

# The Spectroscopic Evolution of V1674 Hercules: The Fastest Nova Ever

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# WHY DO WE CARE?

A Nova Outburst may be only the third largest explosion that  
can occur in a Galaxy                      But:  
They are the Largest Hydrogen Bomb in the Universe\*

\*They may also make all the  ${}^7\text{Li}$  in  
the galaxy  
and  
possibly some of the Cosmic rays

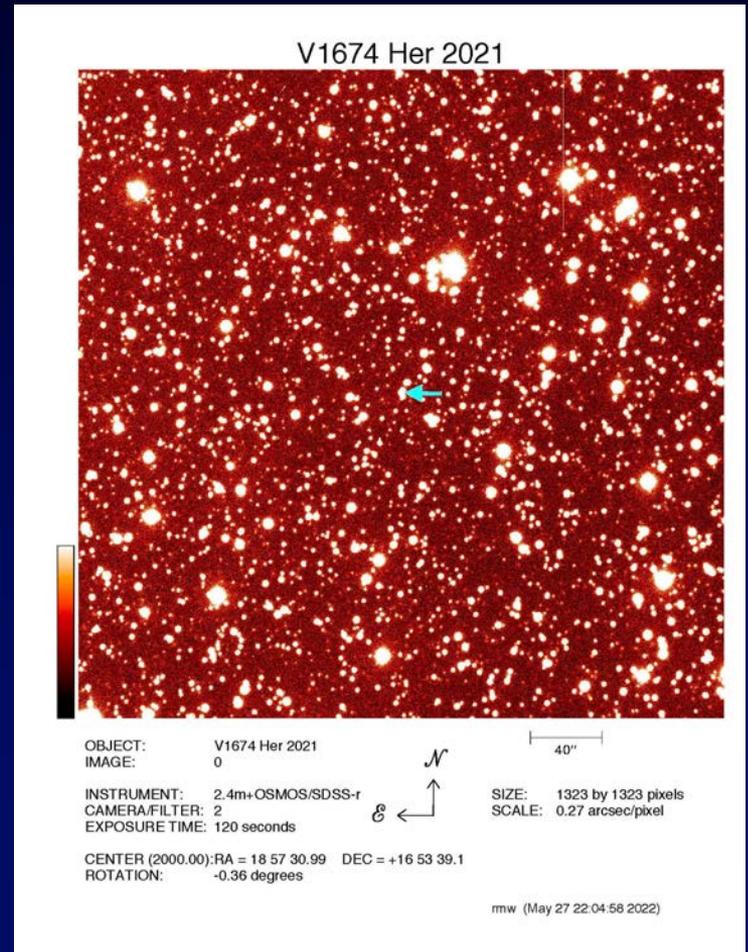


# V1674 Hercules:

- Erupted: June 12, 2021
- $V$  (max)  $\sim 6.2$
- Distance  $\sim 4700\text{pc}$  (15,000 ly)
- Dimmed a factor of 6 (2 mag) in “about” 1 day
- Dimmed a factor of 16 (3 mag) in 2 days
- $\sim 500$  second oscillation discovered by ZTF (WD rotation?)
- Binary orbital period is 3.67 hours (ATEL # 14835)
- Gas ejected at speeds greater than 6000 km/s (13 million miles/hr)

# What Is a Nova Explosion?

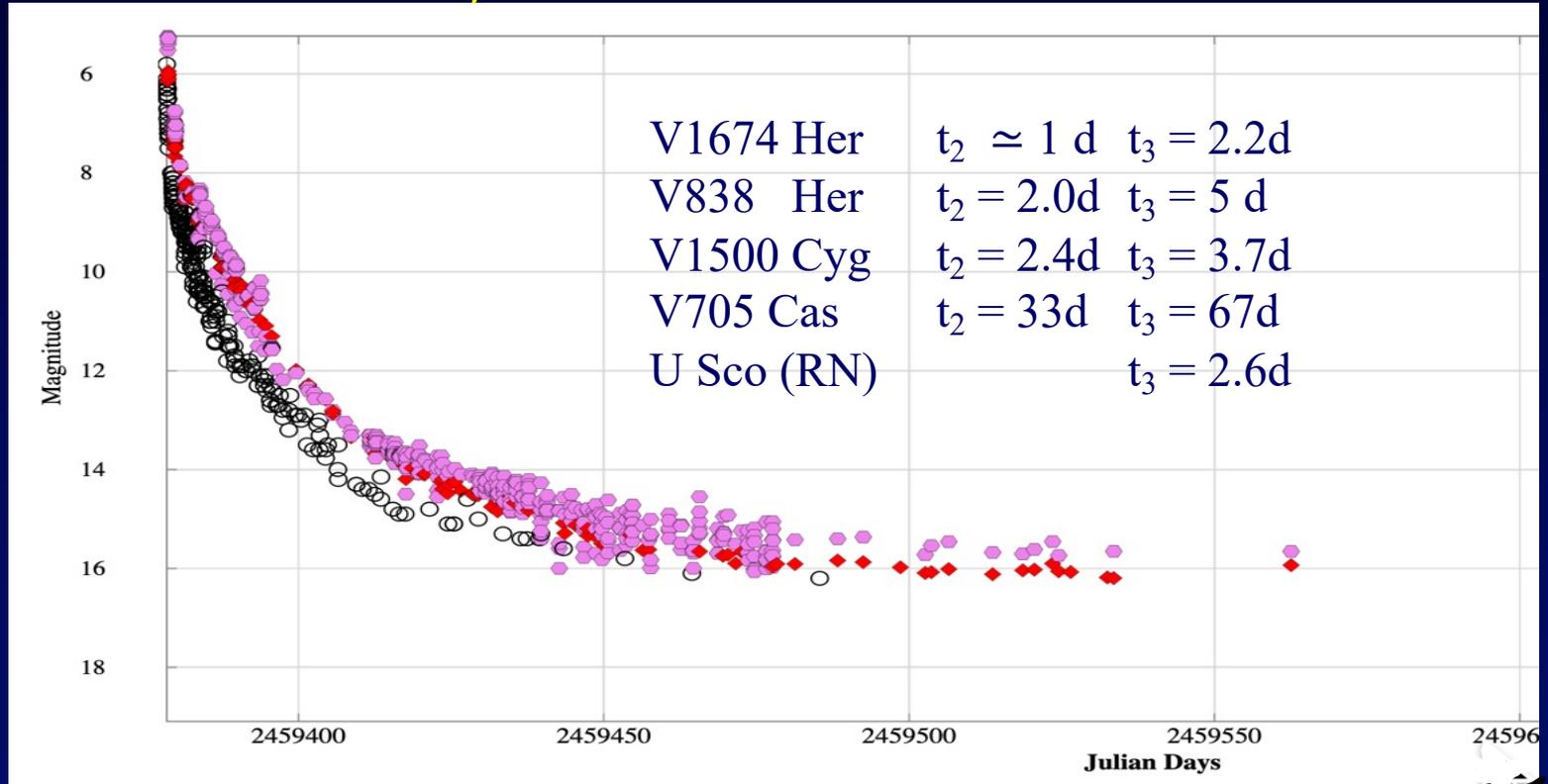
A “new” star appears  
and then stays bright  
for days to weeks  
before fading back to  
quiescence.



# We Follow the Evolution of the Brightness:

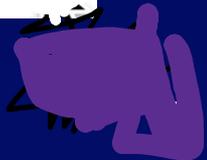
Done by Amateur Astronomers: AAVSO

Mag (Log Optical Brightness)



$t_2$  -> time to fade by 2 mags (factor of 6.3 from maximum light)

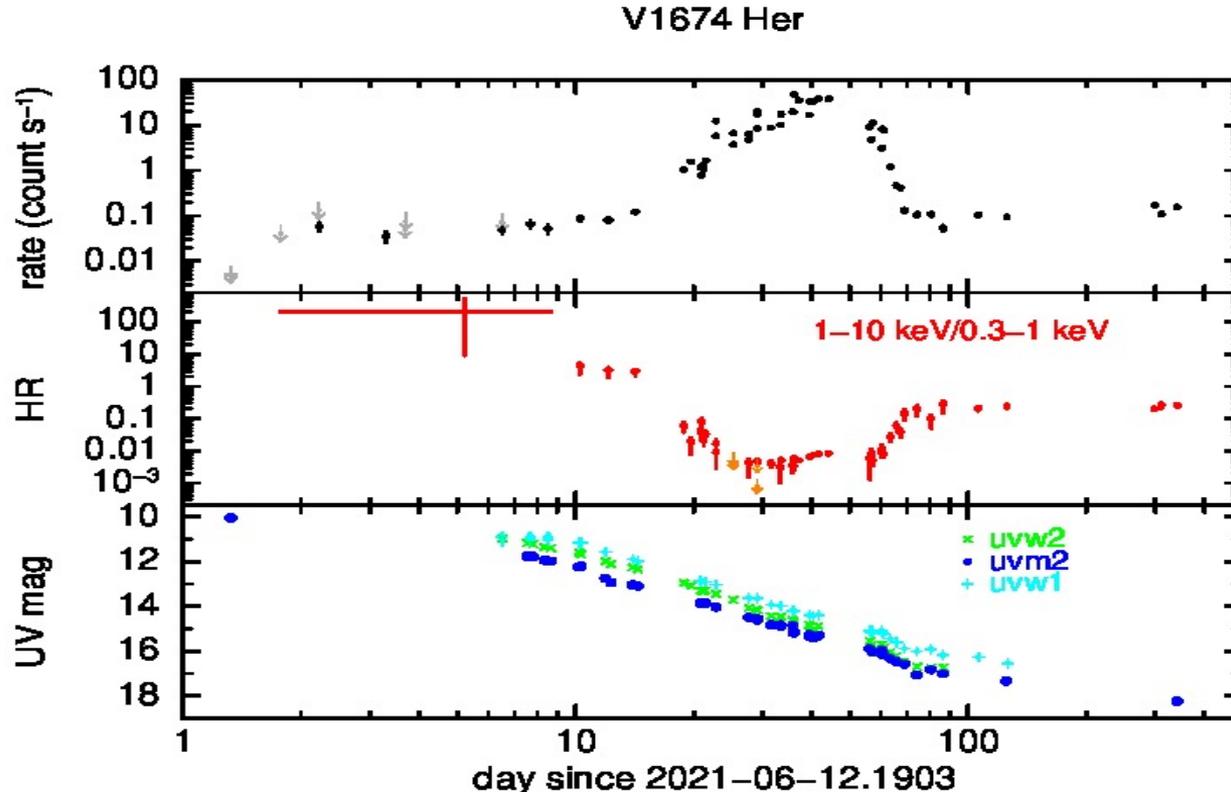
$t_3$  -> time to fade by 3 mags (factor of  $\sim 16$  from maximum light)



# X-ray Light Curve of V1674 Her

## June 2021 to May 2022

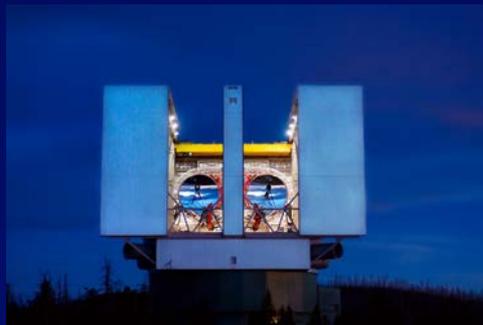
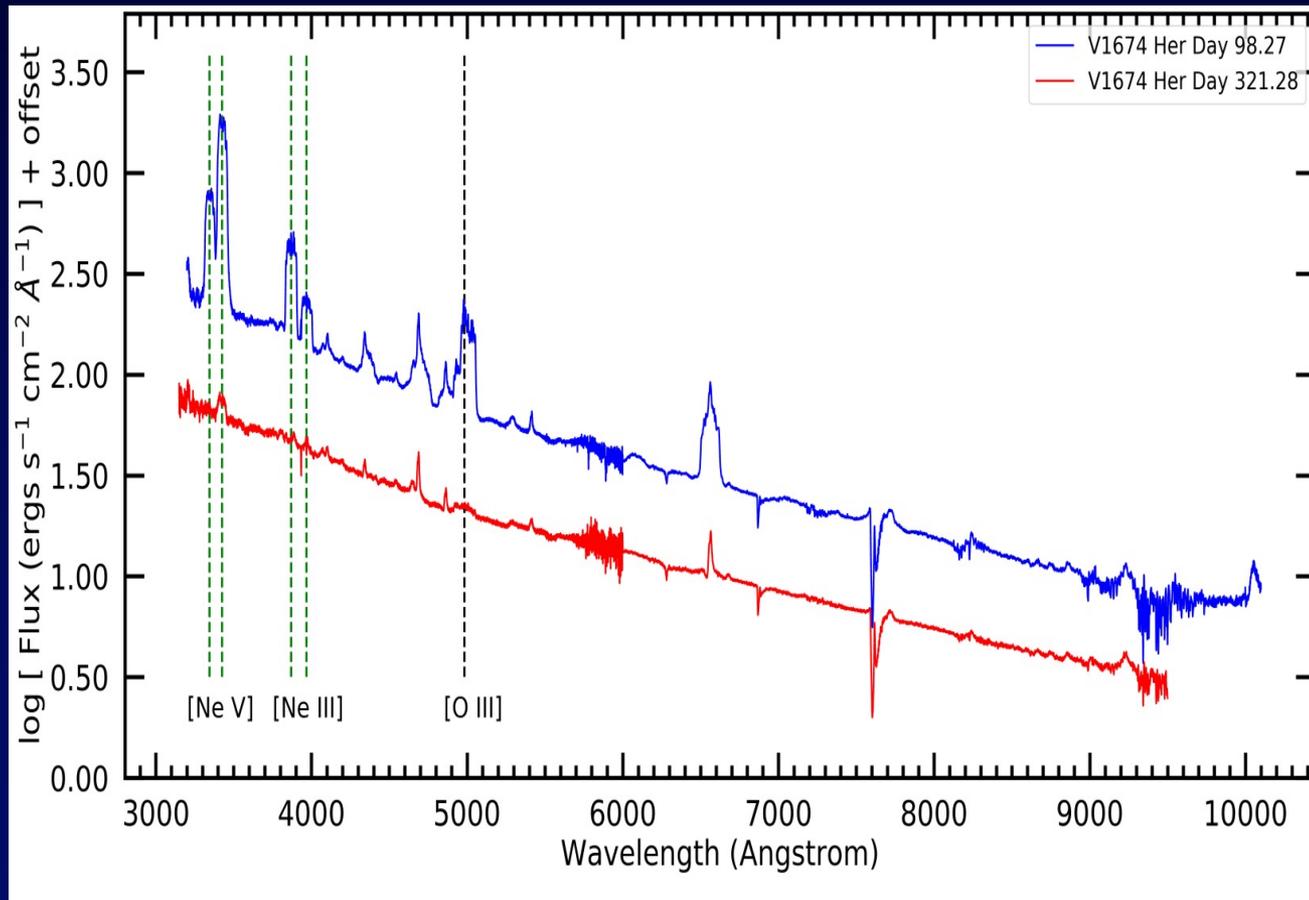
X - ray Count Rate /sec



Data  
From the  
Neil Gehrels  
Swift  
Satellite

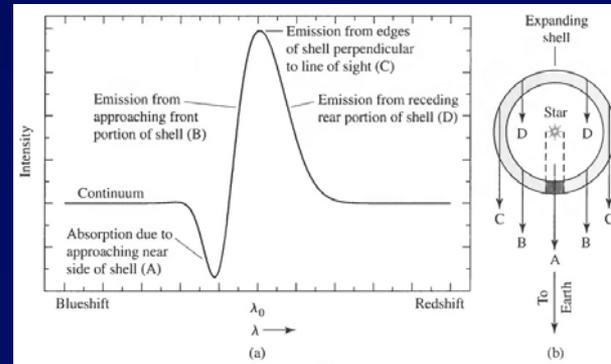
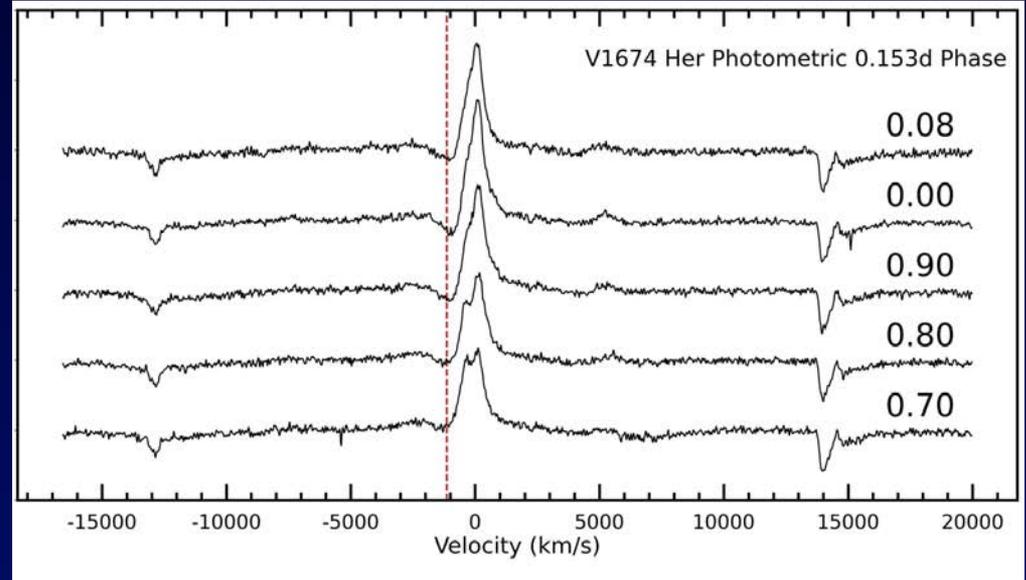
# It is a Neon Nova:

Optical spectra  
obtained with  
LBT/MODS on  
day 98.27 and  
day 312.78 de-  
reddend  
assuming an  
 $E(B-V) = 0.55$



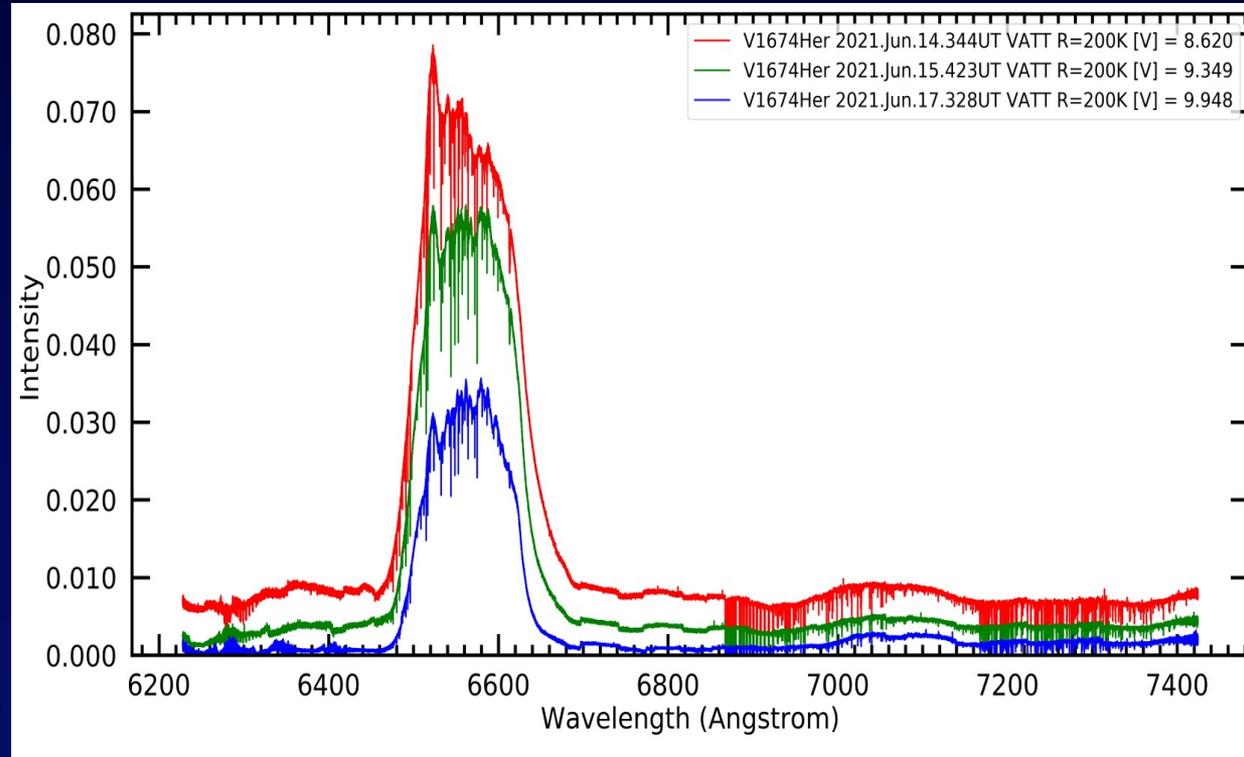
# Time Series spectra taken with LBT/MODS around $H\alpha$

1. Taken on April 29, 2022 (day 312).
2. Shows a P-Cygni Profile.
3. Phased with the Schmidt et al. ephemeris.
4. The dotted red vertical line emphasizes the P Cygni-like absorption component.
5. The “orbital” phases are indicated on the right.
6. There appears to be ongoing mass loss coincident with the broad deep minimum seen in the light curve.



# The rapid decline in H $\alpha$ : June 14 to 17, 2021

- R = 200,000 optical observations of H $\alpha$
- PEPSI on the VATT
- AAVSO V-band magnitude given in the legend.
- FWZI of H $\alpha$  was of the order 9910 km/s.



# They Occur on a White Dwarf in a Close Binary Stellar System

The  
explosion  
of  
RS Oph

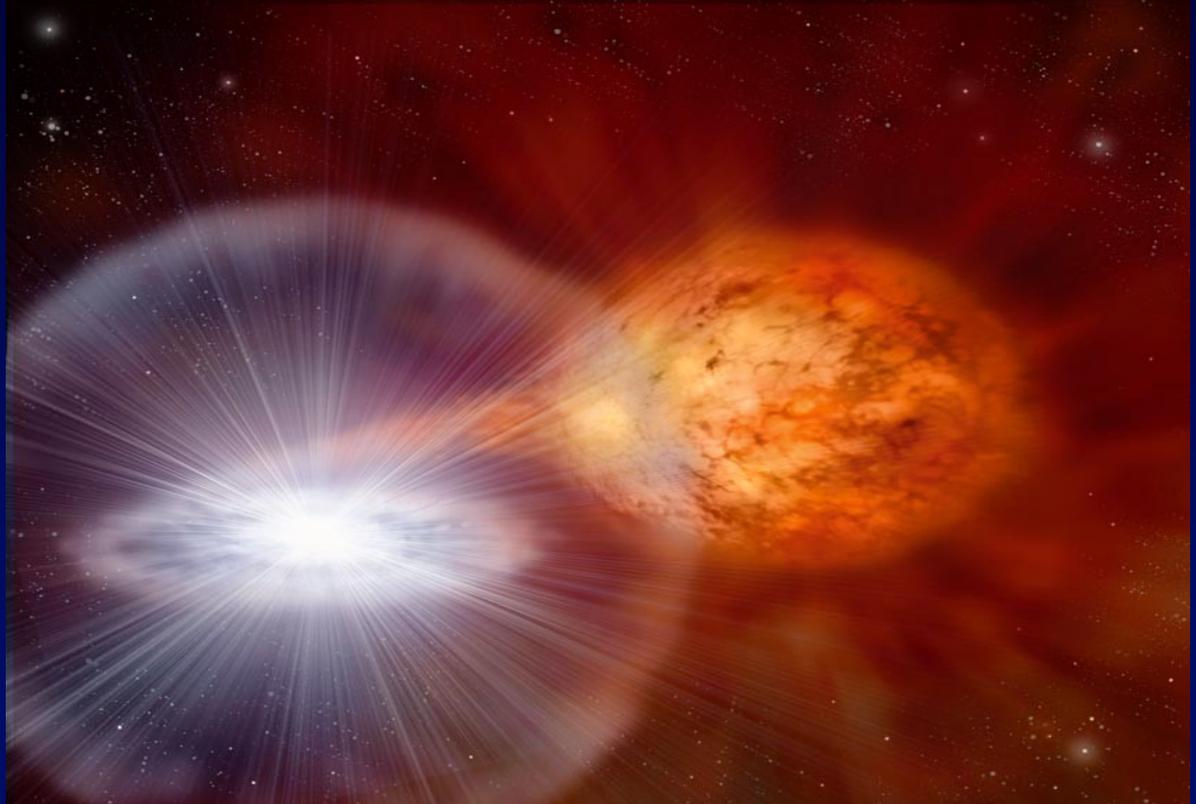


Illustration by David A. Hardy

# They Occur on a White Dwarf in a Close Binary Stellar System

An example  
of an  
Intermediate  
polar (IP)  
system

We think  
V1674 Her is  
an IP

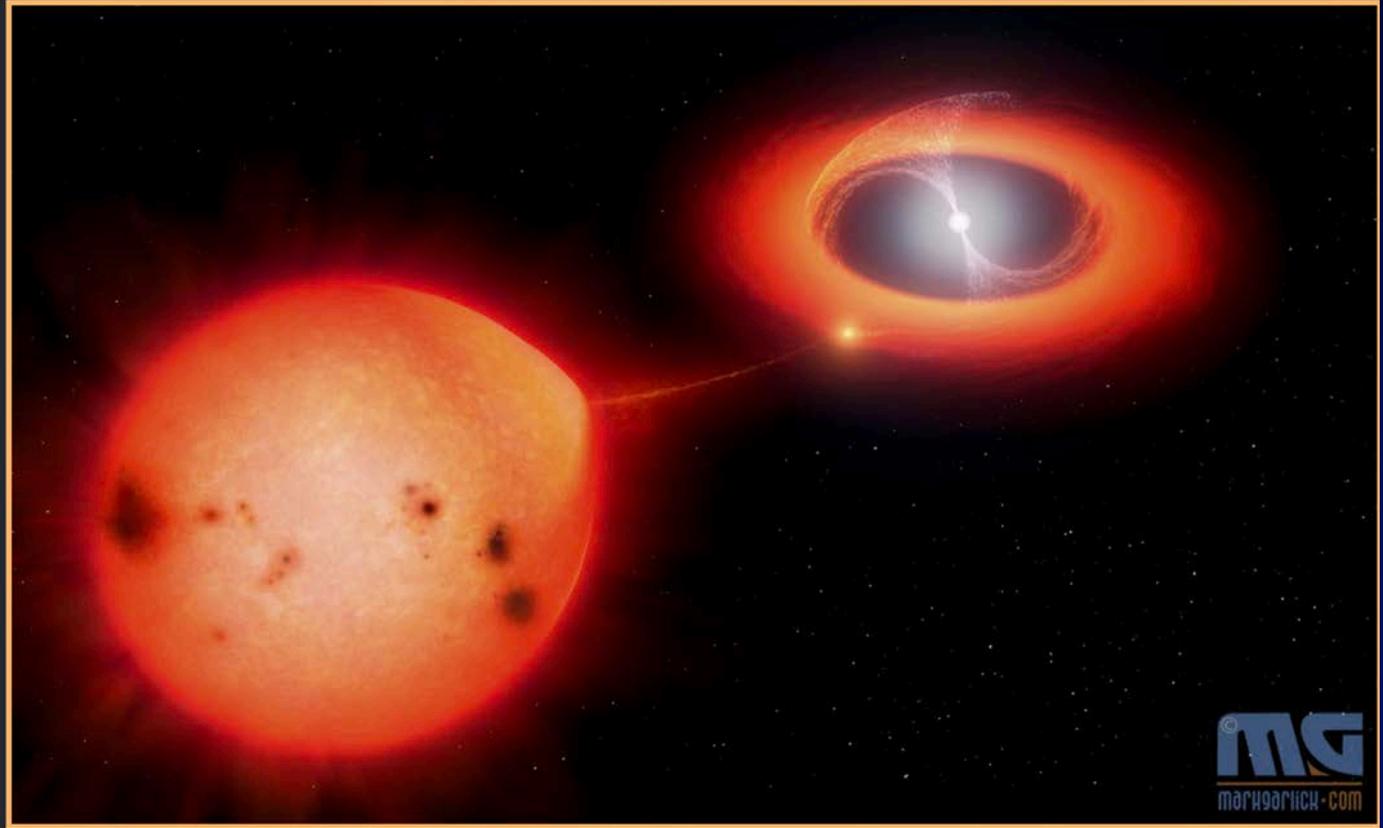


Illustration by Mark Garlick: used with his permission

# **Cause of The Nova Outburst is a TNR :**

- 1. The White Dwarf (WD) accretes gas from the secondary**
- 2. When “enough” gas has fallen onto the WD**
- 3. (Amount of gas is inversely proportional to the WD mass)**
- 4. Runaway nuclear reactions occur and an explosion results**
- 5. This is called a thermonuclear runaway (TNR)**
- 6. The accreted gas mixes with the WD to produce a fast outburst.**
- 7. The WD has either a carbon-oxygen or oxygen-neon composition.**

# Predictions of the TNR theory:

1. There are enriched light elements in the ejected gases (1972 – confirmed in the late 1970's)
2. “Rough” light curve behavior
3. Enriched  ${}^7\text{Li}$  in the ejecta (1978 – confirmed in 2015)
4. X-ray outburst at beginning when explosion reaches the surface of the WD (1980's – confirmed in 2022)
5. WD is growing in mass to a Supernova Ia explosion (predicted since 1988 for U Sco [last eruption on June 6, 2022])

# Why was the decline so fast?

1. Massive WD → less mass accreted implies less mass ejected
2. Massive WD → higher surface gravity produces higher peak nuclear fusion temperatures
3. Accreted matter mixed with WD core matter, and higher temperatures produced more nuclear energy
4. High ejection velocities ( $> 6000$  km/s) → density drops rapidly
5. Opacity drops rapidly → then see deeper into outflowing gas where temperatures are higher
6. Emission peak rapidly moves out of the optical into the UV, X-ray,...