Search for rapid inner disk re-arrangements in a young eruptive star

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“From atoms to pebbles”
Herschel’s view of
Star and Planet Formation
March 22, 2012
The isolated star formation paradigm

Class 0:
$10^4$ yrs; 10-10$^4$ AU; 10-300 K

Class I-II:
$10^5$-$^6$ yrs; 1-1000 AU; 100-3000 K

Class II-III:
$10^6$-$^7$ yrs; 1-100 AU; 100-5000 K

Class IV:
$10^7$-$^9$ yrs; 1-100 AU; 100-5000 K

Figure courtesy of Mark McCaughrean
Episodic accretion

- Material accumulates close to the star
- Thermal instability $\rightarrow$ ionization front
- Material suddenly flows onto the star
- Outburst powered by enhanced accretion
- Outbursts are rare, episodic, unpredictable

Eruption affects the disk:
- density, temperature, chemical structure
- conditions for planet formation

Schulz et al. (1995)
Classical picture: FUors and EXors

Accretion rate: up to $10^{-4}$ $M_\odot$/yr

Spectrum: absorption lines

Hartmann & Kenyon (1996)
Classical picture: FUors and EXors

Accretion rate: up to $10^{-6} \, M_\odot/\text{yr}$
Spectrum: emission lines
Herbig (1977), AAVSO

Accretion rate: up to $10^{-4} \, M_\odot/\text{yr}$
Spectrum: absorption lines
Hartmann & Kenyon (1996)
Recently discovered outbursts

- Do not fit into the classical FUor/EXor groups

- Extinction changes play an important role

Kun et al. (2011), Kóspál et al. (2005), Acosta-Pulido et al. (2007)
Open questions

- Why does the extinction change? Is it caused by the outburst? Is the dust evaporated by the heat of the outburst?
- Are eruptive young stars special objects? Are all low-mass young stars undergo eruptive phases?

To answer these questions, we need to study those objects where the extinction changes are particularly large, and the effect is very well visible.
Our target
Our target
Our target

V2492 Cyg

image credit: Anna Morris (www.eprisephoto.com)
Why is V2492 Cyg so special?

Huge outburst amplitudes: \( \Delta J = 7.9 \) mag
\( \Delta H = 6.7 \) mag
\( \Delta Ks = 4.8 \) mag
Why is V2492 Cyg so special?

Peculiar light curve

Kóspál et al. (2011), Kóspál et al. (in prep.), AAVSO
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Why is \( V2492 \) Cyg so special?

Peculiar color changes

Kóspál et al. (2011), Kóspál et al. (in prep.)

Kóspál et al. (in prep.)
Possible reasons for flux changes

Muzerolle et al. (2009)  
Flaherty et al. (2011)  
Turner et al. (2010)

Existing dust cloud/lump in the disk orbits the star  
Due to turbulence/magnetic activity, dust clouds are lifted off the surface of the disk

Let's look for far-infrared flux variations!
What do we expect?

Pre-existing, orbiting dust cloud/lump

⇓

Constant far-infrared flux

Forming/disappearing dust cloud/lump

⇓

Variable far-infrared flux

Kun et al. (2011)

PV Cep
Herschel DDT monitoring of V2492 Cyg (coordinated with Spitzer)

<table>
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<th>Date</th>
<th>Instrument</th>
<th>Wavelength</th>
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FIR light curves of V2492 Cyg

Kóspál et al. (in prep.)
SED of V2492 Cyg

Kóspál et al. (2011), Kóspál et al. (in prep.)
Summary

• V2492 Cyg went into outburst reaching a peak around August 2010

• Since then, the optical-infrared light curves show signs of changing extinction ($\Delta A_V = 20$ mag, $\Delta$(column density) = 0.07 g cm$^{-2}$) → dust inhomogeneities/clouds/lumps in the inner disk

• We performed a co-ordinated Spitzer-Herschel monitoring to see if there is any indication for changing illumination of the outer disk/envelope

• The 70 µm monitoring shows constant flux → favors the model of an orbiting dust cloud in the system
Outlook

• **Question**: what is the physical mechanism which could produce and maintain such huge dust concentrations?

• **General significance**: the existence of large density fluctuations in the inner part of the system, the planet-forming zone, may have consequences for grain growth and planetesimal formation

• **Work in progress**: the broader environment of V2492 Cyg
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