

# Multi-Wavelength Properties Of FU Orionis Objects



V1331 Cyg



FU Ori

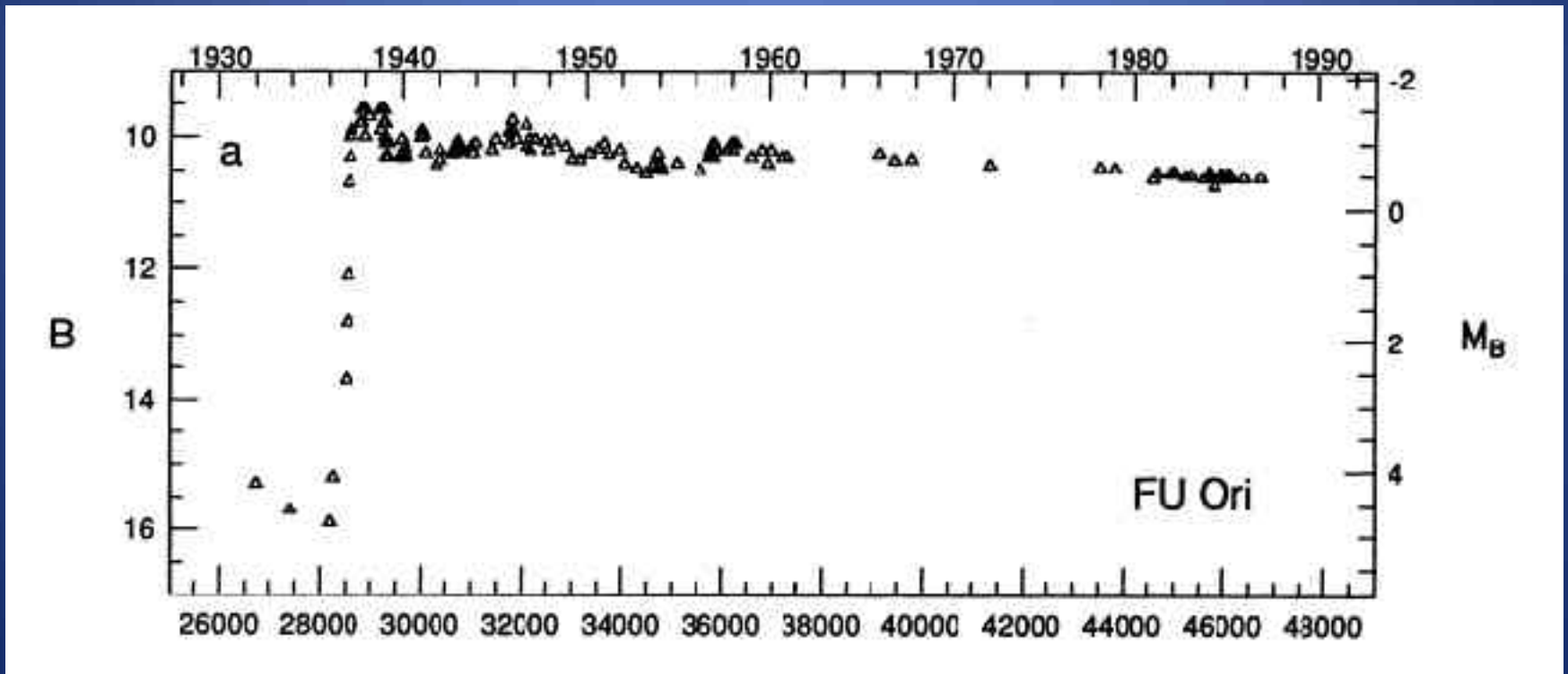
By

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4<sup>th</sup> Year Mphys Astrophysics

# What are FU Orionis Objects?

- FU Ori was the founder of this class of Stellar Objects.
- Observed outburst in 1937.
- Increased from 16<sup>th</sup> to 10<sup>th</sup> magnitude in just 2 years.



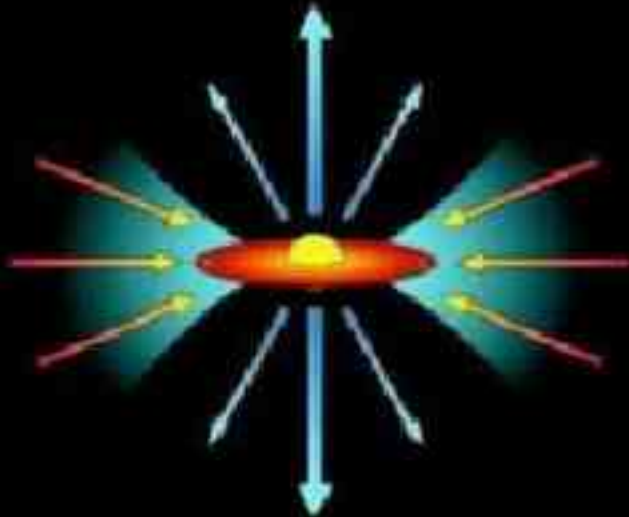
# What are FU Orionis Objects?

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- At first FU Orionis events (FUors) thought to be novae.
- But spectroscopic evidence suggested otherwise.

# What are FU Orionis Objects?



$10^{5-6}$  yrs; 1–1000AU; 100–3000K

**Class 1 Protostar**



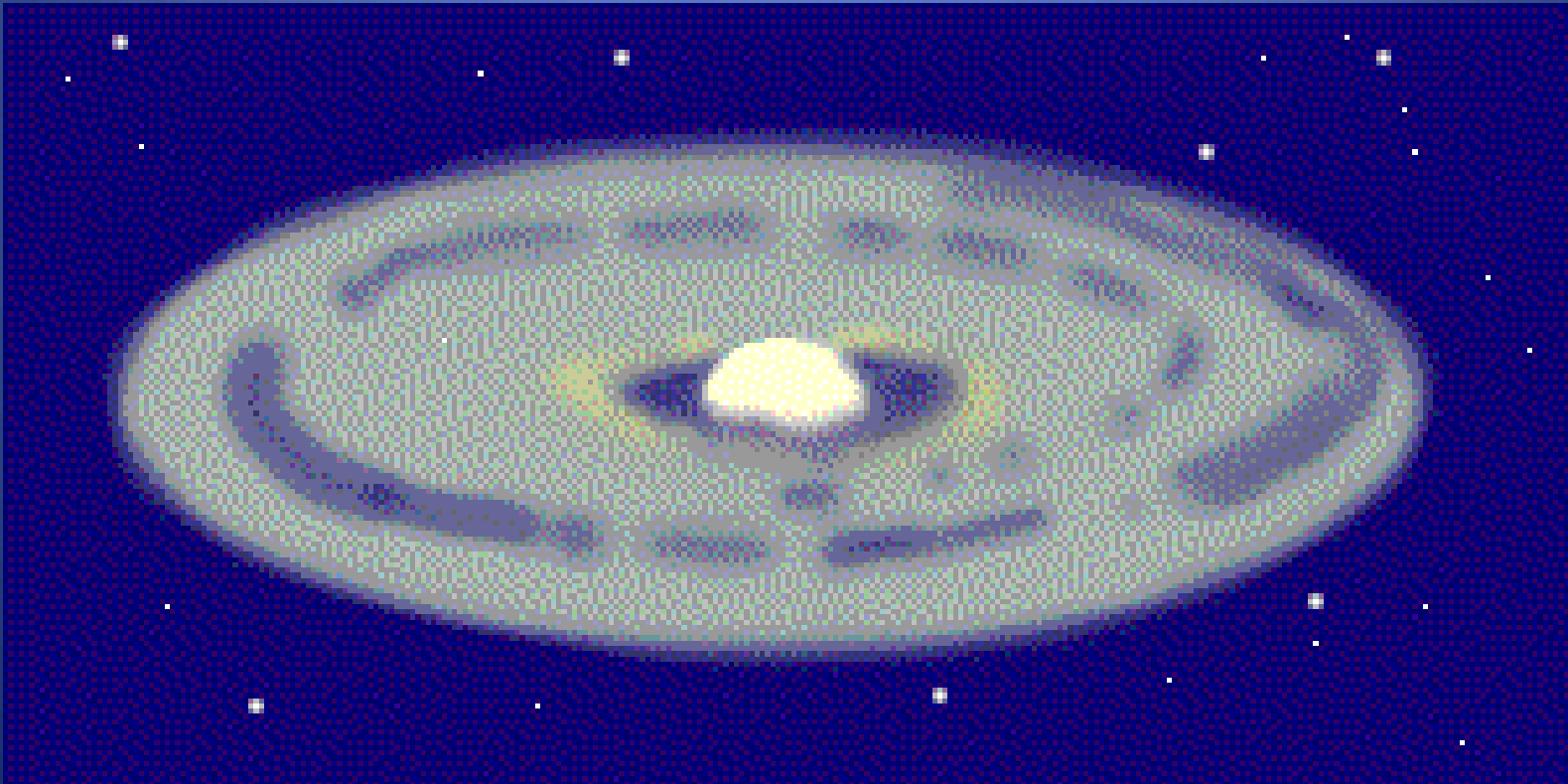
$10^{6-7}$  yrs; 1–100AU; 100–3000K

**Class 2 Protostar**

- Now thought to be young, pre-main sequence stars.
- Show similar spectra (I.e. High lithium abundance).
- Outbursts generally attributed to Thermal Instabilities.

# Thermal Instability

- High accretion rates required;  $\dot{m} \sim 10^{-4} M_{\text{solar}}/\text{year}$
- Increased central temperatures lead to runaway Outburst.
- Ceases when ionised H destroyed or inner disc is drained.



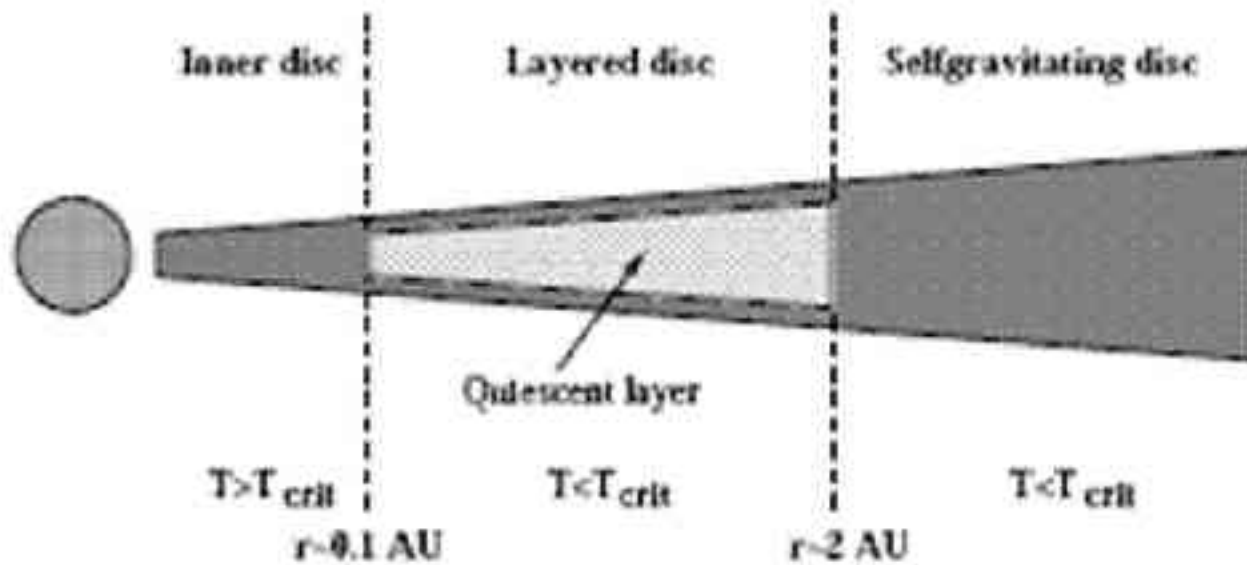
# Aims of Project – Part 1

- To conduct an extensive literature review, comparing and contrasting current theories about the origin of this phenomena.
- Image all known FUors in a range of wavelengths using Aladin to look for signs of extended structure.
- Make luminosity estimates using Subaru.
- Compile light curves of all known FUors using archive data and reconstruct their

# Aims of Project – Part 2

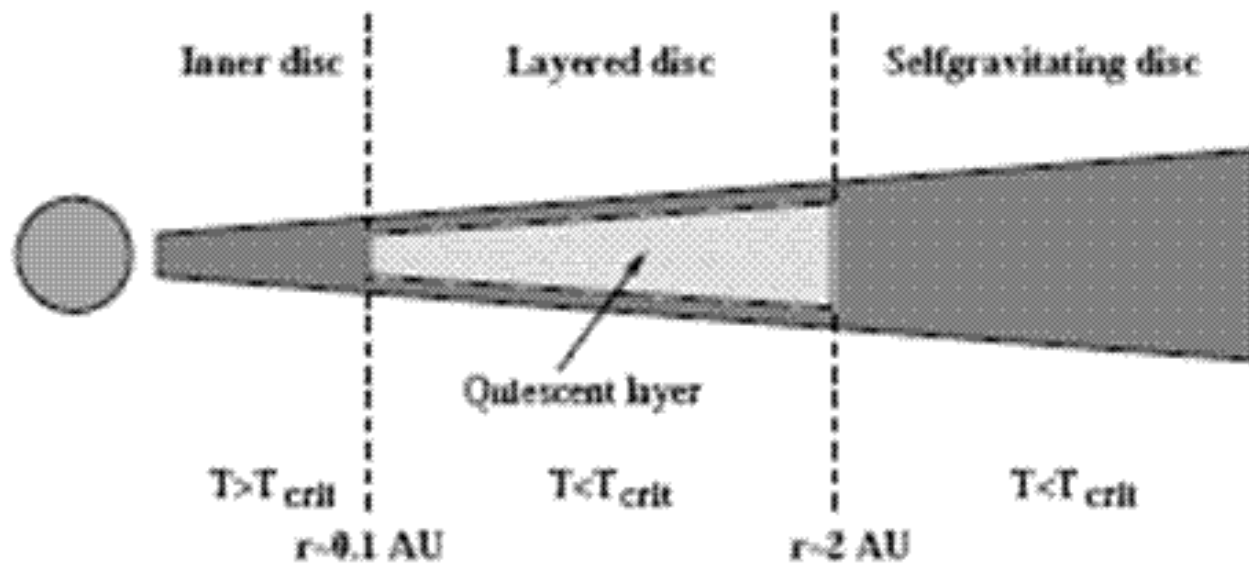
- Use the knowledge gained to assess the current theories and conclude the most likely mechanism / stage in stellar evolution.
- Assess the possibility of FU Orionis objects being one off events or a process that may reoccur many times in a stars life.

# MHD-Planet Theory

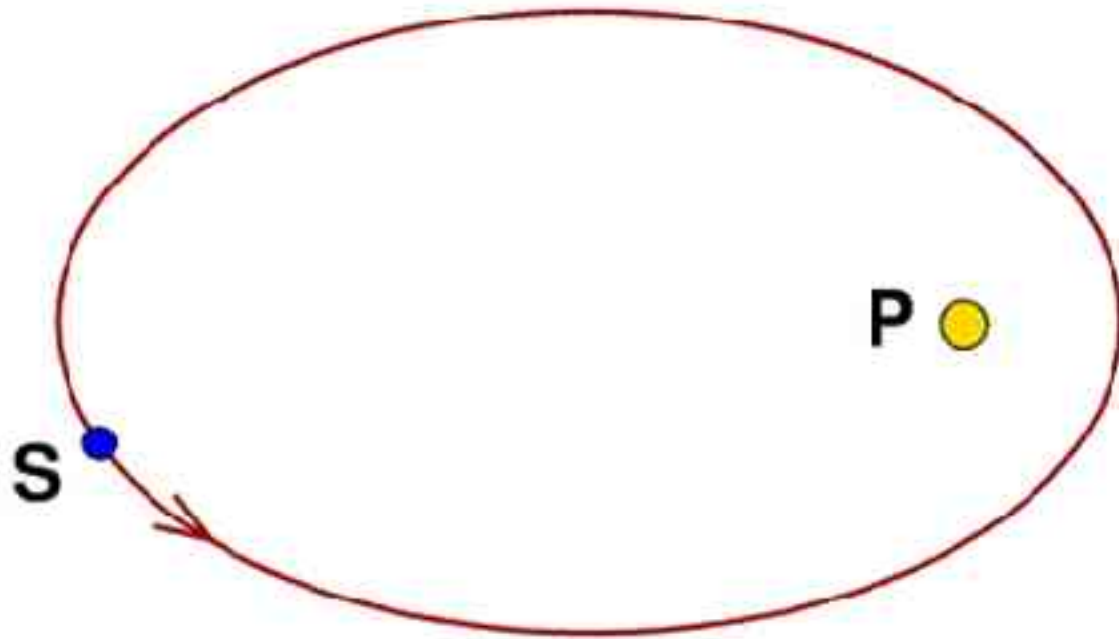




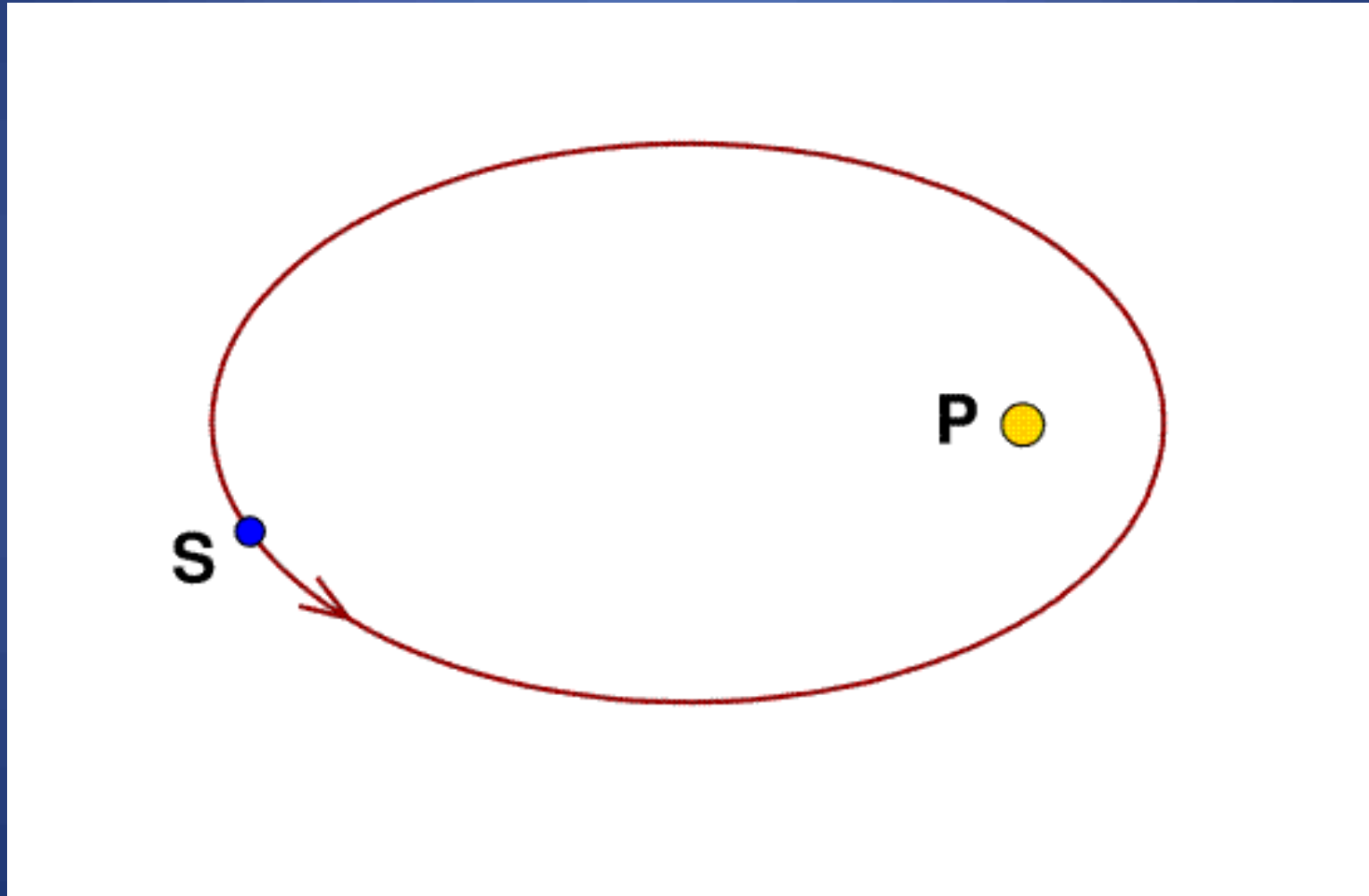
# MHD-Planet Theory



# Binary Theory



# Binary Theory



# Predictions

	MHD-Planet	Binary	FUors (Observed)
$T_{(rise)}$	2-5yrs	1-10yrs	~1-5yrs (Max 20yr)
$T_{(outburst)}$	Upto 100yrs	~30yrs	+50yrs
$T_{(reoccur)}$	10,000yrs	1000yrs	Unknown
Other	Planet	Binary	Unknown

# Problems

## MHD-Planet Theory

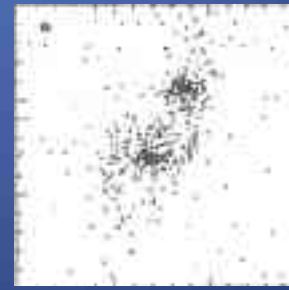
- Requires planet formation in early stages (Highly Stochastic Process).
- Planet would likely be obscured by the disc at this stage if it did indeed exist.
- Cannot look for evidence in main sequence as protostar likely to engulf planet during expansion.



(Clarke & Armitage 2004)

## Unequal Mass Binary Theory

- Requires complex evolutionary scenario in multiple body cases.
- Hard to identify binary nature due to obscuration of larger primary.
- Requires eccentric orbits for  $T_{(reoccur)}$ .



(Bonnell & Bastien 1992)

# Conclusion

- MHD-Planet Theory seems to be the most likely mechanism behind FU Orionis Objects.
- A Class 2 Protostar surrounded by an abnormally large disc best fits this theory & the observed properties to date.
- Likely to be re-occurring events, up to 10 times in a stars pre-main sequence life.
- More studies need to be carried out before a definitive conclusion about their nature can be given.

# Future

## MHD-Planet Theory

- High resolution hydrogen line profile variation studies of FUor stars could determine whether a large planet around 3 Jupiter masses resided at  $\sim 0.5$  AU.
- Advances in proto-planetary evolution models for pre-main sequence stars could better indicate the likeliness of such a planet forming so early on.
- New planet finding missions in the future could help resolve this issue.

## Unequal Mass Binary Theory

- High resolution Infrared studies could discover the “hidden primary” if it is indeed obscured by the surrounding natal material.
- As more examples appear binary nature could become more apparent than at present.
- Studies of the largest Herbig-Haro objects could help us understand the hierarchical evolution of multiple bodied systems leading to FUor Outbursts.

# References

- Bell & Lin, 1995.
- Armitage et al, 2001.
- Vittone & Errico, 2006.
- Bonnell & Bastien, 1992.
- Clarke & Armitage, 1994.



V1515 Cyg



**Thank you  
For  
Listening**

**Any Questions  
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