Orbital Evolution of Protoplanetary Dusty Clumps

-- The case in UXor type young star GM Cep

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Cluster mini workshop, 20 Nov 2015

Pre-Introduction

- YETI project (Young Exoplanet Transit Initiative)

  The purpose of YETI project is to find the exoplanet in the open cluster.

- XinJiang Astronomical Observatory (XAO)
- Maidanak Astronomical Observatory (MAO)
- Michael Adrian Observatorium

Pre-Introduction

Targets	Age(Myr)	Distance(pc)
Trumpler 37	4	900
25 Ori	7-10	300
IC 348	2-7	300
Col 69	5	450
NGC 1980	5-10	400

Each campaign observes 3 rounds

Each round takes about 2 weeks

Motivation

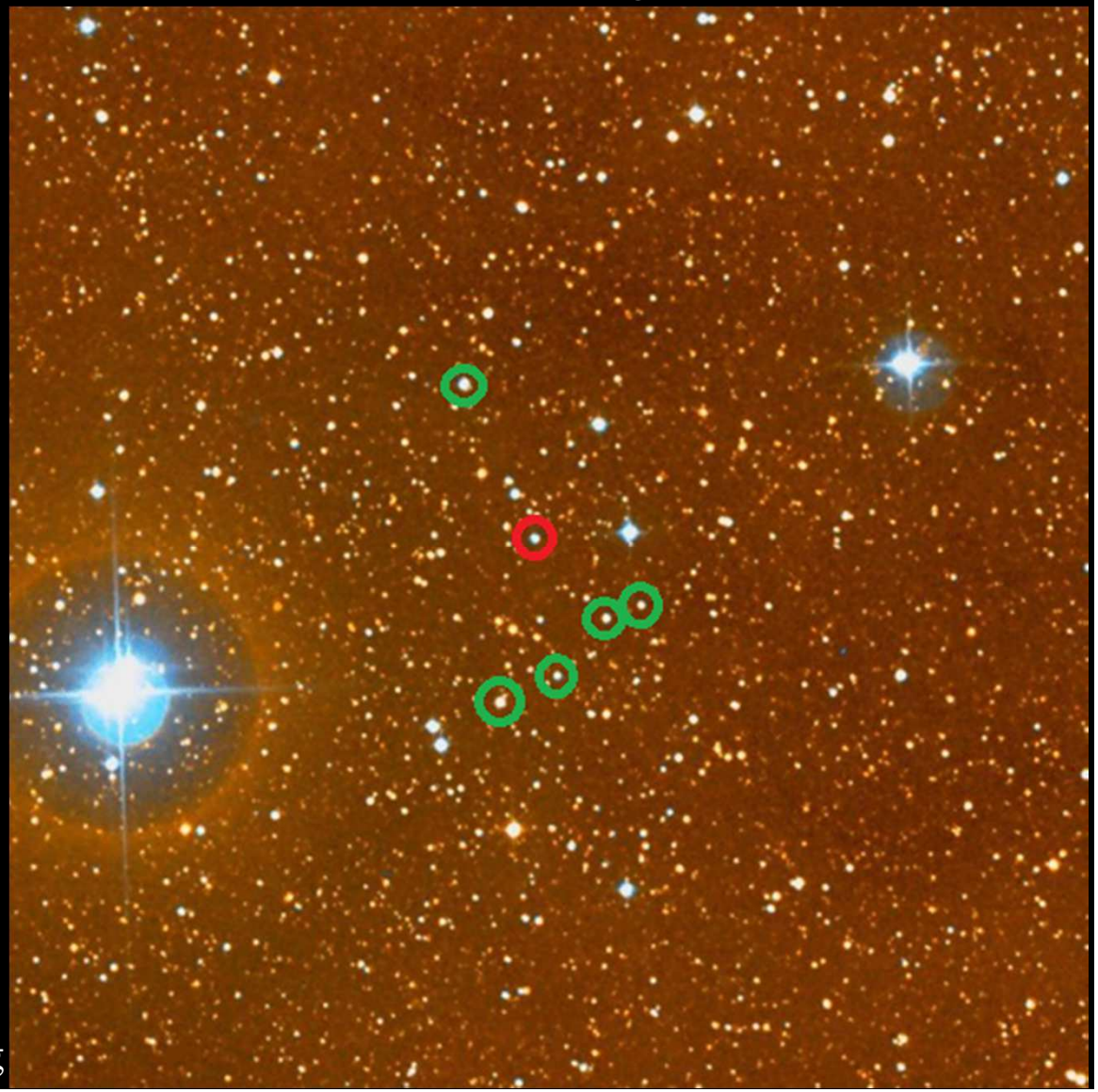
- To find evidence of exoplanet in the open cluster

  So far we did not find any young exoplanet in the young star system. By studying the young star system, trying to find the evidence of the formation and evolution of planet

Introduction

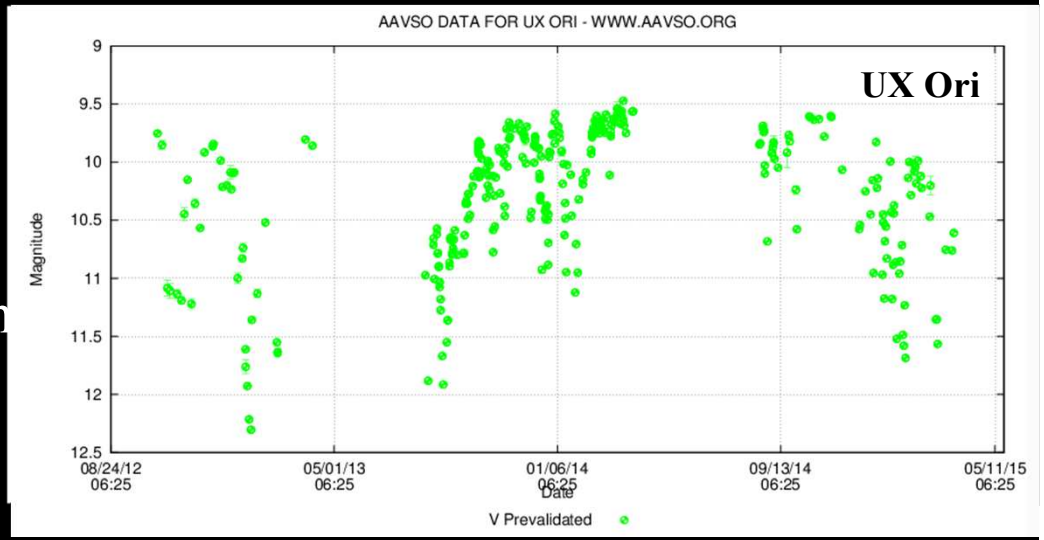
- GM Cep
  - Mass: ~2.1 $M_{\odot}$
  - Radius: 3-6 $R_{\odot}$
  - Solar type: G7V-K0V
  - Infrared excess
  - H-alpha emission
  - Polarization
  - Large amplitude brightness variation
  - Flare activity
  - Rapid rotation Vsin*i*=28 km/s

(Sicilia-Aquilar et al. 2008, Chen et al. 2012)



Introduction

- FUors - Herbig 1977 & 1989
  - ✓ Large accretion rate and outburst ~ 6 mag
- EXors - Herbig 1989
  - ✓ Recurrent outburst ~ 5 mag
- UXors - Herbst 1994
  - ✓ Circumstellar dust extinction



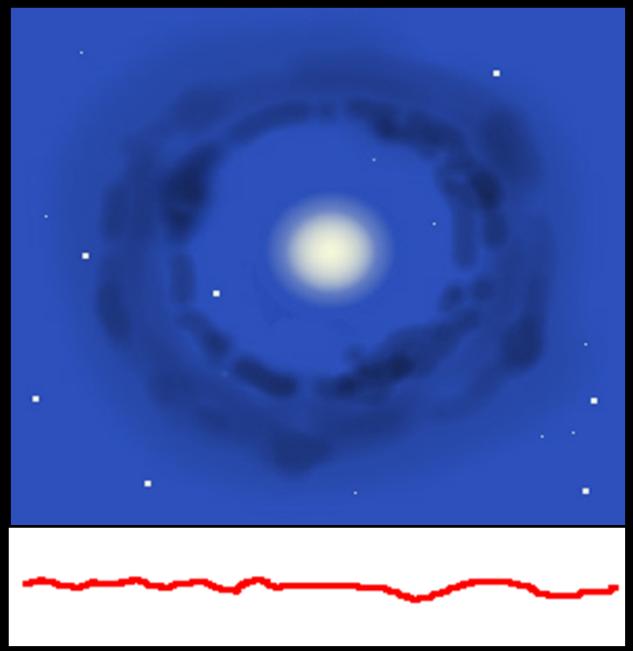
Histories of GM Cep

- ✓ Sicilia-Aquilar et al. regarded as an outburst star in 2008
- ✓ The outburst phenomenon was ruled out by Xiao et al. in 2010
- ✓ GM Cep was classified as UXor type star by Chen et al. in 2012
- ✓ Semkov et al. thought the star did not have period in 2015

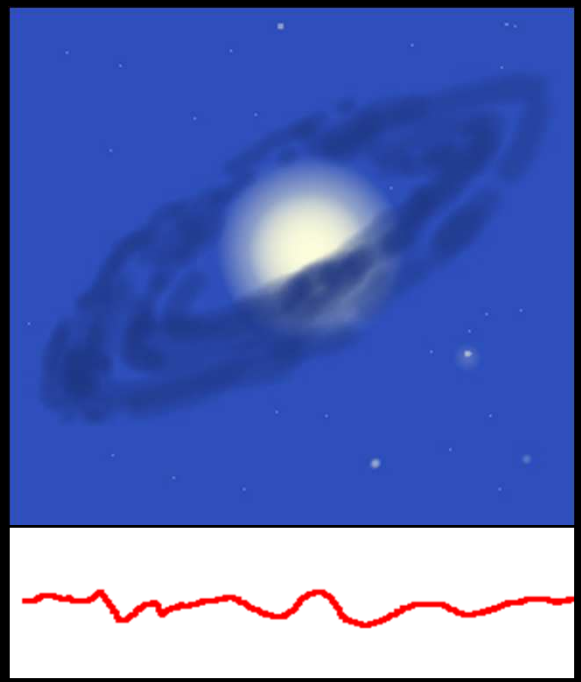
Introduction

UX Orionis stars – Mad variation

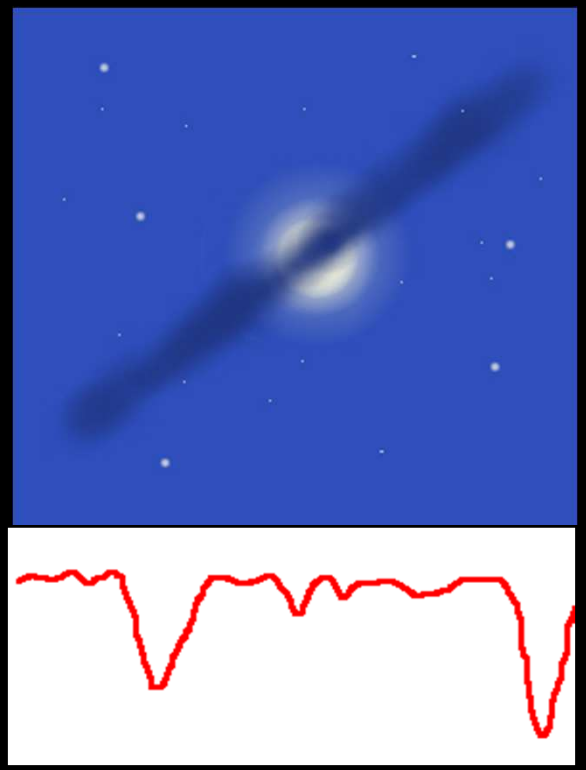
Named after the prototype of the class, UX Ori type variables (commonly called UXOrs) are intermediate mass, pre-main sequence Herbig Ae/Be and T-Tauri stars.



pole-on: Basic variation (if any) derives from Star spots only



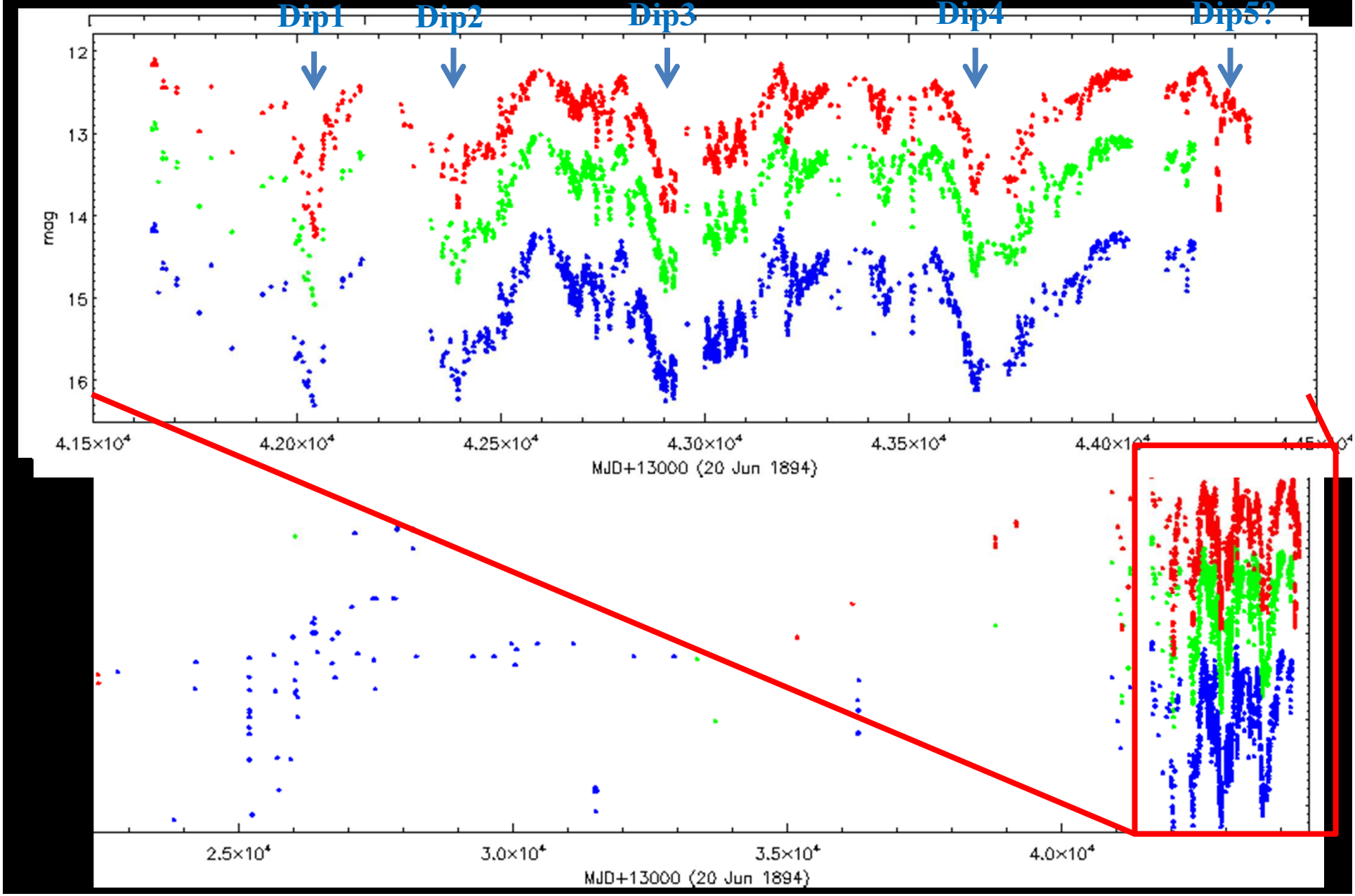
Oblique view: Basic variation plus some light variation due to transit of disc clumps



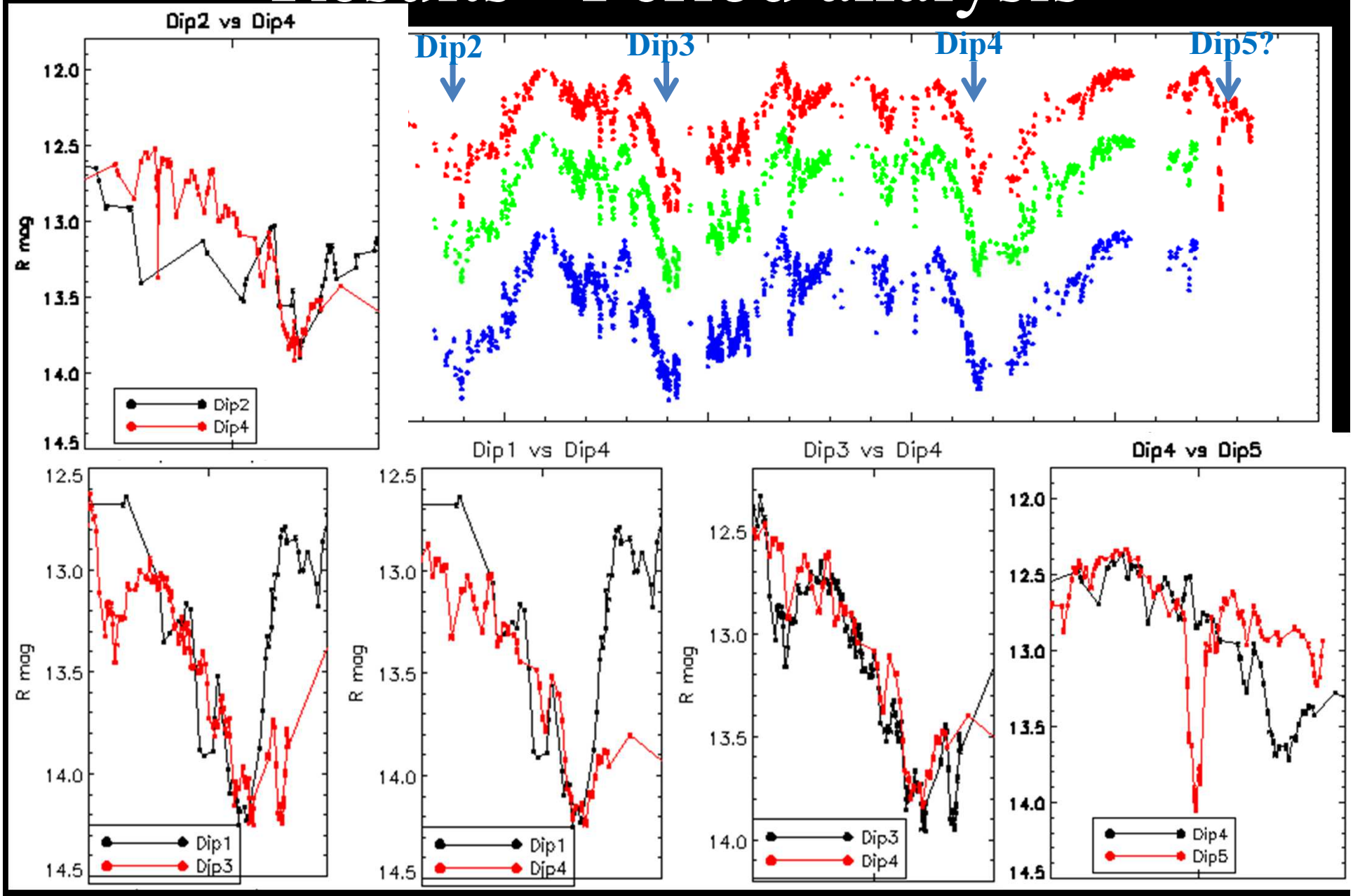
Edge-on view: Deep, more frequent fading due to transit of disc clumps

Credit by Prof. Pandey

Results - Brightness variation



Results - Period analysis



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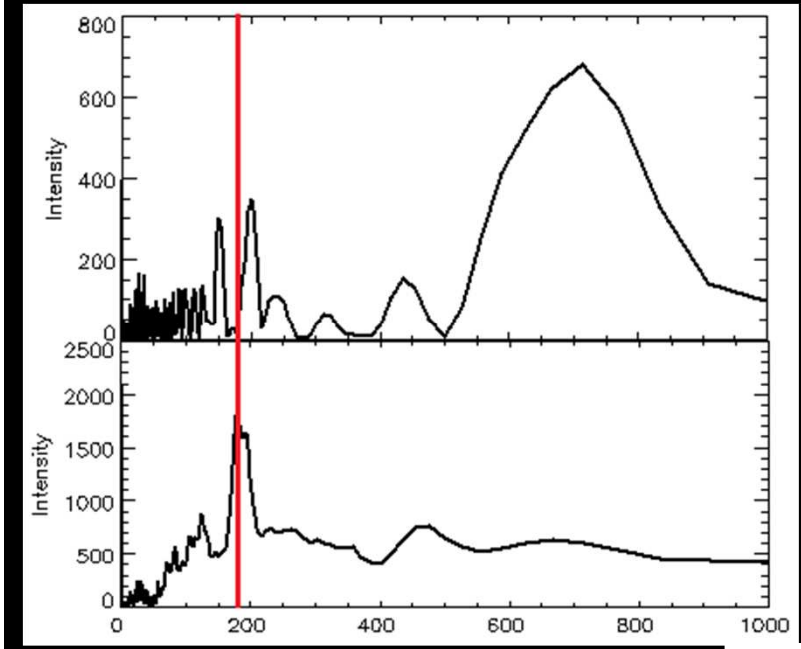
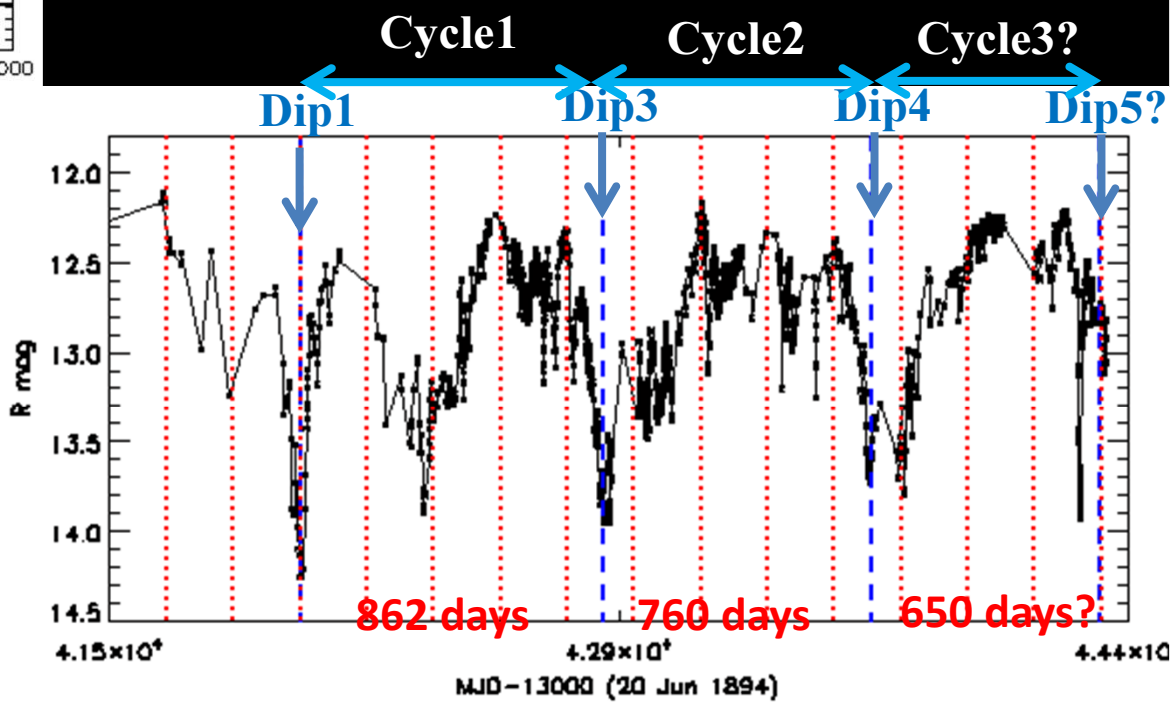


Top: Lomb-Scargle power spectra of the actual input light curve

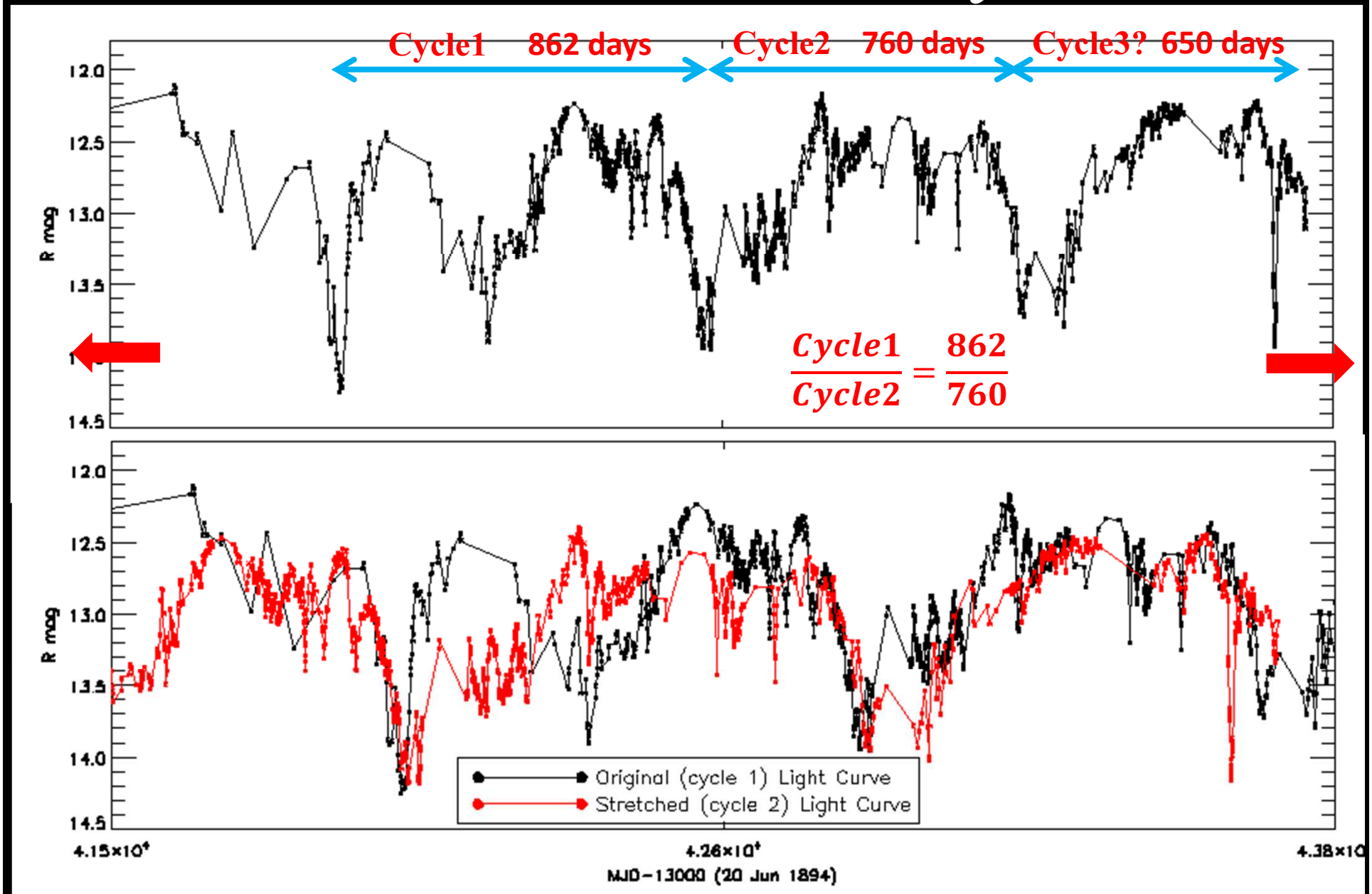
Bottom: An input of unity at every sampling time of the actual light curve

Red: Time scales of 190 days (false period)

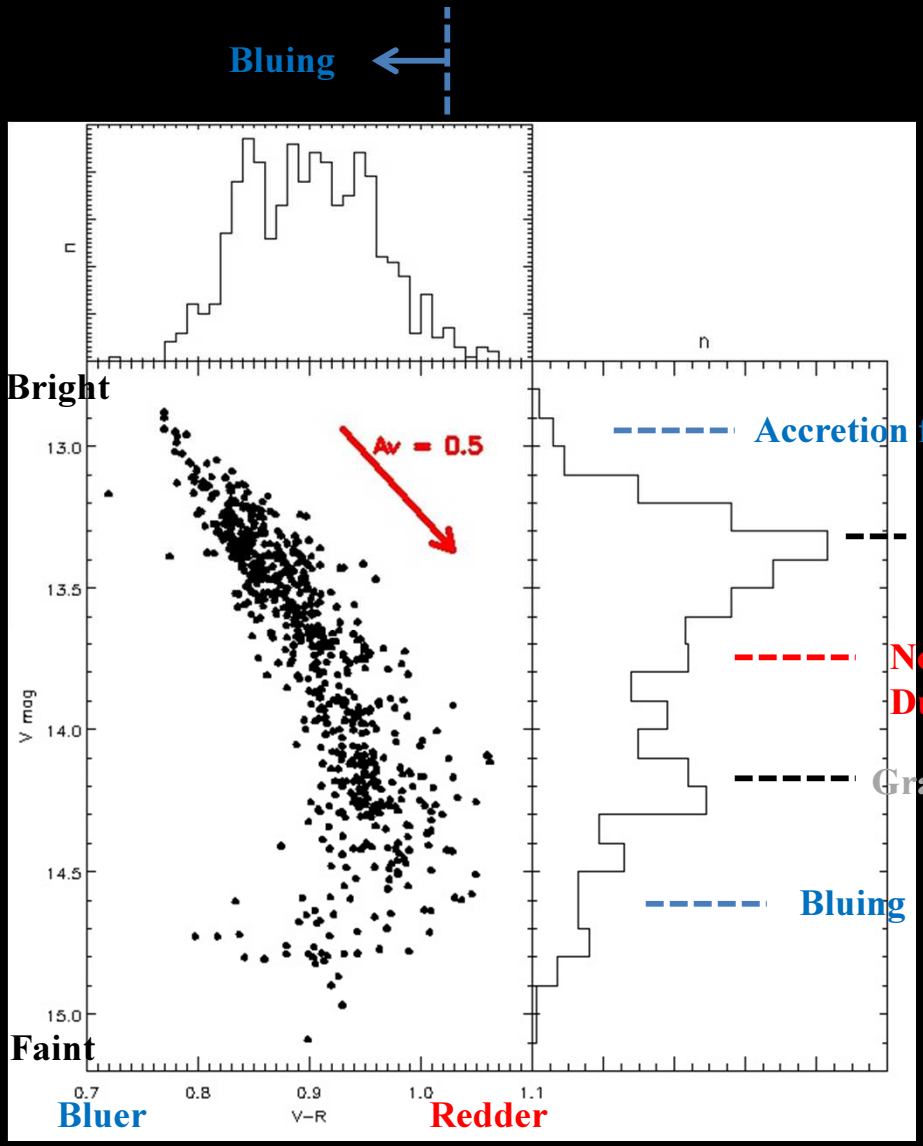
Blue: 862 and 760 days are the spans of cycle1 and cycle2



Results - Period analysis

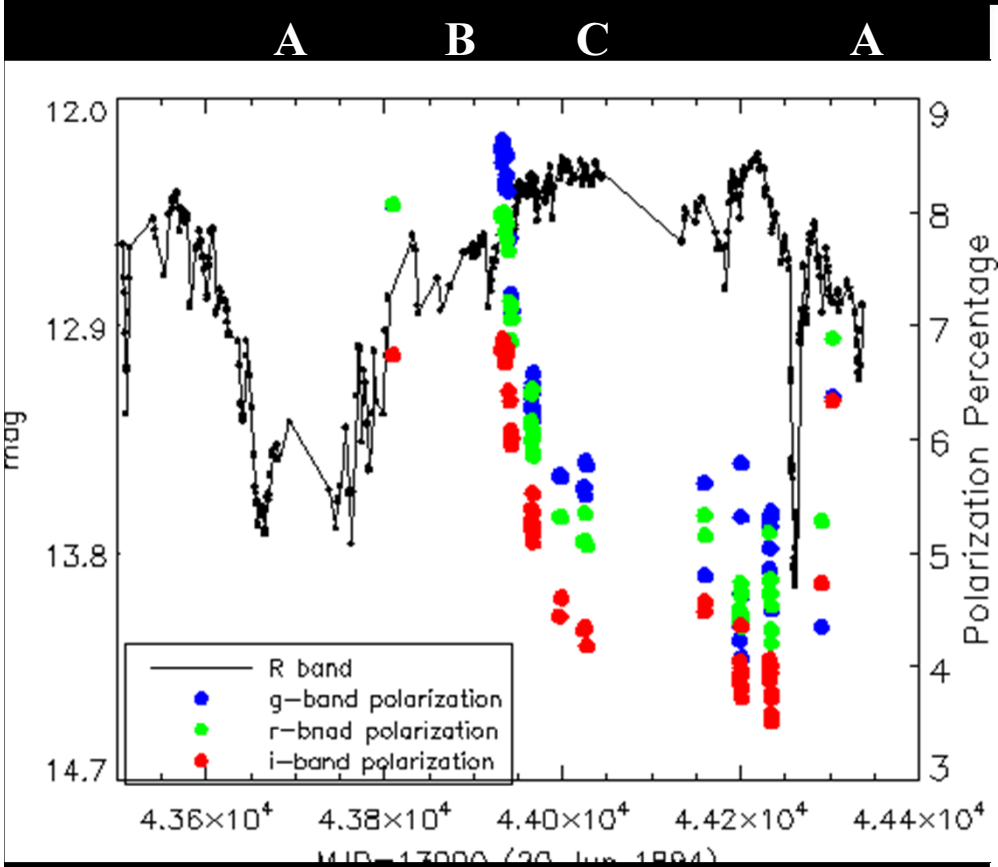


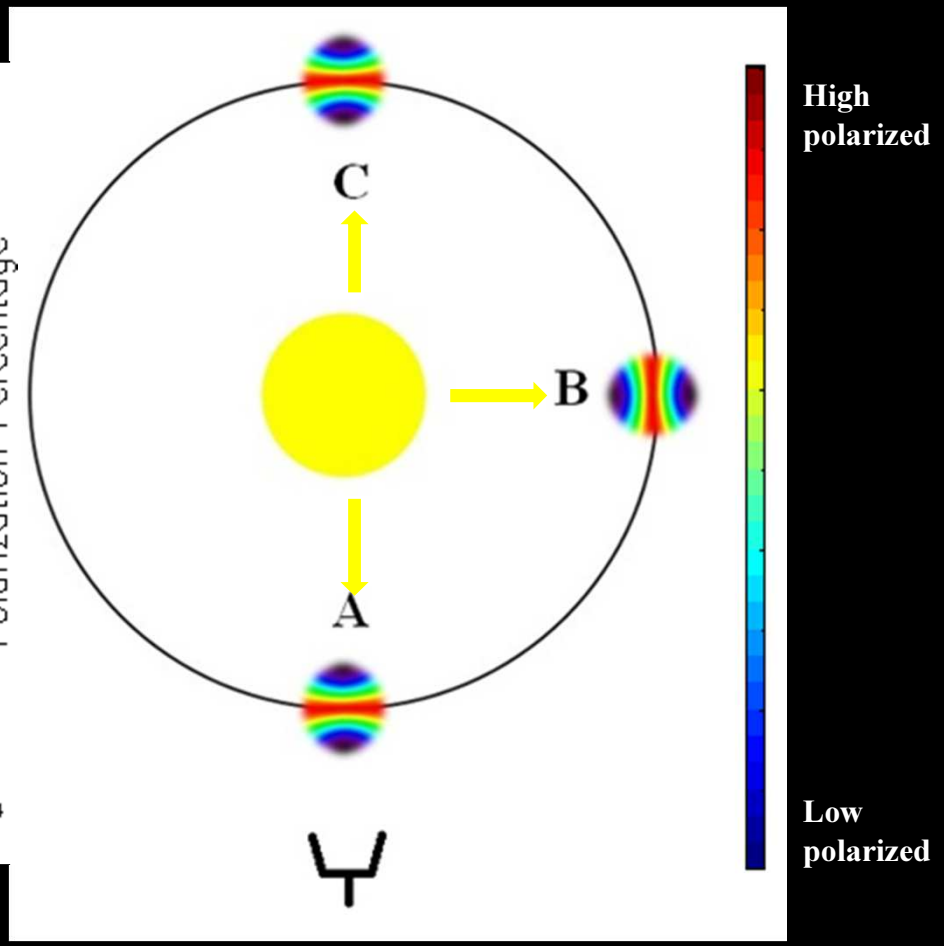
Results - Bluing effect



- During the bright phase, the star becomes redder when fainter (Normal reddening)
- When the star is in “dips”, the star becomes bluer when fainter (Bluing effect)

Results - Polarization





- Intermediate brightness: Maximal polarized (position B)
- The brightest brightness: Minimal polarized (position C)

Summary

- GM Cep continues to display active light curves, with sporadic brightening due to young stellar accretion, and different levels of dimming due to circumstellar dust extinction.
- Our light curves from 2009 to 2015 witness 4 brightness dips likely arising from the extinction of the same dust clump, with the time separation between dips shortened from ~860 days to ~760 days.
- The star shows normal reddening when brighter, but unusual bluing at brightness dips. If an orbiting dust clump is responsible (Chen et al. 2012), during the occultation of the central star, the circumstellar disk, either via scattering or accretion spots, contributes relatively more emergent light. This explains the bluing and the polarization results.
- The polarization of the star suggest asymmetry in dust distribution. During the bright state, the polarization is anti-correlated with the brightness, in support of the dust scattering. Polarization measurements during the dip state becomes higher due to strong scattering of light.
- We suggest that the dust clump is spiraling-in feature, and tidally stretched.

Thanks for your attention !