QUASI-PERIODIC JET LAUNCHING IN HD 163296

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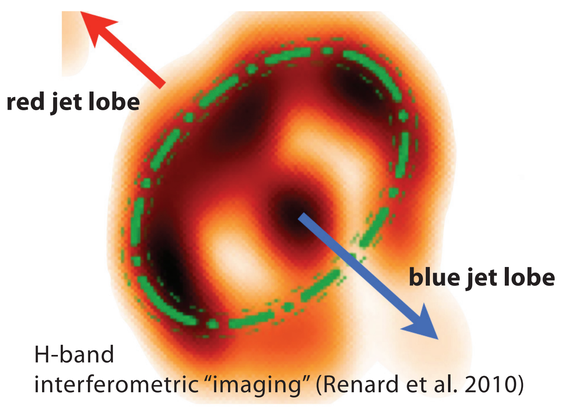
ABSTRACT

From the structure of the jet from the Herbig Ae star HD 163296 we infer that it is the result of nearly periodic (15 yr) ejection events. Iron is not depleted in the high-velocity jet, indicating its dust content is low. However, the photometric behavior of the central source does indicate that a significant amount of dust is episodically lifted from the disk surface, probably on larger radial distances and lower velocities than the atomic jet.

8 mas ~ 1 AU

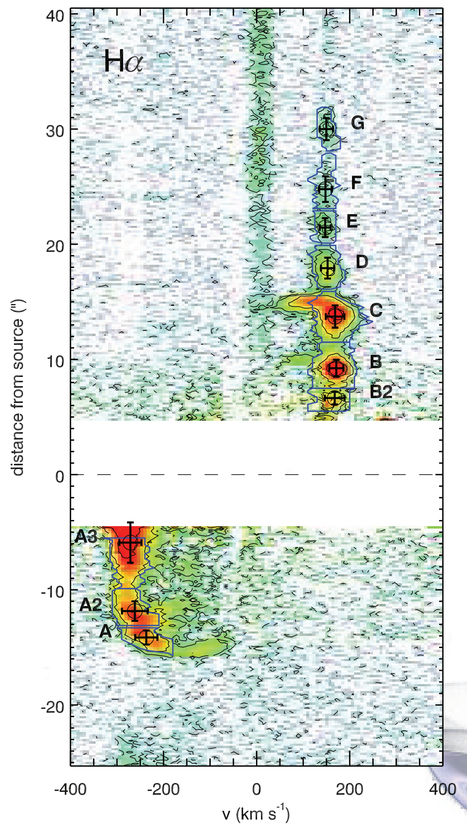


H-band interferometric "imaging" (Renard et al. 2010)

HD 163296
d=120 pc, T=9250K, i=48°
PMS Herbig Ae star
Gas & dust disk, R_{sub}= 0.5 AU
drives a jet (HH 409)

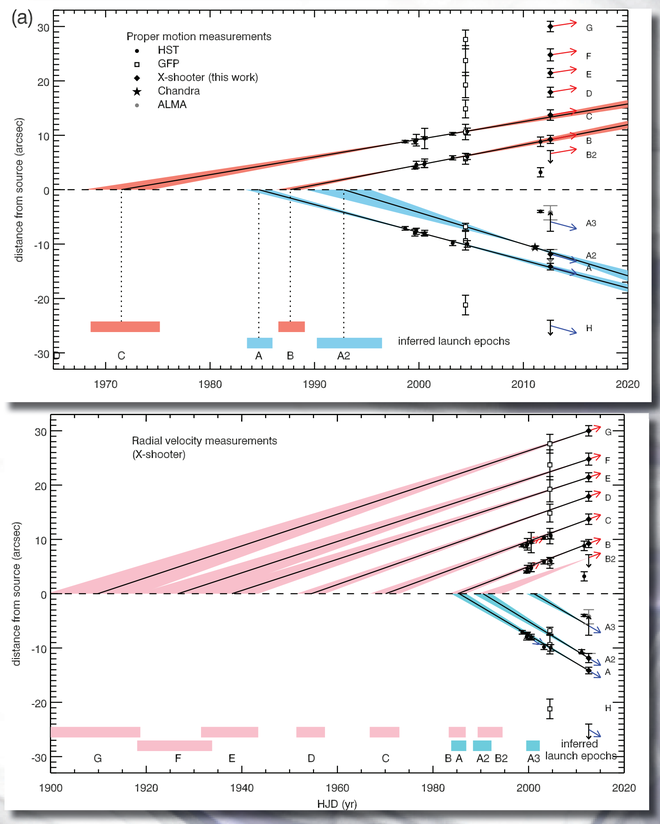
VLT/X-shooter spectrum

The jet consists of a "blue" and "red" lobe which are made up of knots...



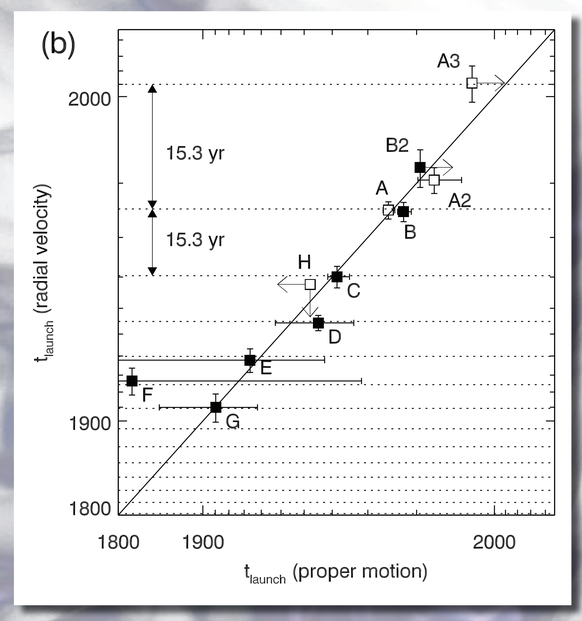
Kinematics

...which have a constant motion, allowing an estimate of their launching times as far back as the early 1900s.



Launch events

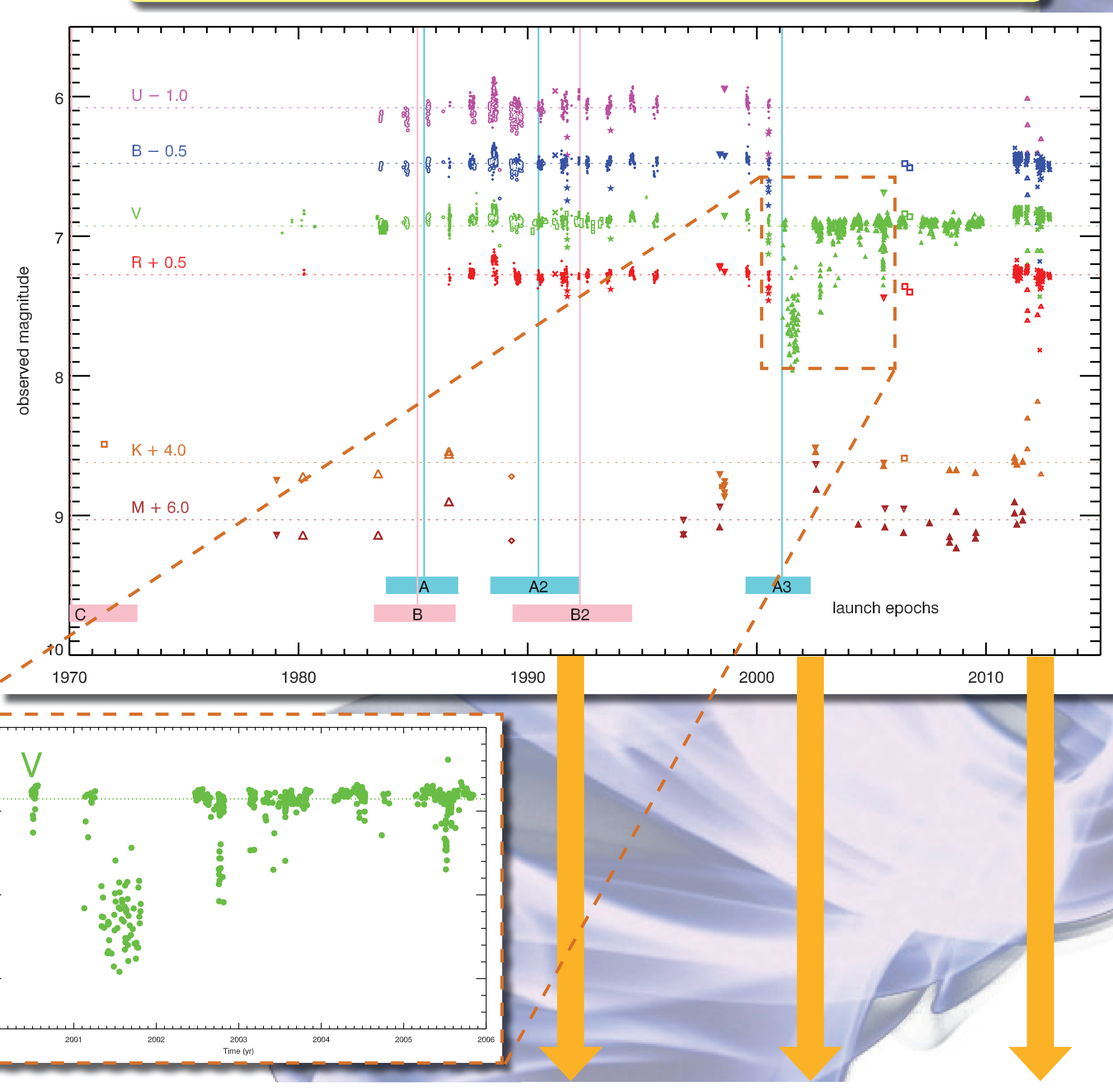
These "launch events" occur on regular 15 year intervals.



The events in both jet lobes appear to happen simultaneously.

Lightcurve of the central source

Archival photometry shows extinction events and NIR flares occur episodically. Some of these events occur simultaneously with "launch events"; limited coverage prevents us from establishing a direct correlation.

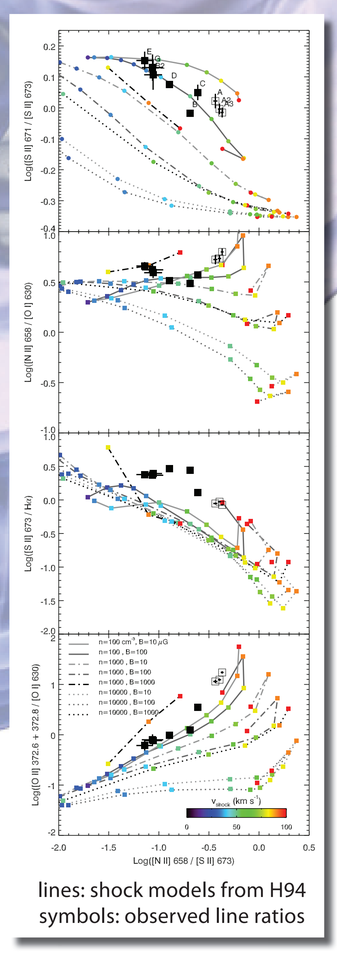


Physical conditions in the jet

From line ratios we infer that the blue lobe has higher ionization, higher shock velocities and lower compression compared to the red lobe. Yet the mass loss rate and launch periodicity are similar in both lobes.

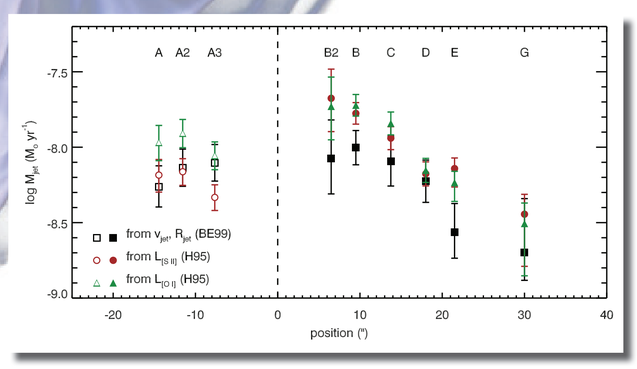
	n_H (cm-3)	ionization fraction	Compression	vshock (km s^{-1})	B field (μG)	Mass loss ($M_\odot$ yr^{-1})
blue lobe (A-A3)	~1000	0.7-0.8	~5	80-100	~100	~10^{-8}
red lobe (B2-G)	~1000	0.1-0.3	5-30	30-50	<100	~10^{-8}

Shock diagnostics

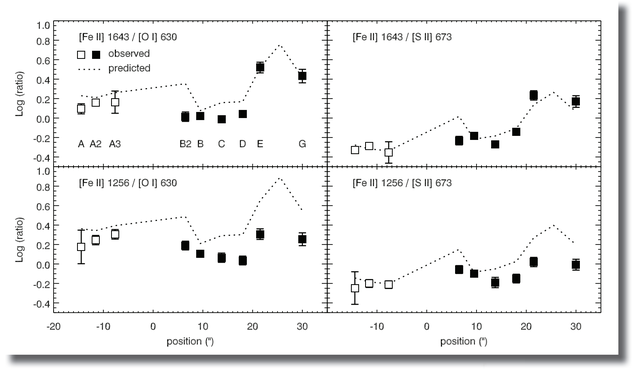


lines: shock models from H94
symbols: observed line ratios

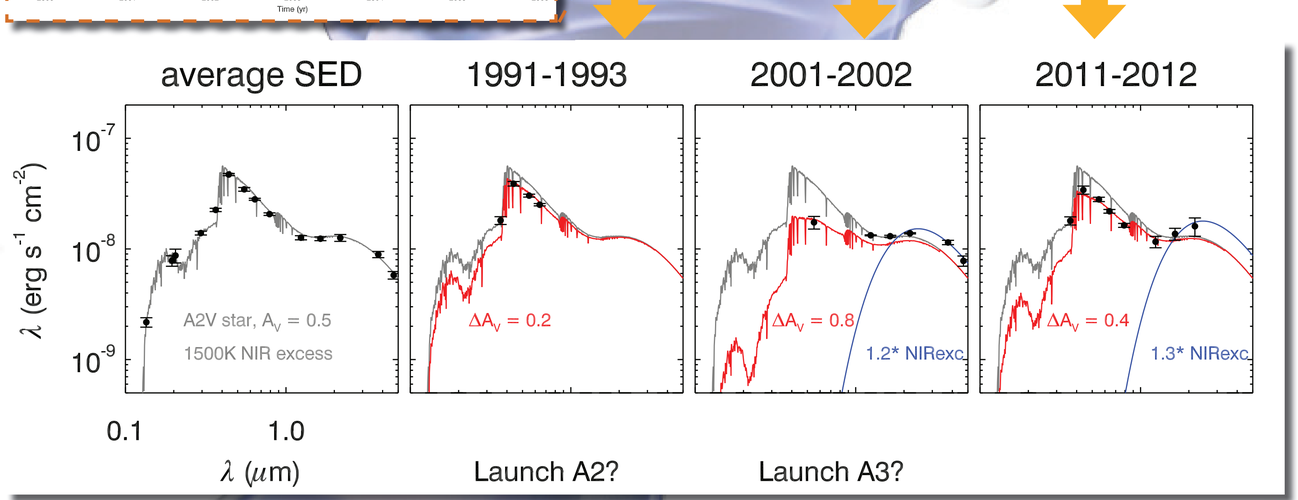
Mass loss rates



Iron depletion



No significant iron depletion is seen in the high-velocity jet. Its dust content is probably low; dust may yet be present at lower velocities.



References: Hartigan et al. (1987, 1994 = H94, 1995 = H95), Bacciotti & Eislöffel (1999 = BE99), Devine et al. (2000), Grady et al. (2004), Wassell et al. (2006), Podio et al. (2006), Tannirkulam et al. (2008), Sitko et al. (2008), Renard et al. (2010), Benisty et al. (2010), Bans & Königl (2012), Günther et al. (2013), Klaassen et al. (2013)

During these events the source becomes redder and shows an increased NIR excess. This is likely due to dust >0.5 AU above the disk plane. The 2001 event lasted 0.5-1.2 yr, which would correspond to a cloud of ~3 AU moving at intermediate velocity (~30 km/s).

CONCLUSIONS

In the HD 163296 disk-jet system, periods of intensified outflow activity occur on a regular interval of ~15 yr.

Although physical conditions in the two lobes are different, mass loss rates are similar and launch events are synchronized. This suggests the launch mechanism operates similarly on both sides of the disk. The assymetry of the lobes further away from the source may then be due to external factors (e.g. magnetic field configuration, ISM conditions).

No significant amount of dust is (indirectly) observed in the jet, but episodic, prolonged photometric events (optical deepening, enhanced NIR excess) suggest dust is launched above the disk plane. (Atomic) jet launch events may be linked with these dust ejections.

The ejected dust does not end up in the jet (no depletion), but co-timing of jet launch events and dust ejections tentatively suggest these do have a common origin.