ALMA reveals a large structured disk and nested rotating outflows in DG Tau B

Aloïs de Valon (IPAG)

Dougados Catherine (IPAG), Cabrit Sylvie (LERMA), Zapata Luis (UNAM), Louvet Fabien (CEA), Mardones Diego (UdeChile)
Rotating molecular flows-cavities

**Role of protostellar jets/outflows in disk accretion and dissipation?**
DG tau B : Global view

**Class 1 protostar in Taurus**

$\text{Zapata et al. (2015)}$

CO (2-1) emission

$\text{SMA (1.63x1.87'')}$

$\text{HST (0.1'')}$

$\text{Padgett et al. (1999)}$

Scattered IR light

$\text{Mottram et al. (2017)}$

CO (3-2) emission

$i = 63^\circ$
DG tau B : Global view

Does the scattered light define the interface between cavity and envelope?

- Rotating CO outflow
- Proposed Interpretation: Interaction between internal fast wind and envelope
DG tau B: Global view (CO 2-1)

\[ V - V_{LSR} = -4.8 \text{ km/s} \]

ALMA (0.13x0.18")

de Valon et al. (2019, Coming soon...)
- Disk is large in dust and gas: \( R_{\text{dust}} = 174 \text{ au} \)

- Disk with internal structure: \( R_{\text{gas}} = 700 \text{ au} \)

Modeled with an exponentially tapered power law and two Gaussians (Long et al. 2018.).

Gaps at 53 and 80 au
DG tau B: A conical and rotating nested outflow...

Conical outflow

- Opening angle decreases with increasing velocity. → Stratification?
- Tilt in Position-Velocity diagrams.
- Extrapolation of the conical structure

\[
V - \nu_{\text{LSR}} = 2.8 \, \text{km/s}^{-1} \quad \text{ml} / \text{beam}^{-1} \\
V - \nu_{\text{LSR}} = 4.4 \, \text{km/s}^{-1} \\
\delta z = 6^\prime \quad \delta z = 2^\prime
\]

\[
\nu_{\text{LSR}} \approx 70 \, \text{au km/s} \\
r_0 < (10 - 60 \, \text{AU})
\]
Large and slower parabolic structure
- Surround the conical structure
- Tilt in Channels maps
- Increase in height with the velocity

Rotation.
Apparent acceleration.
DG tau B: Infall?

- Infalling layer (Ulrich 1976) with $\theta = 70^\circ$ and Rd = 700 au
- Large extent and apparent acceleration could not be reproduced by infalling structure
- The outer structure is outflowing!
DG tau B : Summary : Global view

Our ALMA data shows:

- A large structured disk with gaps at 53 and 80 au

- With a rotating, stratified and conical outflow that comes from the inner parts of the disk (10-60au) : opening angle coherent with scattered light cavity

- Surrounded by a large and rotating outflowing structure

- Weak signatures of infall
DG tau B : Origin of the outflow

Conical structure:
- Not tracing an interaction with the envelope!
- Stratified structure typical for disk wind
  \[ \text{RV}_\phi \to r_0 < 7 \text{ au if unperturbed} \]
- Interaction between Jet bowshocks and external winds?

Outer structure:
- Difference in origin or ejection mechanism?
- Could be an interface with outer envelope

Necessity of a proper modelling taking into account complex projection effects

---

Tabone et al. (2018)
DG tau B is a Class I protostar with outflow, infall and ...

Gap at:
- 53 au ($\Delta=9$ AU)
- 80 au ($\Delta=40$ AU)

... gaps coming from planet formation
- Planet mass at 0.1Mj and 2.4 Mj.
- Coherent with taurus surveys
  (Long 2018, Lodato 2019, Andrew 2018...)
- Early stage! And cohabitation with Infall and outflow

... gaps created by magnetic field
- Recent MHD simulations have shown that magnetic field could create gaps
  (Suriano 2017, Riols & Lesur 2019, Béthune et al 2017...)
- First gap corespond to external footpoint of conical structure
- Link with magnetic field on the disk
Thank you for your attention!

Aloïs de Valon
