Looking into the heart of a young outbursting star: First AU-scale observations of V1647 Ori with VLTI/MIDI

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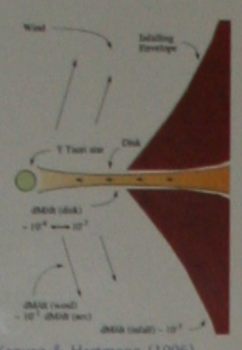
FU Orionis-type stars (FUors)

- Low-mass, pre-main sequence stars exhibiting optical outbursts of ≈ 5 mag;
- Outbursts are due to enhanced accretion from the circumstellar disc to the star, caused by thermal instability;
- The enhanced accretion can be
  - spontaneous
  - triggered by the passing of a close companion



Kenyon & Hartmann (1996)

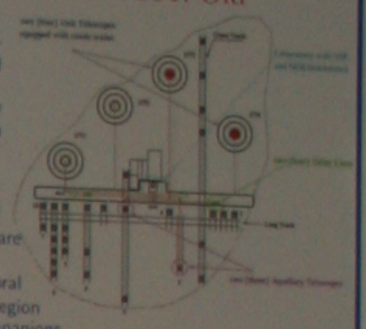
The outburst of V1647 Ori

- In January, 2004 a new reflection nebula (McNeil's Nebula) appeared in the LDN 1640 dark cloud of the Orion B molecular cloud complex;
- V1647 Ori, whose outburst caused the appearance of McNeil's Nebula, is a low-mass, pre-main sequence object;
- Optical brightening: 5 mag in I_C-band;
- Pre-outburst luminosity: 5.4 $L_\odot$
  Outburst luminosity: 44 $L_\odot$;
- Spectrum: flat in νF_ν between 2 and 60 μm;
- FU Orionis-type candidate.

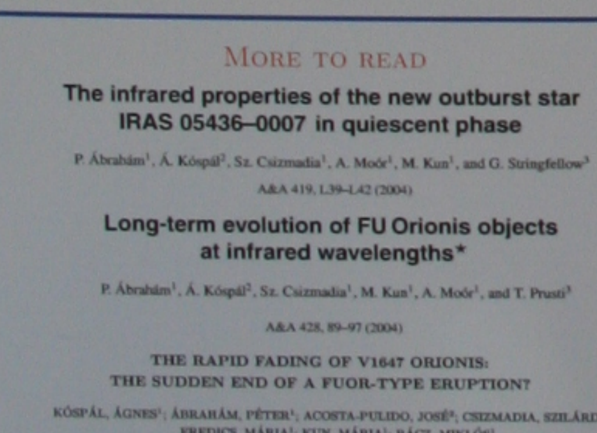
Reipurth & Aspin (2004)

MIDI observations of V1647 Ori

- MIDI: Mid-Infrared Interferometric Instrument on the VLTI
- DDT (Director's Discretionary Time) proposal to ESO in November 2004
- Aims:
  - Investigate the structure of the hot inner source, compare to models
  - Start monitoring the temporal evolution of the hot inner region
  - Look for possible close companions
- Successful observation: March 2, 2005
- Data reduced with MIA (see e.g. Leinert et al. 2004)



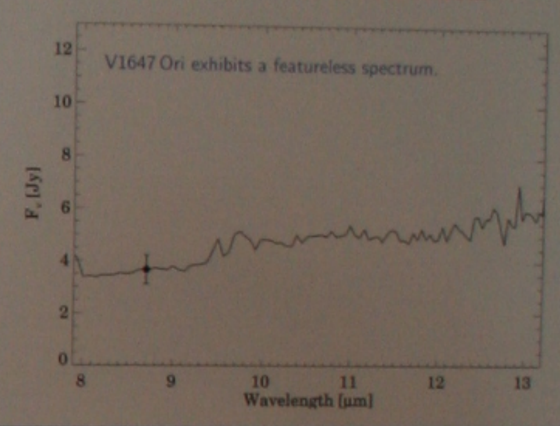
Results: spectrally resolved visibilities



Results: Search for companion

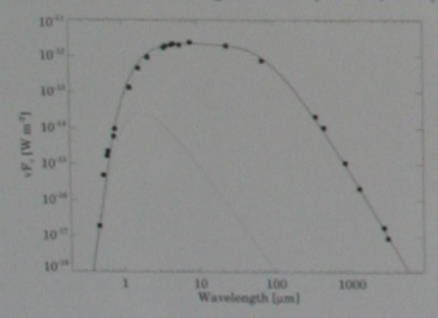
- A signature of a companion is the sinusoidal modulation of the spectrally resolved visibilities.
- We determined an upper limit for the brightness of a possible companion.
- No companion is detected at the measured position angle whose separation is less than 100 AU and brightness ratio to V1647 Ori is greater than 10%.

Results: N-band spectrum



Analysis: Step 1 – Fit the SED

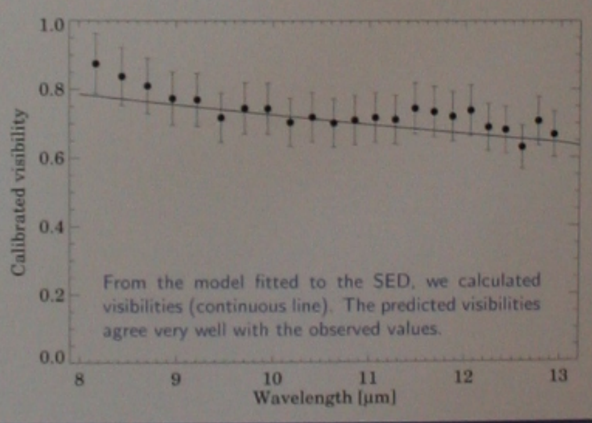
We collected simultaneous observations from the whole optical–infrared–submillimetre wavelength regime.
We fitted the spectral energy distribution (SED) with the sum of the spectra of a star and a geometrically flat, optically thick disc.



Model parameters:

$R_{in} = 5$ AU
$T(1\,\mathrm{AU}) = 680$ K
$T(r) \sim r^q$ with $q = -0.53$
$\Sigma(r) \sim r^p$ with $p = -1.5$
$M_{disk} = 0.05\,M_\odot$
$A_V = 10$ mag
$i = 60°$

Analysis: Step 2 – Predict visibilities



Analysis: Temperature distributions ($T \sim r^q$)

flat disc	flared disc	envelope
$q = -0.75$	$q = -0.75 \ldots -0.5$	$q = -0.5 \ldots -0.33$

- V1647 Ori: $q = -0.53$, consistent with both the SED and the N-band visibilities (this work)
- FU Ori: $q = -0.71$, consistent with both the SED and the K-band visibilities (Malbet et al. 2005)
- V1057 Cyg and V1515 Cyg: $q = -0.45$ from the SED, $q = -0.65$ from the K-band visibilities (Millan-Gabet et al. 2006)
- Z CMa: $q = -0.75$, consistent with the SED but not with the K-band visibilities (Millan-Gabet et al. 2006)

More to read

The infrared properties of the new outburst star IRAS 05436–0007 in quiescent phase

P. Ábrahám[1], Á. Kóspál[2], Sz. Csizmadia[1], A. Moór[1], M. Kun[1], and G. Stringfellow[3]

A&A 419, L39–L42 (2004)

Long-term evolution of FU Orionis objects at infrared wavelengths*

P. Ábrahám[1], Á. Kóspál[2], Sz. Csizmadia[1], M. Kun[1], A. Moór[1], and T. Prusti[3]

A&A 428, 89–97 (2004)

THE RAPID FADING OF V1647 ORIONIS: THE SUDDEN END OF A FUOR-TYPE ERUPTION?

KÓSPÁL, ÁGNES[1]; ÁBRAHÁM, PÉTER[1]; ACOSTA-PULIDO, JOSÉ[2]; CSIZMADIA, SZILÁRD[1]; EREDICS, MÁRIA[1]; KUN, MÁRIA[1]; RÁCZ, MIKLÓS[1]

INFORMATION BULLETIN ON VARIABLE STARS Number 5661

The outburst history of V1647 Ori

A monitoring programme conducted at the Konkoly Observatory (Hungary) and at the Instituto de Astrofísica de Canarias (Spain) revealed that, after nearly 2 years in outburst, V1647 Ori went back to quiescent state by 2006.

References

Kenyon & Hartmann 1996, ARA&A 34, 207

Leinert et al. 2004, A&A 423, 537

Malbet et al. 2005, A&A 437, 627

Millan-Gabet et al. 2006, A&A 641, 547

Reipurth & Aspin 2004, ApJ 606, L119

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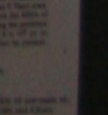

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