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YSOs

• A mini review of Young Stellar Objects observed with VEGA
• Study of the 51 Oph

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Scientific rationale

• Understand the physical mechanism involved around YSOs...

• Spatially and spectrally resolved observations of such targets across the Halpha line with VEGA is crucial as it will enable the relative contributions of the accretion and ejection processes to the line formation to be disentangled.

• Bring direct spatial constraints on the geometry of the winds, and on the accretion/ejection scenario at scales as small as 0.1 AU.
<table>
<thead>
<tr>
<th>Target</th>
<th>Sp. type</th>
<th>L (L$_\odot$)</th>
<th>$R_{\text{sub}}$ (AU)</th>
<th>d (pc)</th>
<th>$R_{\text{sub}}$ (mas)</th>
<th>Ha line</th>
</tr>
</thead>
<tbody>
<tr>
<td>AB Aur</td>
<td>A0Ve</td>
<td>$\sim$ 50</td>
<td>0.5</td>
<td>144</td>
<td>3.4</td>
<td>(variable) P Cygni profile Perraut et al. 2010, A&amp;A, 516, L1 Lima, Perraut et al. in prep</td>
</tr>
<tr>
<td>MWC 275</td>
<td>A1Ve</td>
<td>$\sim$ 30000</td>
<td>11.9</td>
<td>122</td>
<td>97</td>
<td>(variable) P Cygni profile</td>
</tr>
<tr>
<td>MWC 158</td>
<td>B6V[e]</td>
<td>$\sim$ 10000</td>
<td>6.9</td>
<td>500</td>
<td>14</td>
<td>Double-peaked Ellerbroek, Benisty et al. in prep.</td>
</tr>
<tr>
<td>MWC 480</td>
<td>A3Ve</td>
<td>$\sim$ 10</td>
<td>0.2</td>
<td>170</td>
<td>1.3</td>
<td>(variable) P Cygni profile</td>
</tr>
<tr>
<td>51 Oph</td>
<td>B9.5IIIe</td>
<td>$\sim$ 260</td>
<td>0.54</td>
<td>131</td>
<td>4</td>
<td>Double-peaked Dunkin et al. 1999</td>
</tr>
</tbody>
</table>
MWC361: enhanced Ha activity at periastron

3-year follow-up of the young binary system MWC361


VEGA Ha line over the orbital period

VEGA differential visibilities (S1S2) across the Ha line (observations and best model)
MWC361: an enhanced mass-loss event


outburst of accretion, followed by a massive ejection, at the periastron
AB Aur: temporal variability

3-year follow-up VEGA observations:

20 Ha VEGA spectra exhibiting a P-Cygni profile and a fast variability mainly in the blue wing
AB Aur: Constraining the wind

Simultaneous fit of (variable) spectra and interferometric data allow to:

- constrain the disk wind
- study of magnetospheric accretion

Four components:

- the star (1)
- the magnetosphere (2)
- the accretion disk (3)
- the disk wind (4)

AB Aur: constraining the wind

\( i = 30° \)

Disk wind: \( R_{in} = 5 \, R^*, \, R_{out} = 25 \, R^*, \) launching angle = 44\(^\circ\), \( \text{Teff} = 7500 \, \text{K} \)

Mass loss rate = 1.7e-08 Msun/yr without magneto

HD50138: resolving the gas disk

Pre- or post-main sequence B[e] star HD50138

VEGA data included in a multi-technique, multi-lambda study (X-shooter spectra, AMBER K-band and Brgamma data, PIONIER H-band)

VEGA differential visibilities (S1S2) across the Ha line

- emission size of ~1-3 mas more consistent with an outflow than accretion

IR interferometric data
### 51 Oph presentation

<table>
<thead>
<tr>
<th>Altemate name</th>
<th>Spectral type</th>
<th>Distance (pc)</th>
<th>Velocity (v sin i) (km/s)</th>
<th>Magnitude (V)</th>
<th>Age (Myr)</th>
<th>Mass (x stellar mass)</th>
</tr>
</thead>
<tbody>
<tr>
<td>HD 158643</td>
<td>B9.5IIIe</td>
<td>131</td>
<td>267 ± 5</td>
<td>4.83</td>
<td>0.3</td>
<td>4</td>
</tr>
</tbody>
</table>

- Dunkin et al. 1997
- Dunkin et al. 1997
- Van den Ancker et al. 1998
- Perryman et al. 1997
- Mendigutia et al. 2012
Evolutionary status of 51 Oph

**Herbig Ae/Be star??**

- Emission lines
- Infrared excess
- 10 micron silicate feature
- Presence of circumstellar dust

**Be star??**

- Fast-rotating
- Hot molecular lines emission
- The compact gaseous disk

**Beta Pictoris??**

- Edge-on disk with both gas and dust
- Variable absorption features suggesting infalling gas and materials
- Rare nearby example of a young debris disk with gas just entering the late stages of formation

**Beta Pic star age of 8-12 \times 10^6 Myr and mass of 1.75 stellar mass**

- Lacking the far infrared-excess bump
- No dust detection at 18 \mu m
- Absence of H alpha emission in Beta Pic
VEGA Observations:

May (2013) → E1E2W2; Run: VEGA MR: In continuum

July (2013) → S1S2; Run: VEGA MR: H alpha (two points)

W1W2; Run: VEGA MR: poor quality

Fundamental parameters of the star
Study of the gaseous disk
Results of first processing:

From data obtained in May 2013,

Estimated angular diameter: 0.39 +/- 0.01 mas

Assuming all flux in the continuum comes from the central star
Calculating the effective temperature:

\[ T_{\text{eff}} \sim \left( \frac{L_*}{4\pi \theta_{LD}^2 d^2 R_\odot^2 \sigma} \right)^{1/4} \]

First estimation

\[ T_{\text{eff}} = 9500 \pm 62/-53 \text{ K} \]

Estimated with angular diameter in one direction...

L (star) = 260 \pm 60/-50L (sun) ; (Thi et al. 2013)

\[ d = 131 \pm 4 \text{ pc (Perryman et al. 1997)} \]
Results of second processing:

Processing for:
- data obtained in May (baseline E1E2; 1 point)
- data obtained in July (baseline S1S2; 2 points)
Are VEGA data consistent with a keplerian disk?

We use: Keplerian and uniform disk model

Free parameters:

1) Inclination
2) P.A.
3) Major-axis FWHM in the continuum
4) Major-axis FWHM in the line
Derived information:

For star:
1) The angular diameter = 0.39 +/- 0.01 mas
2) First estimation of the effective temperature = 9500 +/- 53 K

For gaseous disk:
1) Gaseous disk is keplerian  →  According with Thi et al. 2005
2) i=88  →  According to (Gil et al. 2006) and (Tatulli et al. 2008)
3) P.A. = 197  ×  In Tatulli et al. 2008  →  P.A. = 129
4) FWHM in the continuum = 3 stellar diameter
5) FWHM in the line = 10 stellar diameter
New observations 2014:

First run: E2S2W2 or W1W2E2 or W1W2S2; VEGA MR: Continuum

Second run: VEGA MR: Halpha S1S2; E1E2; W1W2

To constrain the photosphere (extension and flattening) of this close-to-critically rotating star

To improve our knowledge on the gaseous disk geometry and kinematics and confirm the estimated parameters of the keplerian disk
Conclusions:

For YSOs studies:

1) Importance of adding the IR data in multi wavelengths to visible interferometric data

2) New constrains to modelize the physics involved (wind, accretion, magnetospheric) models.