IRAS 16253-2429: The First Proto-Brown Dwarf Binary Candidate Identified through The Dynamics of Jet

Tien-Hao Hsieh¹,², Shih-Ping Lai², Arnaud Belloche⁴ & Friedrich Wyrowski⁴

¹Academia Sinica Institute of Astronomy & Astrophysics (ASIAA)
²National Tsing-Hua University (NTHU)
³Max-Planck-Institut für Radioastronomie (MPIfR)

Published in ApJ, 2016, 826, 68
Mystery of Brown Dwarf formation

$M_{JEANS} \sim 1 \ M_{\text{sun}}$

$\gg M_{BD} \ (0.08 \ M_{\text{sun}})$

Mystery of Brown Dwarf formation

1. Form through gravitational collapse
2. Form like planet and ejected later
3. Parent core disrupted by nearby massive object

$M_{\text{JEANS}} \sim 1 \, M_{\text{sun}}$

$>> M_{\text{BD}} (0.08 \, M_{\text{sun}})$

Mystery of Brown Dwarf formation

1. Form through gravitational collapse
2. Form like planet and ejected later
3. Parent core disrupted by nearby massive object

Answer is in "Proto Brown Dwarf"!!

Only few proto-BD identified

1. L1014-IRS (Huard+ 2005; Bourke+ 2006)
2. J041757 (Barrado+ 2009)
3. L328-IRS (Lee+ 2009, 2013)
4. L1148-IRS (Kauffmann+ 2011)
5. IC348- SMM2E (Palau+ 2014)

✧ Oph B-11: “Pre-Brown Dwarf” (Starless) André+ 2012, Sci, 337, 69
IRAS 16253

Binary system?

H$_2$ + IRAC1
IRAS 16253

Binary system

$M_{\text{env}} = 0.2-0.5 \ M_{\text{sun}}$

SFE $\sim 10-30\%$

$M_{\text{into}} < 0.025-0.075 \ M_{\text{sun}}$

Proto-BD binary?

$M_{\text{env}}$: Stanke+ 2006; Barsony+ 2010; Enoch+ 2008, SFE: Tachihara+ 2002; Jørgensen+ 2008
IRAS 16253

The outflow
IRAM 30m CO (2—1)
Cavity+Entrained gas
IRAS 16253

The outflow
IRAM 30m CO (2—1) Cavity+Entrained gas
APEX CO (6—5) Cavity+Collimated jet
Very low $F_{\text{outflow}}$

Palau+ (2012, 2014), collect from, André+ (1999); Bourke+ (2005, 2006); Takahashi+ (2013); Onishi+ (1999); Kauffmann + (2011); Dunham+ (2010, 2011); Schwarz+ (2012); Maheswar+ (2011); Lee et al. (2009, 2013); Wiesemeyer+ (1999); Furuya+ (2006); Barrado+ (2009); Palau+ (2012); Enoch+ (2010); Chen (2010, 2012); Pineda+ (2011); Launhardt+ (2010); Pezzuto+ (2012); Huang & Hirano (2013); Hirano & Liu (2014)…
Figure 2. (a) SMA CO (2–1) integrated intensity maps with velocities spanning 0.7–2.7 km s$^{-1}$ (blue) and 4.8–8.5 km s$^{-1}$ (red) overlaid on the Spitzer IRAC 1 (3.6 μm) image. The contour levels are 5, 10, 15, 20, 25, and 30σ with rms noise levels of σ$_{\text{blue}}$ = 0.326 Jy beam$^{-1}$ km s$^{-1}$ and σ$_{\text{red}}$ = 0.2 Jy beam$^{-1}$ km s$^{-1}$. The dashed line indicates the field of view of our SMA observations and the green star indicates the position of the infrared source. The orange contours show the same N$_2$H$^+$ (1–0) map as in Figure 1. (b) Same as (a), but with only the 5σ CO(2–1) contour overlaid on a CFHT H$_2$ image at 2.12 μm. The gray contours show the COMPLETE 850 μm continuum map with contour levels increasing from 3 to 8σ in steps of 1σ with σ = 0.056 Jy beam$^{-1}$.
SMA CO (2—1)

PV diagram Wiggling?
SMA CO (2—1)

Orbital Wiggling Models

Lee et al. 2010; Raga et al. 2009
Non-coplanar disk

$V_{\text{orb}} = 0.52 \text{ km s}^{-1}$
$M = 0.006 \text{ M}_{\text{sun}}$

$V_{\text{orb}} = 0.10 \text{ km s}^{-1}$
$M = 0.026 \text{ M}_{\text{sun}}$

$M_{\text{env}} < 0.5 \text{ M}_{\text{sun}}$
$< 0.025-0.075 \text{ M}_{\text{sun}}$

69 au (0.55")
Summary

A proto-brown dwarf candidate – IRAS 16253-2429:

1. Outflow physical properties
   CO (2-1): Cavity+Entrained gas
   CO (6-5): Cavity+collimated jet
   Very low outflow force as proto-BDs or FHSC

2. Outflow dynamics:
   Orbital wiggling shown in PV diagram
   Keplers’ law => $M_{\text{stars}}: 0.026$ and $0.006 \, M_{\odot}$
Thank you for your attention