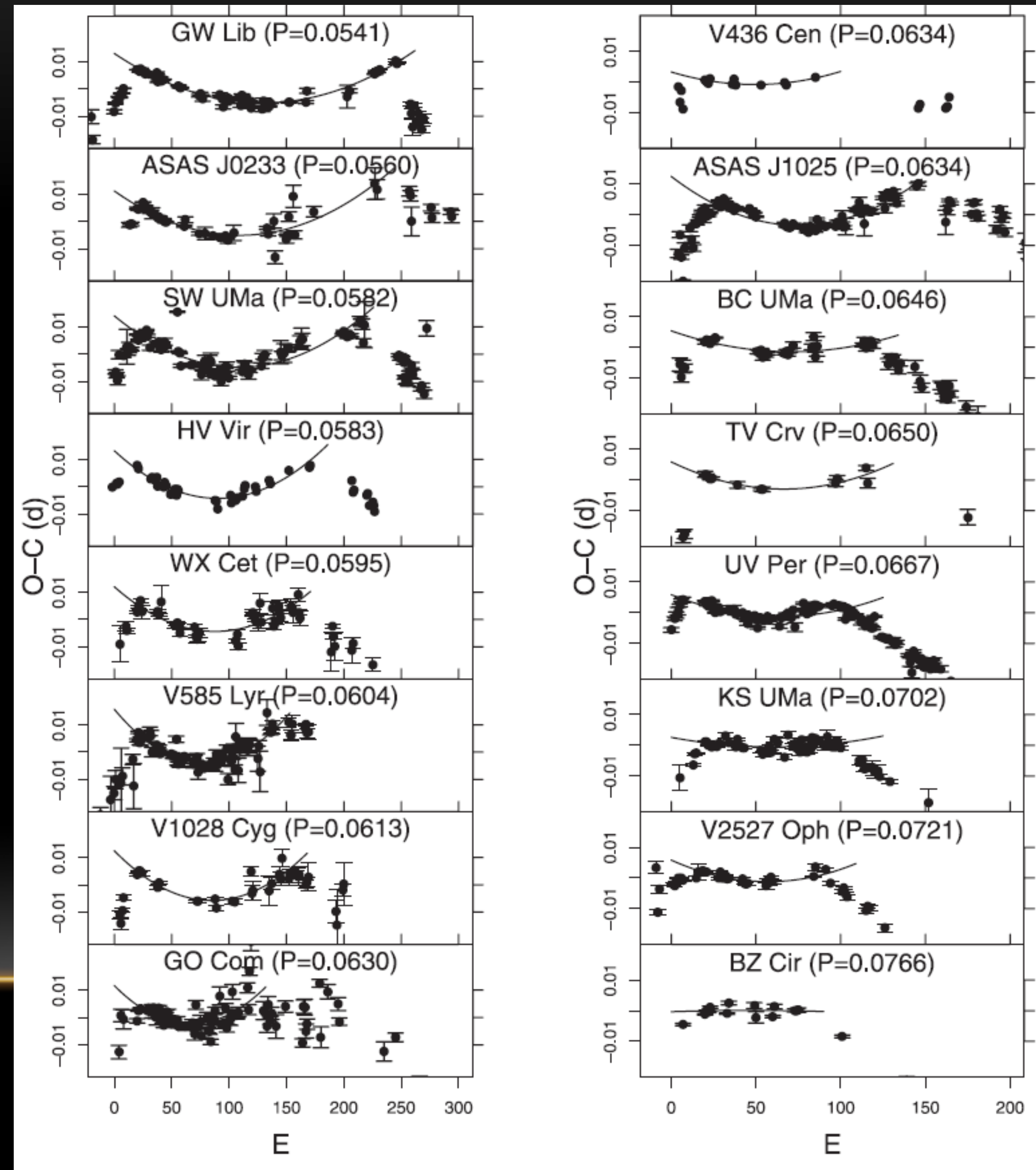
Online network of observers + Small telescopes and CCD cameras at a reasonable cost = Time-series photometry of variable covering ~24 hours



Example of densely sampled superoutbursts of WZ Sge-type dwarf nova (in the case of WZ Sge in 2001)

PERIOD CHANGE OF SUPERHUMPS

- The evolution of superhump period
  - Related to the radius of the accretion disk
  - A probe for the dynamics in the outbursting disk
- Until mid-1990's
  - Sometimes positive, sometimes negative period derivatives
  - No universal feature has not been established.
- Kato, et al. 2009, PASJ, 61, S395-S616
  - Universal features of the period evolution
    - Stage A: an early stage having a longer period
    - Stage B: a middle stage with a positive period derivative. (Outward propagation of an eccentricity wave.)
    - Stage C: a late stage with a shorter period (reappearance of the excitation at the 3:1 resonance radius)



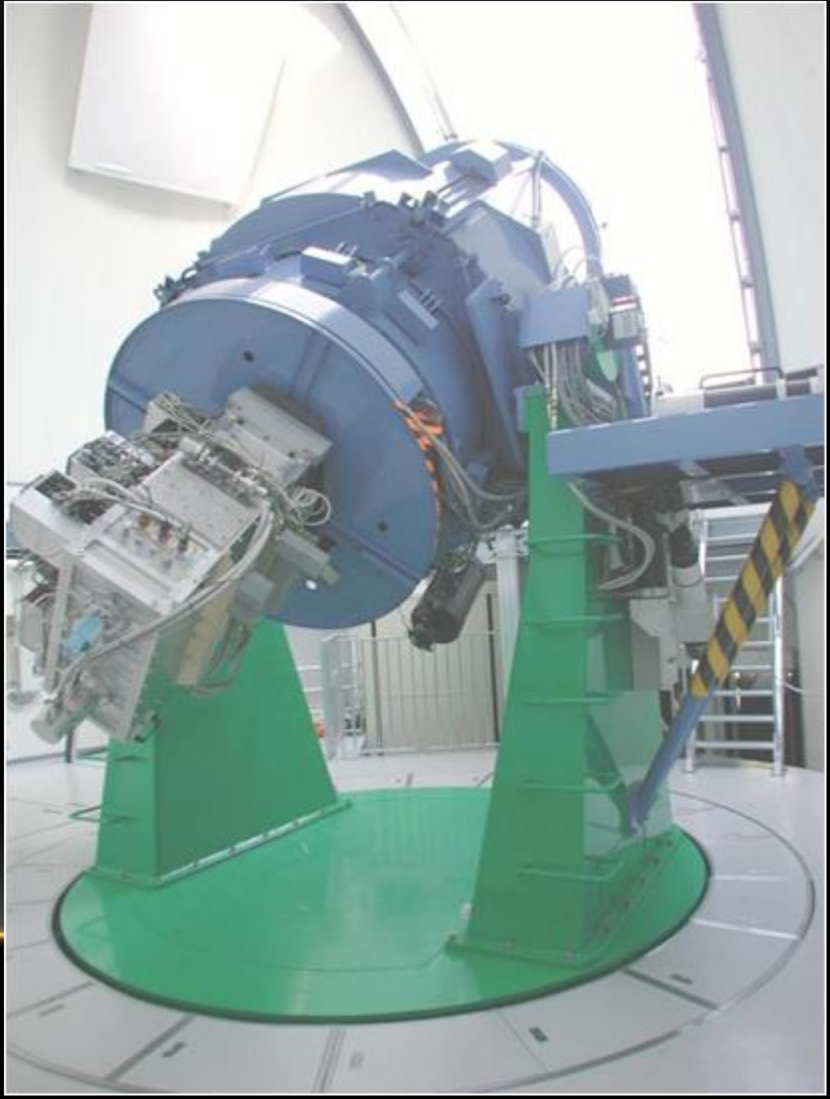
THE GOLDEN DAYS OF TIME-SERIES PHOTOMETRY WITH SMALL TELESCOPES

Online network of observers + Small telescopes and CCD cameras at a reasonable cost = Time-series photometry of variable covering ~24 hours

Aspects from densely sampled ligut curves + 1-m class telescopes having a flexible time for transients = ?

"KANATA": A 1.5-M TELESCOPE OF HIROSHIMA UNIVERSITY

- Since 2006
- Dedicated for astronomical transient objects
  - Cataclysmic variables
  - X-ray binaries
  - GRBs
  - Supernovae
  - AGNs (blazars)
- Unique observation modes
  - Simultaneous optical and NIR
  - polarimetry

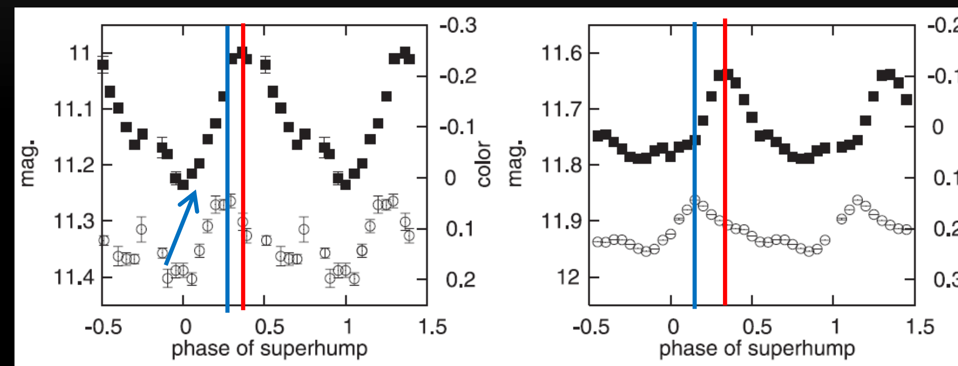


SUPERHUMPS

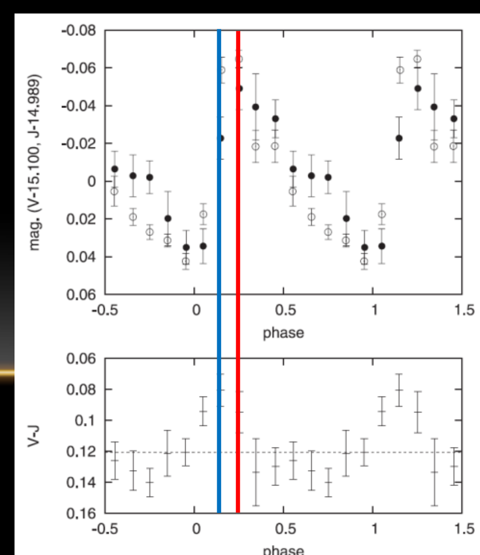
COLOR CHANGE IN SUPERHUMPS

- Previous study of superhump colors
  - Redder at the superhump maximum?
    - Hassall (1985) for EK TrA, Naylor et al. (1987) for OY Car
  - Bluer at the superhump maximum?
    - Schoembs & Vogt (1980), Stolz & Schoembs (1984)
  - Theoretically, the viscous heating lead to a higher temperature (Smak 2005)
- Our optical-NIR observation shows:
  - The bluest time precedes the superhump maximum

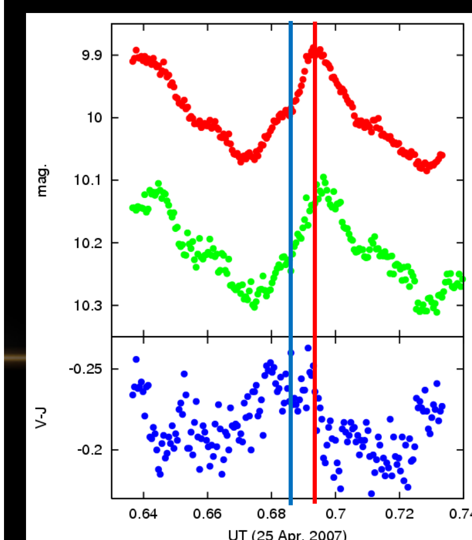
Superhumps in V455 And (Matsui, et al. 2009)



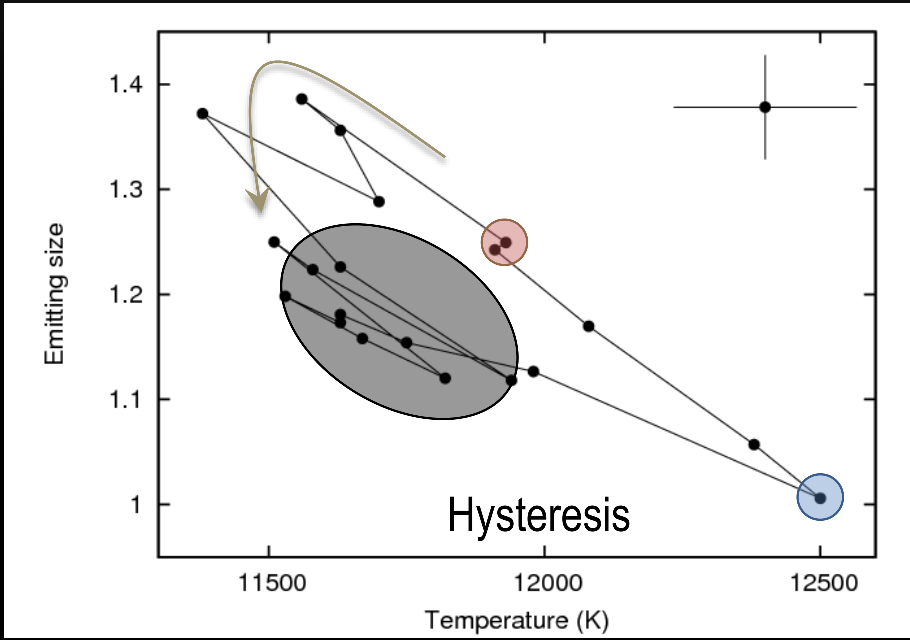
Superhumps in J0557+68 (Uemura, et al. 2010)

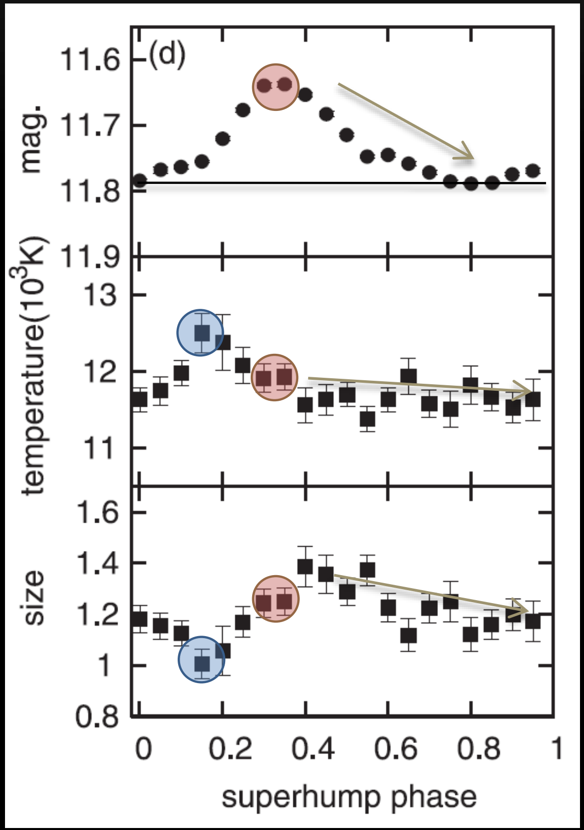


Superhumps in GW Lib (Uemura, et al. 2009)



HEATING AND COOLING PHASES OF SUPERHUMPS





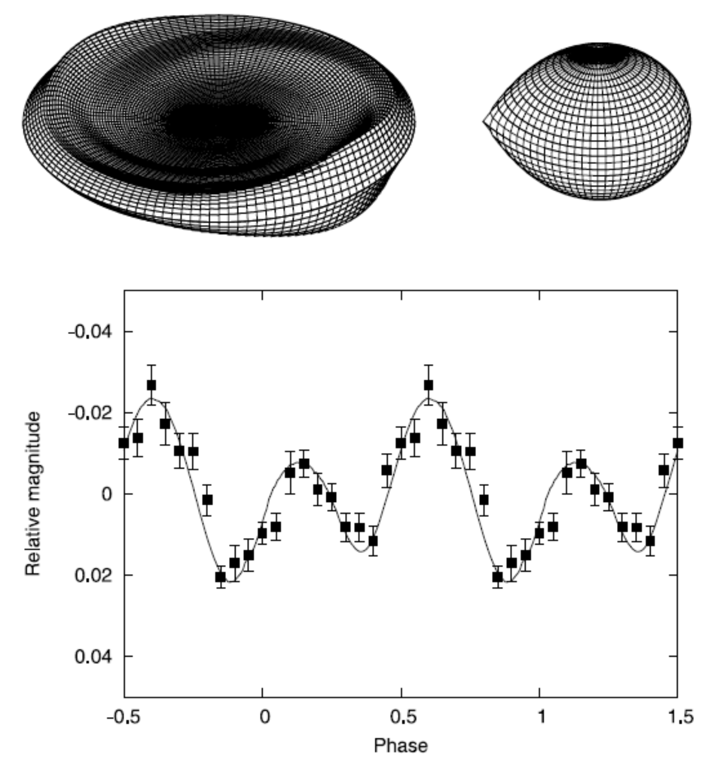
- Viscous heating, then cooling
- Superhump maximum ≠ Temperature maximm
- The expansion of a low tempepature region → superhump maximum

EARLY SUPERHUMPS

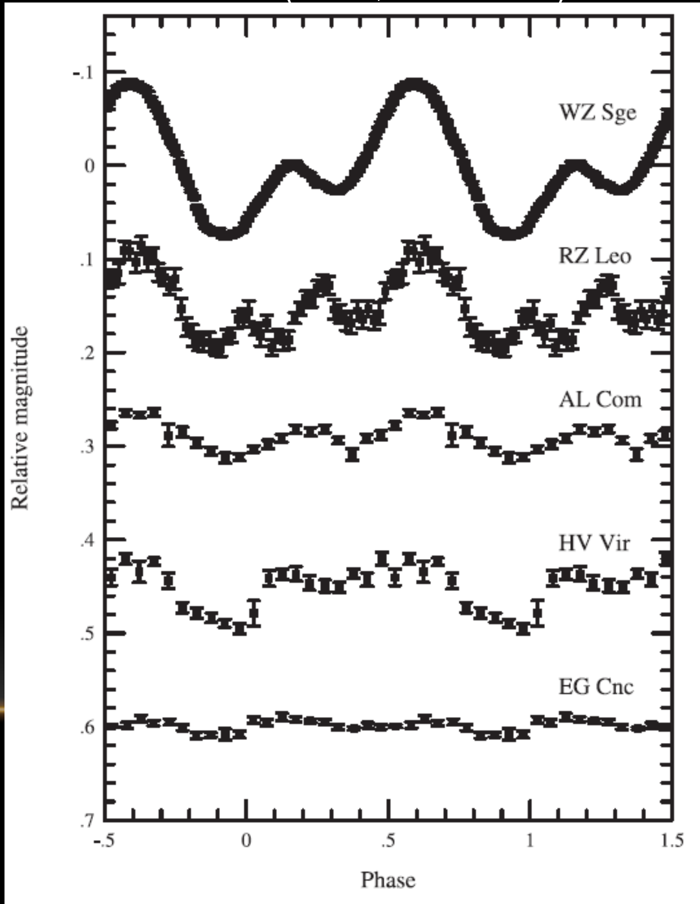
BASIC OBSERVATIONAL PROPERTIES

- Seen only during the earliest stage of a WZSge-type outburst
- Period = orbital period of binary
- Geometrical effect?

Two-armed spirals on the disk and early superhumps (Maehara, et al. 2007)



Zoo of early superhumps (Kato , et al. 2002)

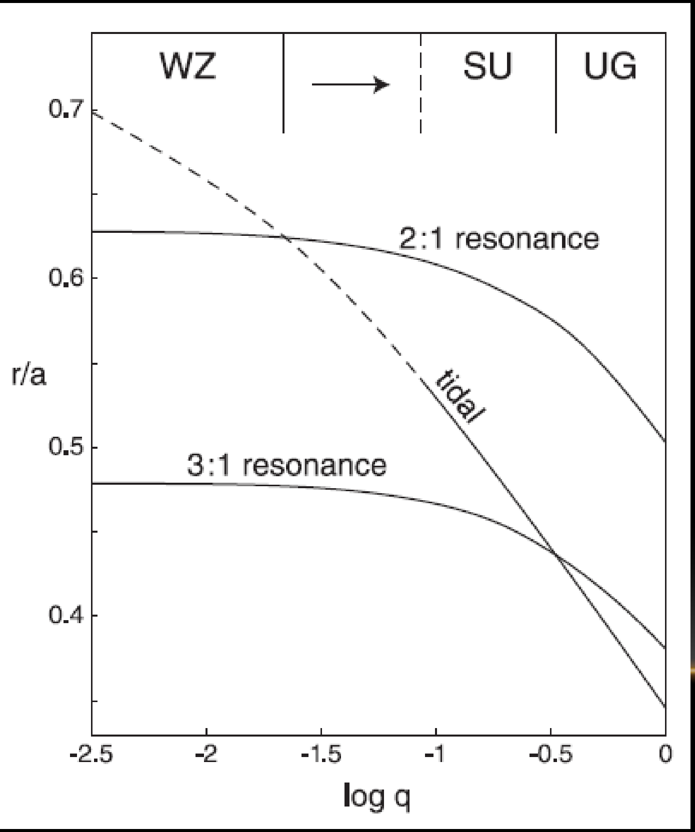


MODELS

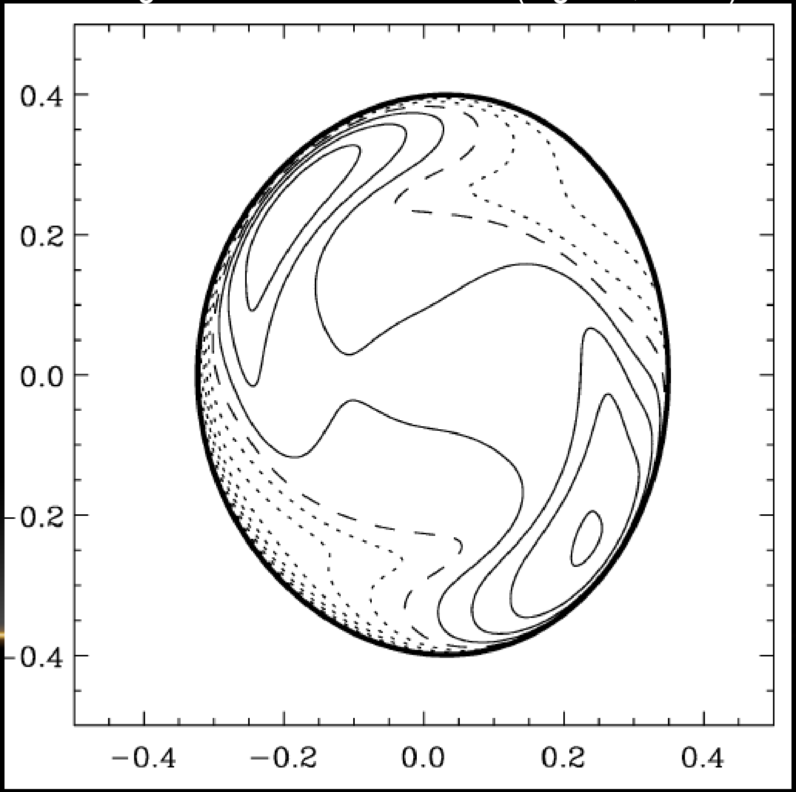
- The 2:1 resonance
  - Osaki & Meyer (2002)

- Tidally distorted disk
  – Kato (2002)
  – Even below the 2:1 resonance radius

Tidal truncation and resonance radii



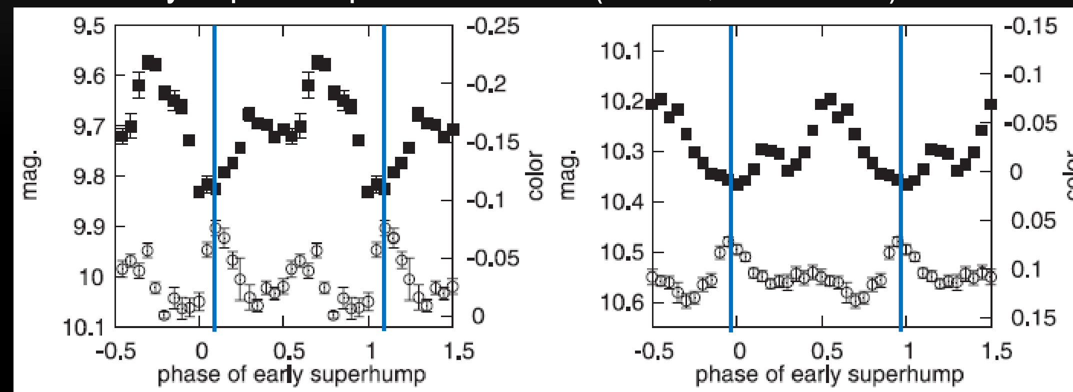
Height distortion in the disk (Ogilvie, 2002)



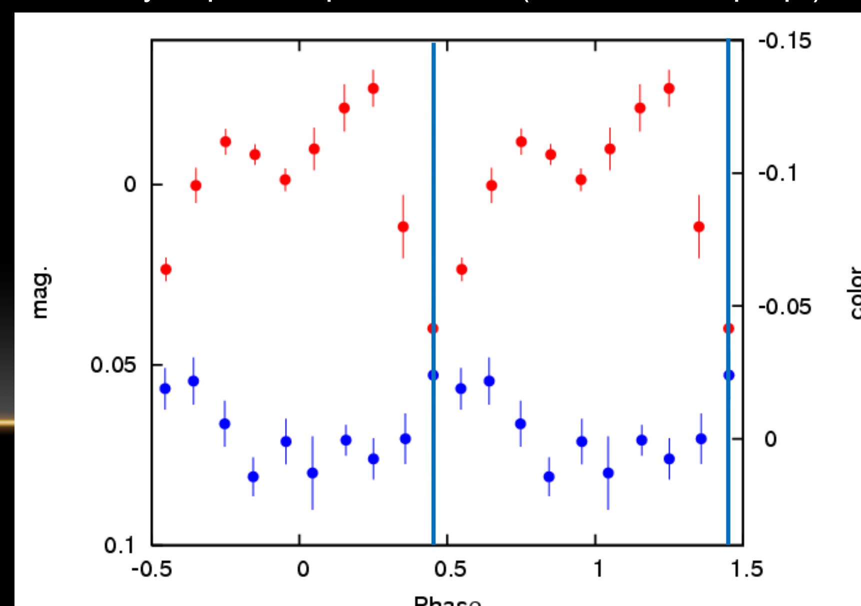
COLOR CHANGE IN EARLY SUPERHUMPS

- Successfully observed in V455 And & HV Vir.
- Bluest at the bottom of early superhumps
  - The hump component is red.
  - An elongated low temperature region is the origin of early superhump.

Early superhumps in V455 And (Matsui, et al. 2009)

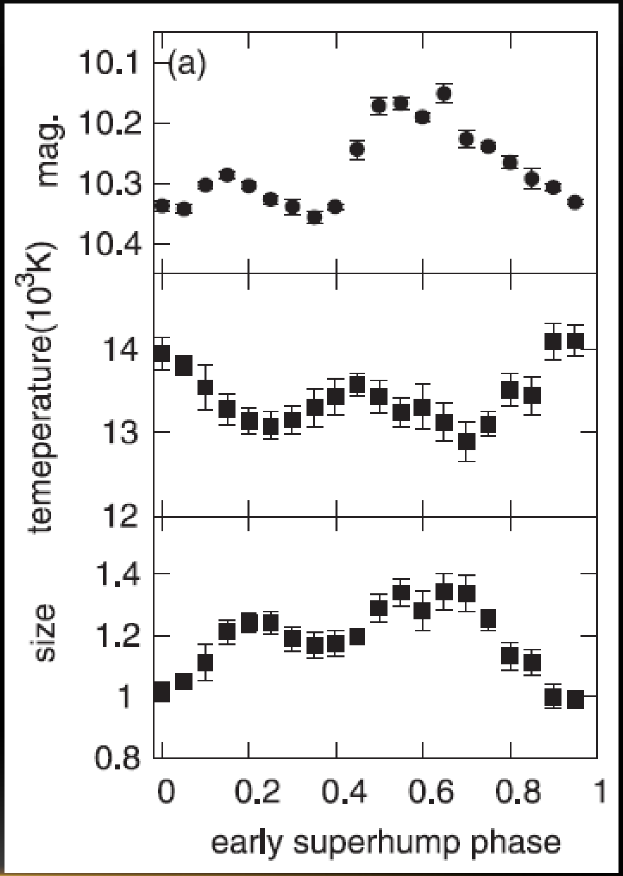


Early superhumps in HV Vir (Arai, et al. in prep.)



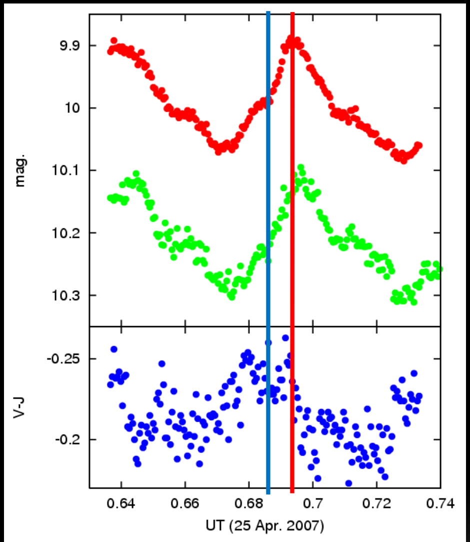
IMPLICATIONS FOR THE STRUCTURE OF DISKS

- The temperature and size of the disk, estimated from g,V,Rc,Ic,J,Ks-band photometric data for V455 And.
- The correlations between the light curve, temperature, and size are very simple.
- We see a elongated low temperature region during early superhumps.
- Tomography of the vertical structure of accretion disks?

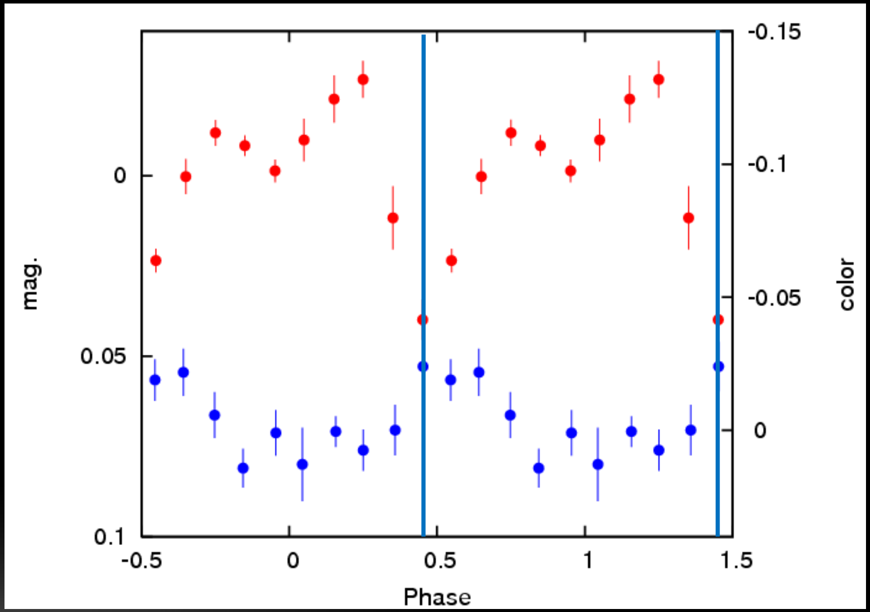


SUMMARY

- Superhump
  - Bluest phase, and then, superhump maximum
- Early superhump
  - Redder when brighter



Superhumps in GW Lib (Uemura, et al. 2009)



Early superhumps in HV Vir (Arai, et al. in prep.)