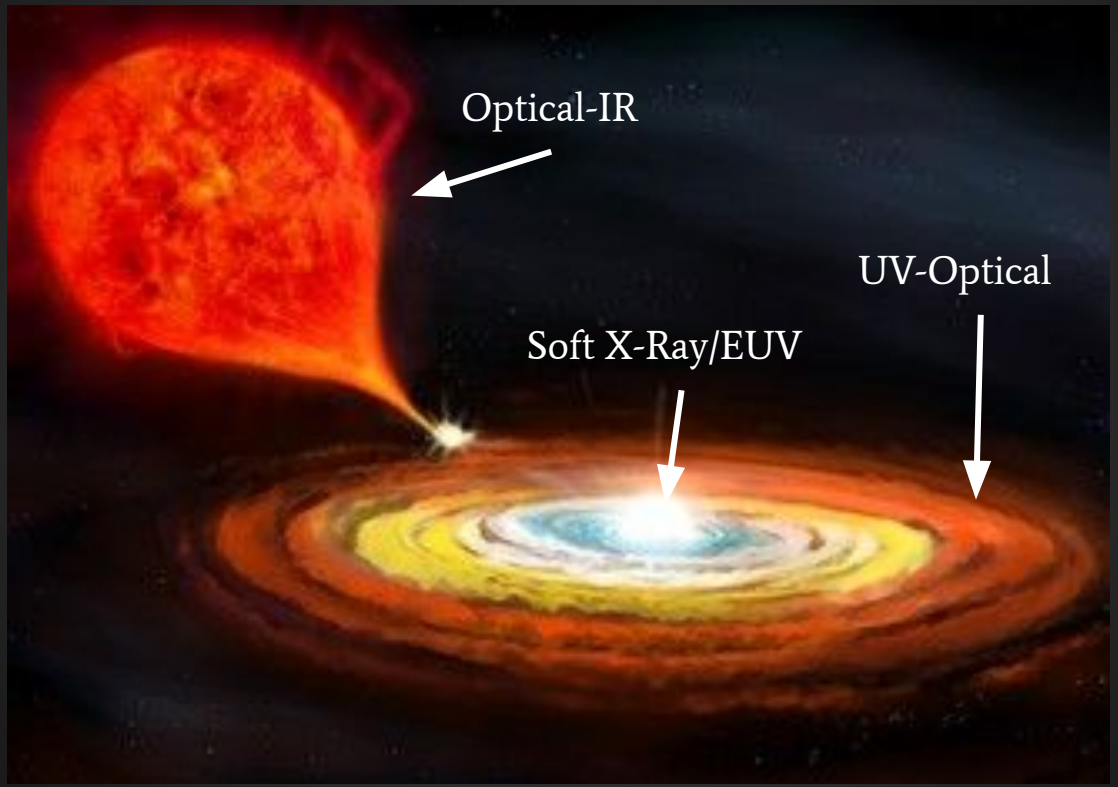
Exploring the Archives: A Search for Novae in UVIT Snapshots of M31

NUVA eMeeting 2024
Judhajeet Basu (PhD Student, IIA)

Collaborators: Krishnendu S., Sudhanshu Barway, Shatakshi Chamoli, G.C.Anupama

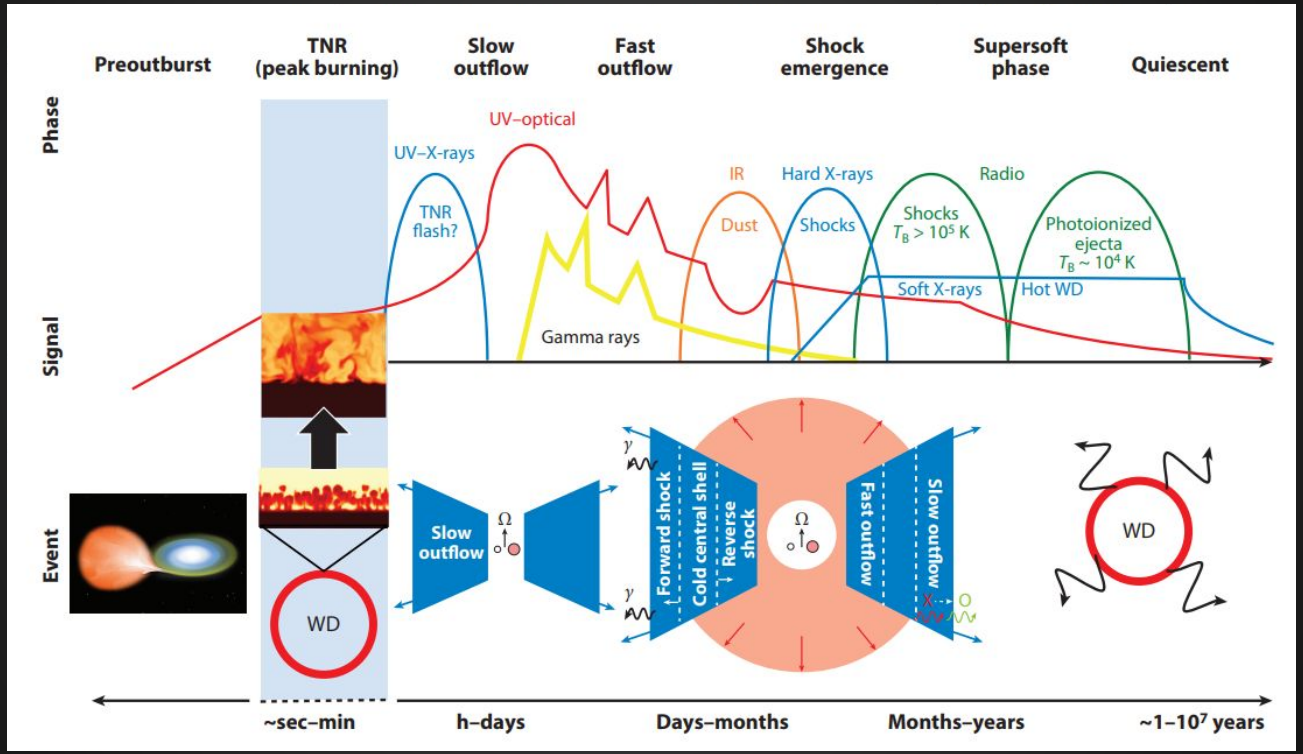
15 October 2024

Introduction



Credits: https://www.camk.edu.pl/en/archiwum/2014/10/10/hot-spot-manifestation-eclipcing-dwarf-nova-ht-cas/

Introduction



Credits: Chomiuk et al. Annu. Rev. Astron. Astrophys. 2021. 59:391–444

M31 survey history

Optical
Arp 1956
Rosino 1964, 1973, 1989
Ciardullo et al. 1987
Sharov & Alksnis 1991
Tomaney & Shafter 1992
Rector et al. 1999, 2022
Shafter & Irby 2001; Shafter et al. 2011b
Darnley et al. 2004, 2006
Kasliwal et al. 2011
Lee et al. 2012
Williams et al. 2014, 2016.

X-Rays
Pietsch et al. 2010
Henze et al. 2010, 2011, 2014.

IR
Shafter et al. 2011a

UV
Cao et al. 2012

Quiescence studies of M31 novae in optical Williams et al. (2014, 2016)

UV survey history

Galactic novae

Starrfield (1986), Selvelli & Gilmozzi (2013, 2019) studied a sample of 18 galactic novae in quiescence in UV, focusing on their SEDs.

Extra-galactic novae

Lessing et al. 2023; Shara et al. 2023 in **M87**

Cao et al. 2012 in **M31**

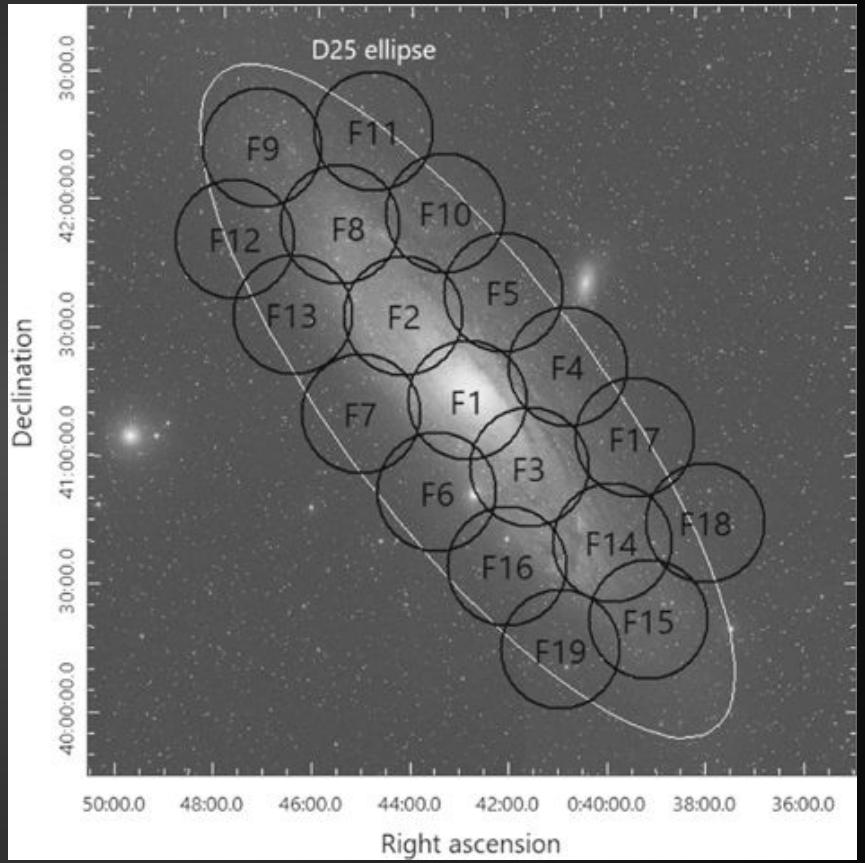
concentrated primarily on

eruption characteristics, spatial distribution, nova rates, and population studies .

Archival UVIT images → Novae captured at different phases

Data and Observations

- PI - D. Leahy
- 19 fields
- Different filters in NUV and FUV
- Data span : 2016 - 2022
- L1 data downloaded and reduced using **CCDLAB**



D. A. Leahy *et al* 2020 *ApJS* 247 47

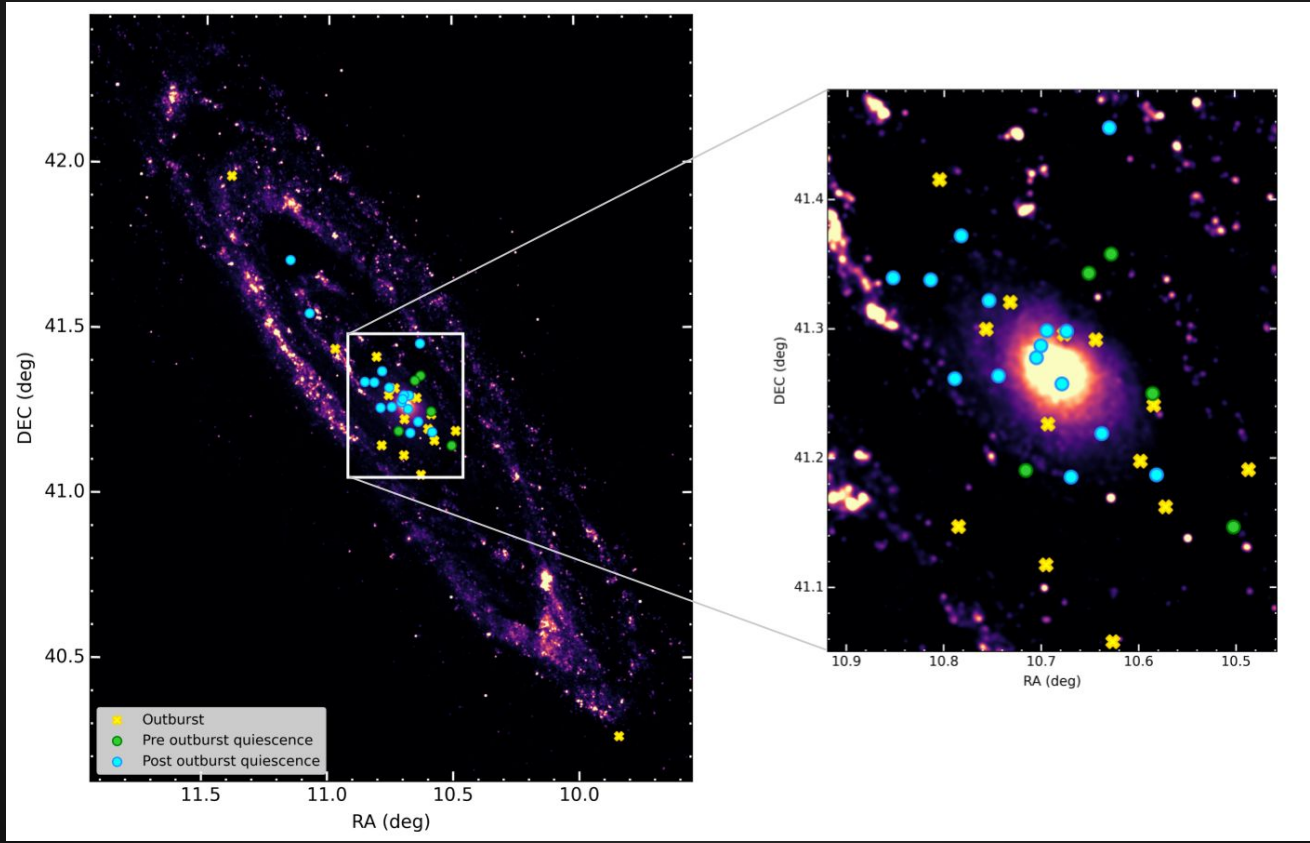
Detection method and Photometry

Source detection in image → Aperture and PSF photometry of all sources → Aperture correction term from “good sources”

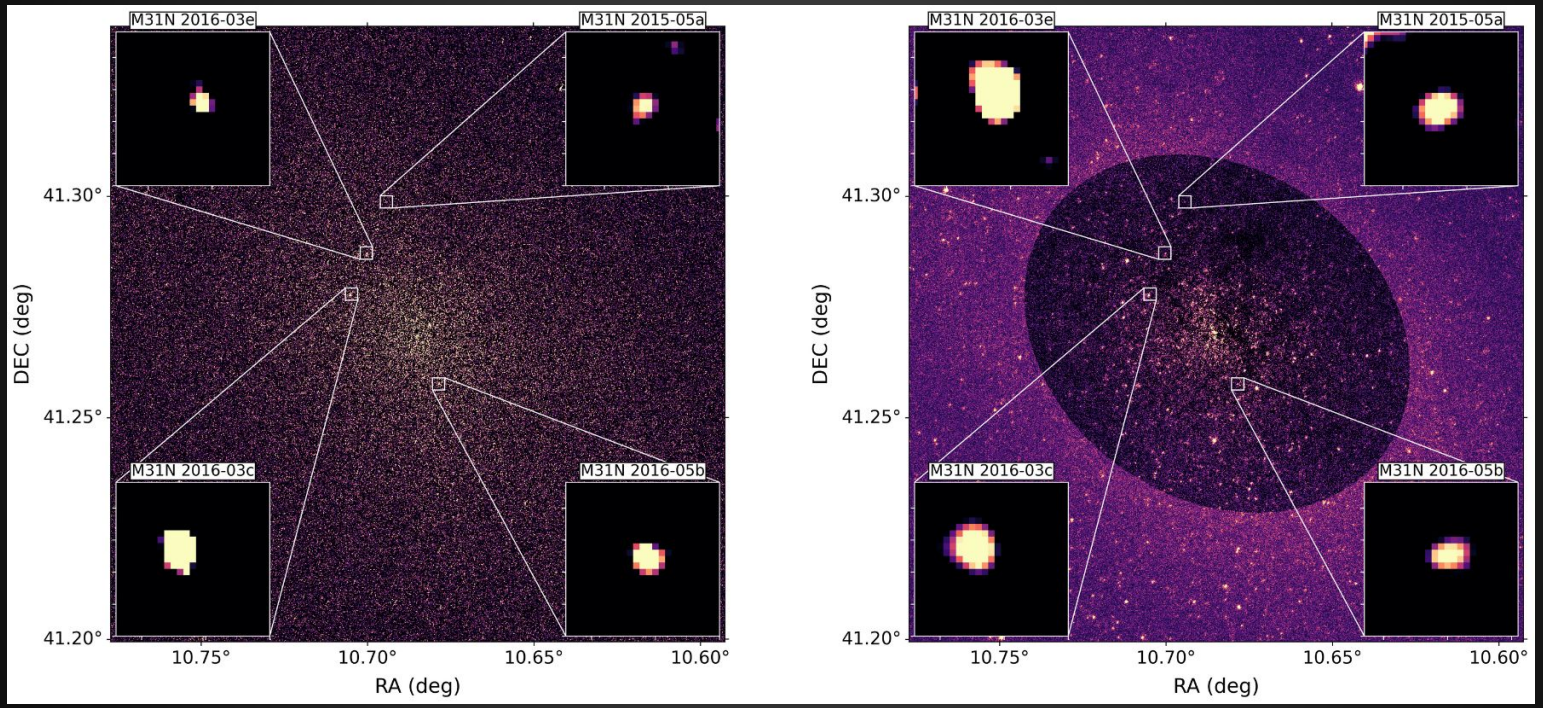
Forced PSF photometry on novae coordinates → Apply aperture correction → Apply ZP correction

Reject sources at the edges of the fields → Reject sources <3σ → Reject crowded sources within 5” region

Detected novae and spatial distribution
For the first time: UV catalog of novae



Novae in the central region

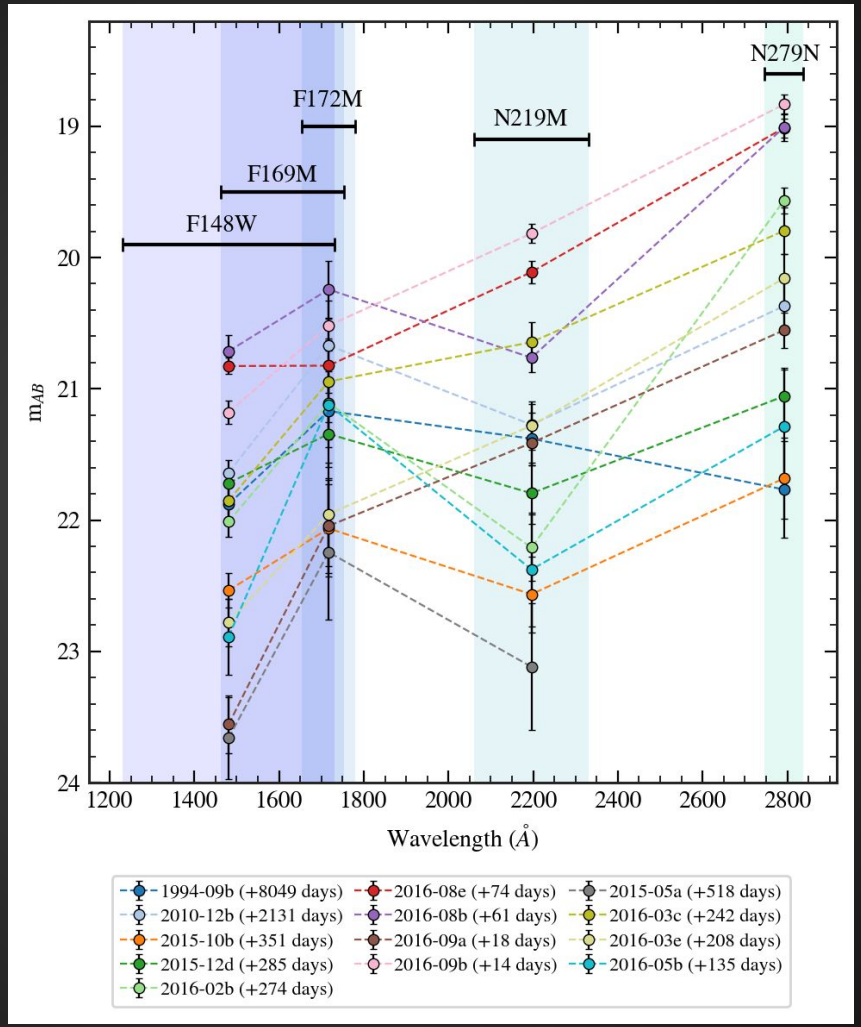


Credits: Shatakshi Chamoli

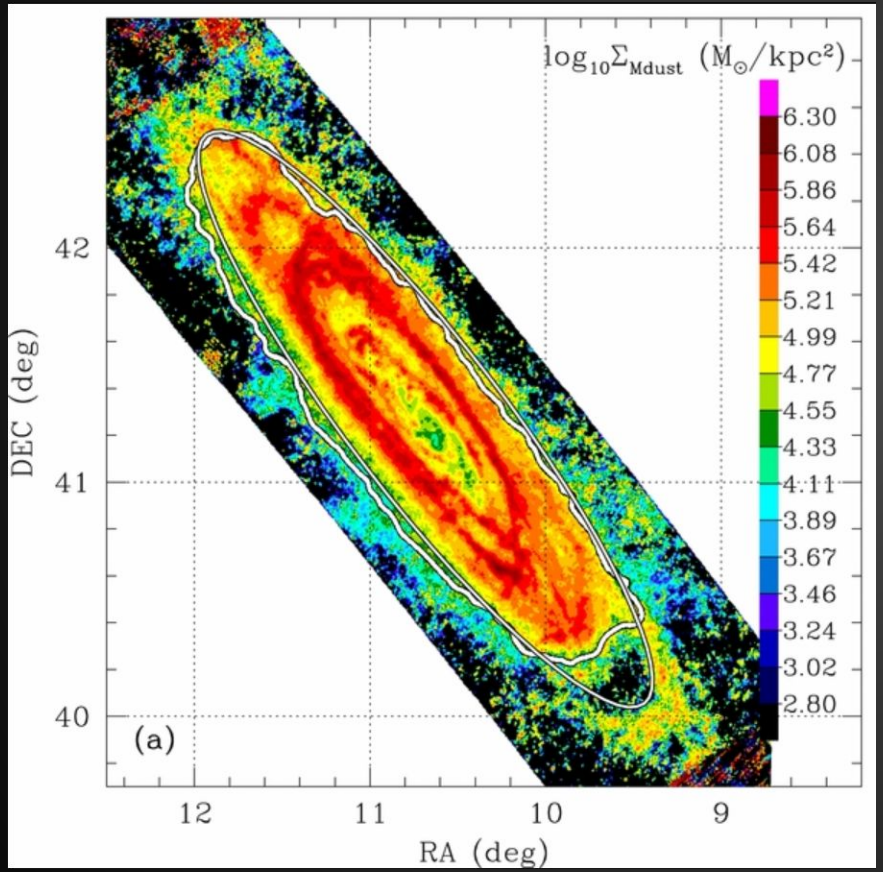
Numbers of detections

Total images analyzed	**92**
Total sources detected	**135**
Total novae detected	**42**
Novae detected in outburst	**16**
Novae detected in both quiescence and outburst	**4**
Novae detected in quiescence (before eruption)	**5**
Novae detected in quiescence (after eruption)	**21**
Novae detected in both FUV and NUV	**15**

SEDs of novae



Extinction estimation



$$A_V = 0.74 \left(\frac{\Sigma_{Md}}{10^5 \, M_\odot \, \mathrm{kpc}^{-2}} \right) \mathrm{mag.}$$

- M31 dust maps from Spitzer Space Telescope and Herschel Space Observatory
- Median dust mass in a 1 arcmin region
- Over-estimation correction factor = 2
- Extinction functions from Cardelli et al. (1989)

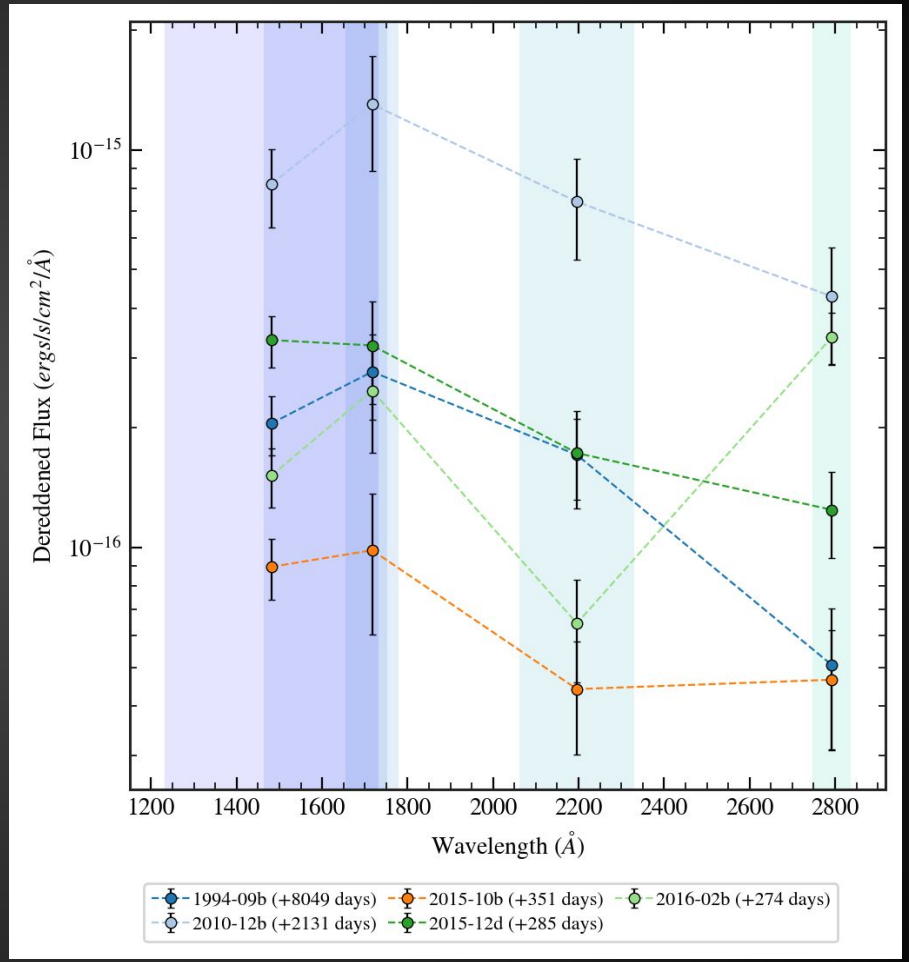
B. T. Draine *et al* 2014 *ApJ* 780 172

SEDs of quiescent novae

$F_\lambda \propto \lambda^{-\alpha}$

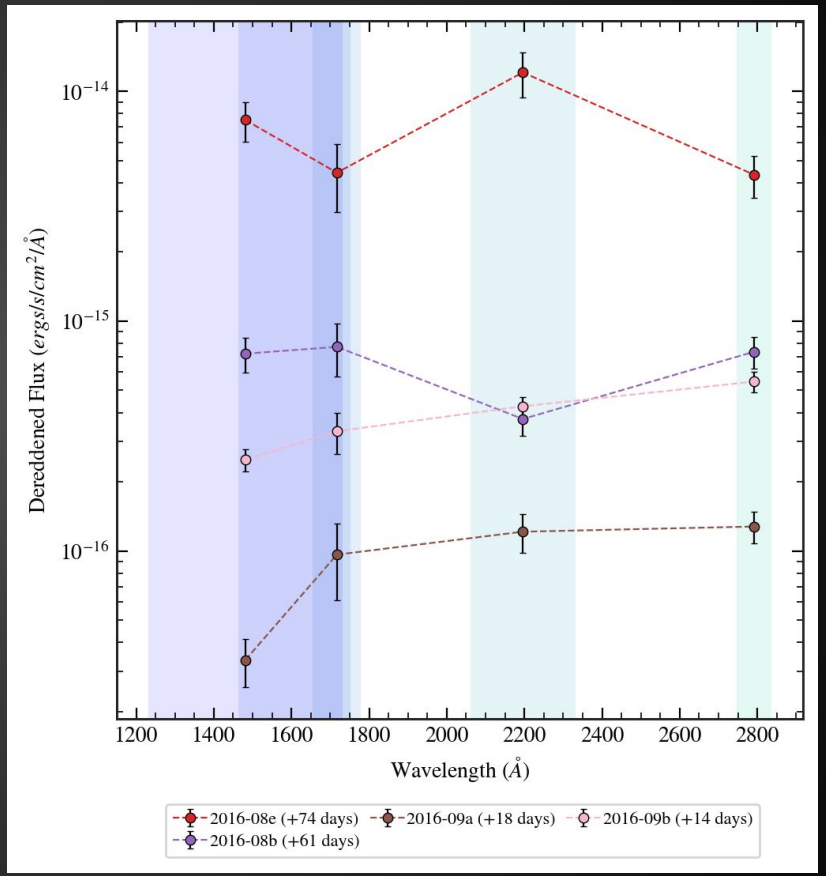
$\alpha = 2.33$ for accretion disks

M31N	a	a_2
1994-09b	2.71 ± 0.81	3.28 ± 0.79
2010-12b	2.29 ± 0.01	2.29 ± 0.94
2015-10b	2.01 ± 0.96	1.34 ± 1.32
2015-12d	2.15 ± 0.33	1.92 ± 0.82

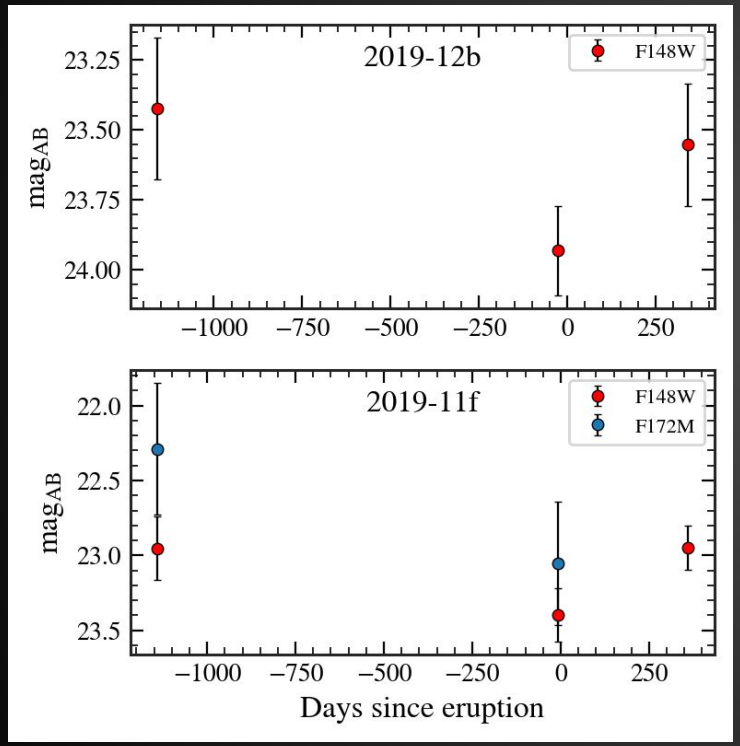


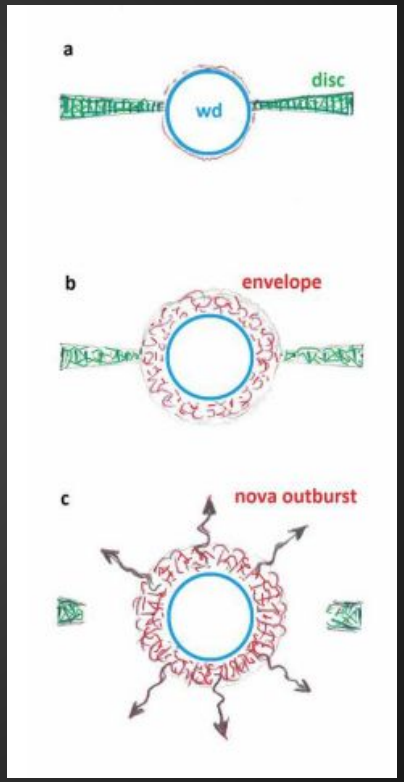
SEDs of outburst novae

- Close to eruption, SED traces the pseudo-photosphere
- Under-correction could mean the object is away from us wrt the galactic plane
- Over-correction could mean that the object is towards us wrt to the galactic plane



Lightcurves with pre-eruption dips





Zamanov et al. arXiv:2308.04104v1

Summary

- Detected 42 novae in M31 archival UVIT images.
- 4 novae at quiescence show accretion disk signatures.
- 2 novae with multi-epoch data show pre-eruption dips.
- Most quiescent novae show near constant UV magnitude.

Need of survey: Unsolved questions

Poorly constrained nova rates in Milky Way and M31.
Inconsistencies between different studies.

Testing nova theories: Can we catch the elusive early X-Ray–UV flash?

UV evolution after outburst: Extent of destruction and reformation of accretion disk.

Watch out for the talks on small UV telescopes by the Space Payload Group at IIA

Related paper

THE ASTROPHY

OPEN ACCESS

Exploring the Arch
Snapshots of M31

Judhajeet Basu[1,2], Krishner
G. C. Anupama[1]

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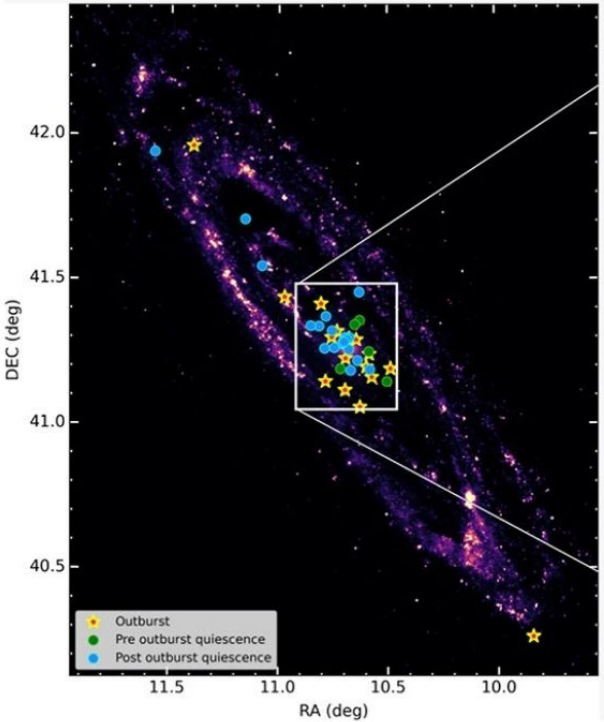
RESEARCH HIGHLIGHT | 16 September 2024

Explosive stars that outshine the Sun

Novae emit ultraviolet light and make life-forming molecules



Mosaic image of M31 generated using SWarp. The locations of all the novae detected in the archival images are marked in the figure. Credit: Basu, J. *et al* 2024 ApJ 971/ CC BY 4.0

New insights into 'novae', stars that run out of fuel and explode violently, show that some are 10,000 times brighter than the Sun[1].

Located at the centre of the Andromeda galaxy, the stars plunge into a dormant stage before and after such intense activity and emit ultraviolet light.

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Appendix

Image subtraction in the central region