

# Ejected! The First Eclipsing Magnetic Propeller in a Cataclysmic Variable Binary

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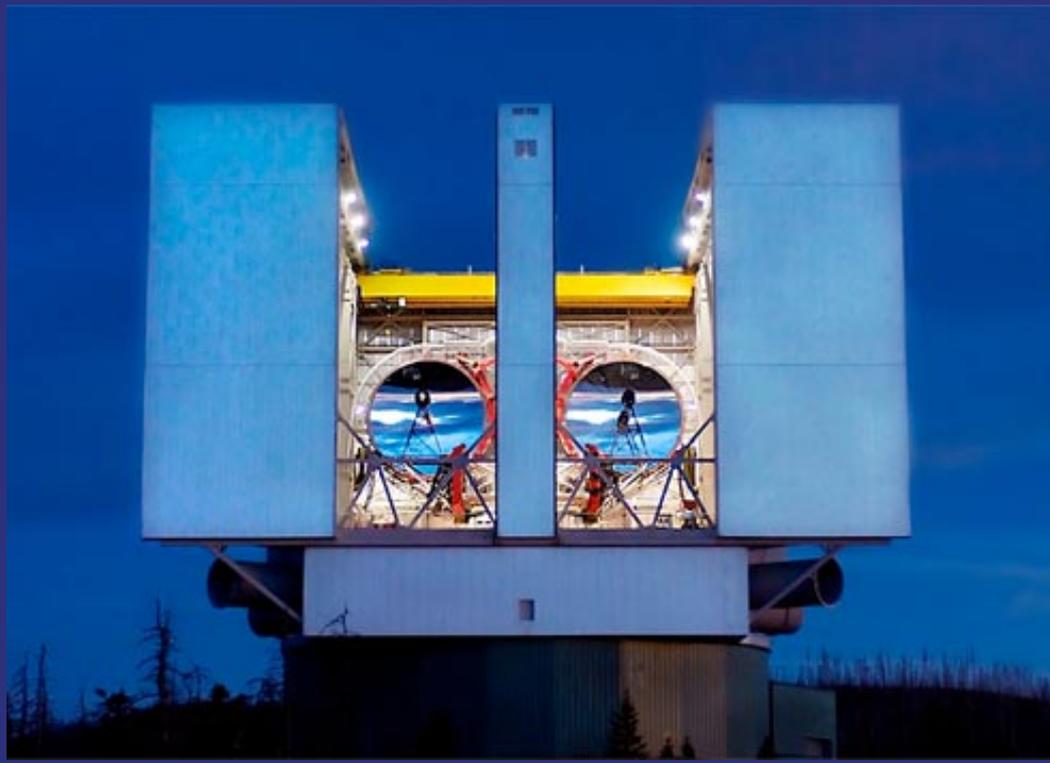
Telescopes:

Large Binocular Telescope (LBT)

Palomar 200-inch

MDM Observatory

Apache Point Observatory



# Normal Cataclysmic Variables

- ✧ Red star donating mass to a white dwarf star
- ✧ White dwarf is a dense remnant of a Sun-like star  
Mass of the Sun, size of the Earth
- ✧ Gas stream feeds an accretion disk
- ✧ Disk gas accumulates on the white dwarf
- ✧ Magnetic white dwarfs: intermediate polar or polar, but the donated gas accretes on white dwarf

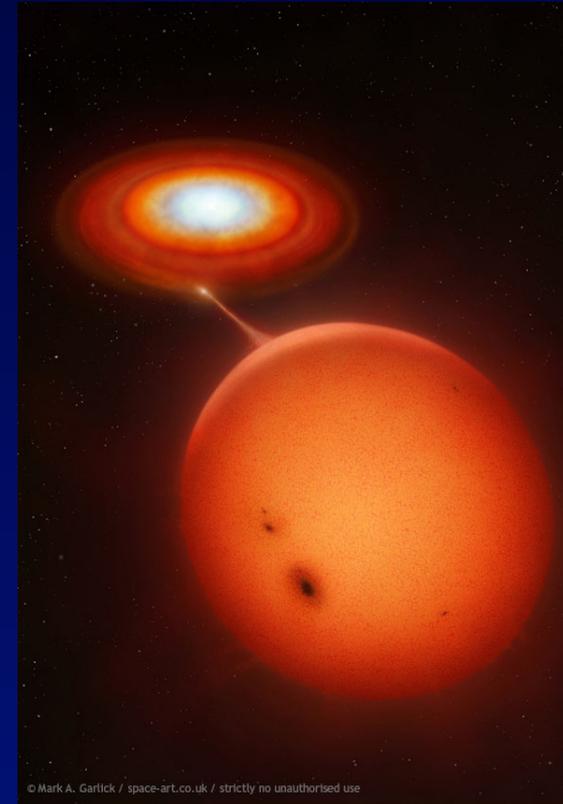


Illustration of a Cataclysmic Variable (CV)  
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# A Propeller CV

- ✧ Red star sends gas toward white dwarf
- ✧ Rapidly spinning, magnetic white dwarf accelerates the blobs of gas
- ✧ Gas is ejected from the binary system
- ✧ Only known propeller was AE Aquarii
- ✧ We identified a second propeller:  
LAMOST-J024048.51+195226.9 or “J0240”
- ✧ J0240 is viewed close to its orbital plane
- ✧ We directly detect the ejected gas

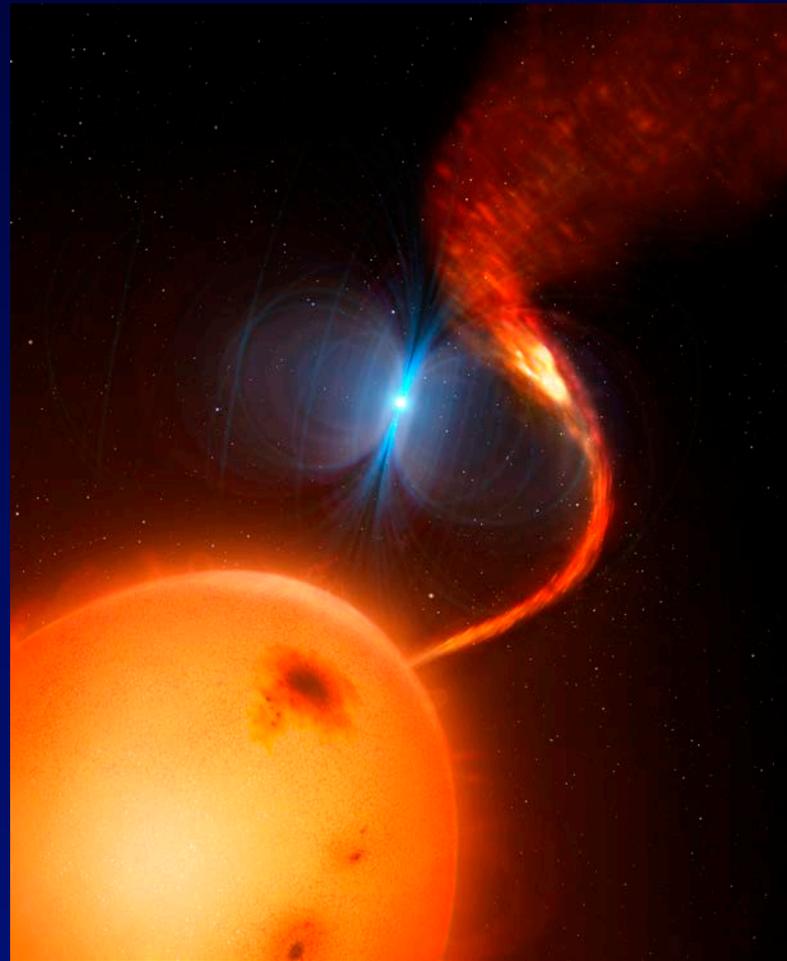
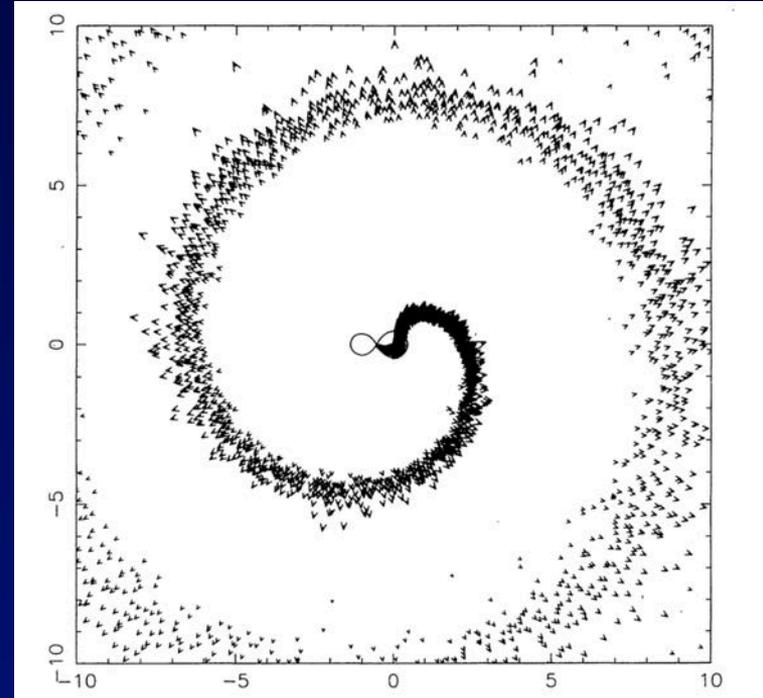


Illustration of propeller J0240  
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# Propeller Ejects Gas

- ✧ In J0240 we see ejected gas for the first time
- ✧ Velocities of 400 to 700 km/s or 1 million miles/hour
- ✧ Exceeds “escape velocity” from system
- ✧ Sent out in spiral pattern like a giant lawn sprinkler

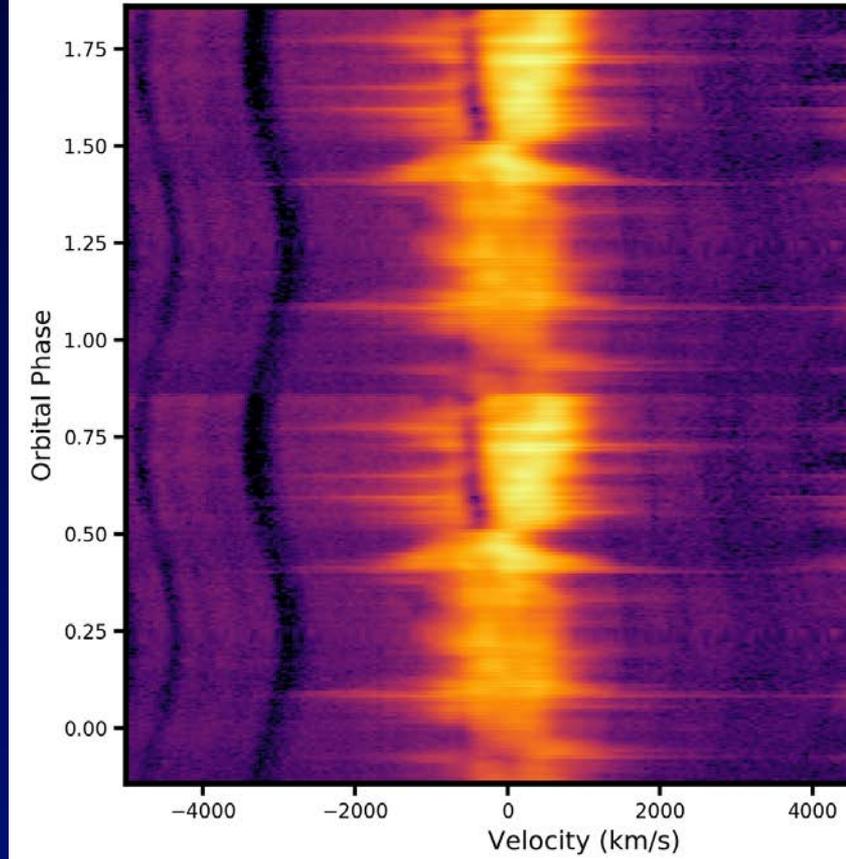


Model of AE Aqr from Wynn et al. 1997

# Bright Flares in Propellers

- ✧ Flares in light curve and spectra
- ✧ Flares blast gas away at up to 3000 km/s = 6 million mph or 1% of the speed of light
- ✧ Near the white dwarf, the gas gets dragged by the spinning magnetic field – shock heated
- ✧ Narrow absorption  $\frac{1}{2}$  the orbit: direct detection of ejected gas
- ✧ J0240 orbit seen nearly edge-on

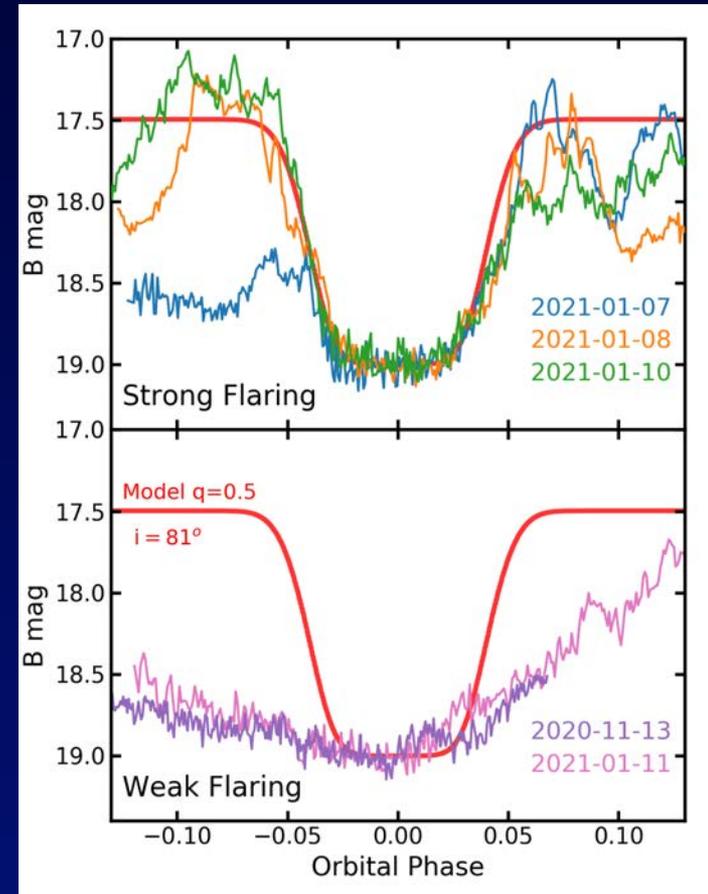
$\leftarrow \leq 7.3 \text{ hours} \Rightarrow$



Time series of hydrogen emission spectra from the LBT. One orbital cycle repeated.

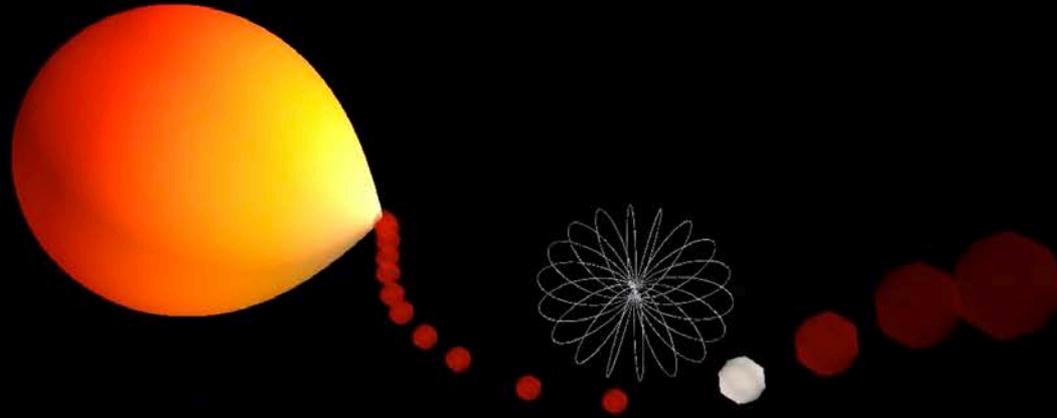
# Origin and Fate of J0240

- ✧ Spinning up the white dwarf requires a period of unstable mass transfer
- ✧ Energy from the spin is being used to drive away the gas – spin rate is slowing
- ✧ Eventually, the slowing spin will lead to a normal cataclysmic variable
- ✧ Have not measured the spin rate in J0240

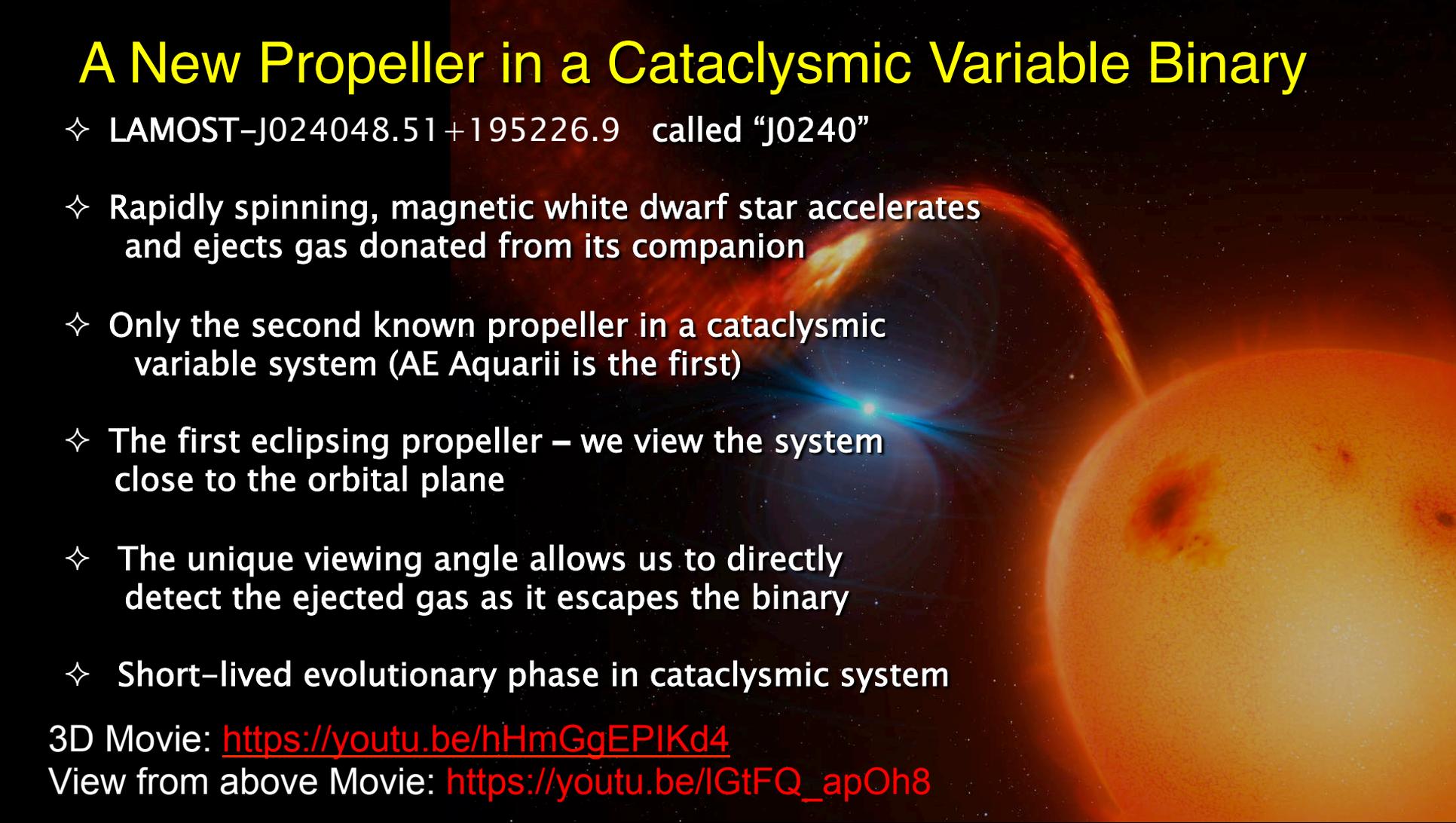


Eclipse Photometry from MDM Observatory.  
Flare region blocked by red companion star.

Simulation of J0240 – Colin Littlefield (Notre Dame) <https://youtu.be/hHmGgEPIKd4>



# A New Propeller in a Cataclysmic Variable Binary



- ✧ LAMOST-J024048.51+195226.9 called “J0240”
- ✧ Rapidly spinning, magnetic white dwarf star accelerates and ejects gas donated from its companion
- ✧ Only the second known propeller in a cataclysmic variable system (AE Aquarii is the first)
- ✧ The first eclipsing propeller – we view the system close to the orbital plane
- ✧ The unique viewing angle allows us to directly detect the ejected gas as it escapes the binary
- ✧ Short-lived evolutionary phase in cataclysmic system

3D Movie: <https://youtu.be/hHmGgEPIKd4>

View from above Movie: [https://youtu.be/lGtFQ\\_apOh8](https://youtu.be/lGtFQ_apOh8)

# Origin and Fate of J0240

- ✧ Spinning up the white dwarf requires a period of very high mass transfer
- ✧ Energy from the spin is being used to drive away the gas – spin rate is slowing
- ✧ Eventually, the slowing spin will lead to a normal cataclysmic variable
- ✧ Have not measured the spin rate in J0240

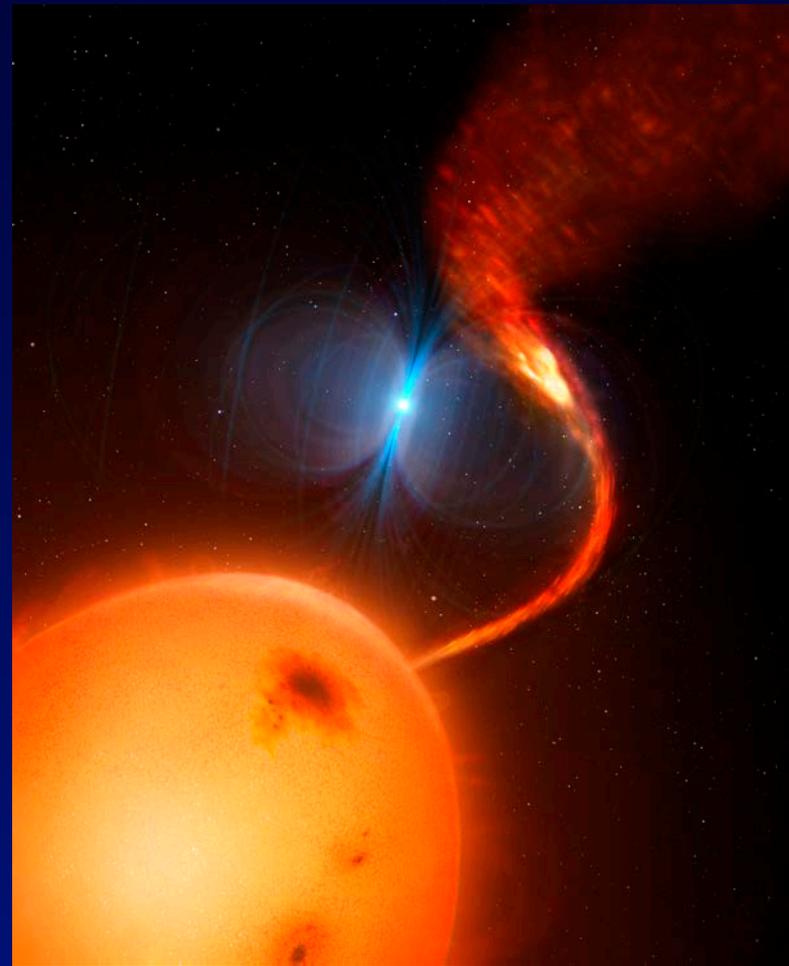


Illustration of propeller J0240  
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