Tearing the Veil - Interaction of the Orion Nebula with its neutral environment

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The Veil of Orion

Huygens, *Systema Saturnium* (1656)

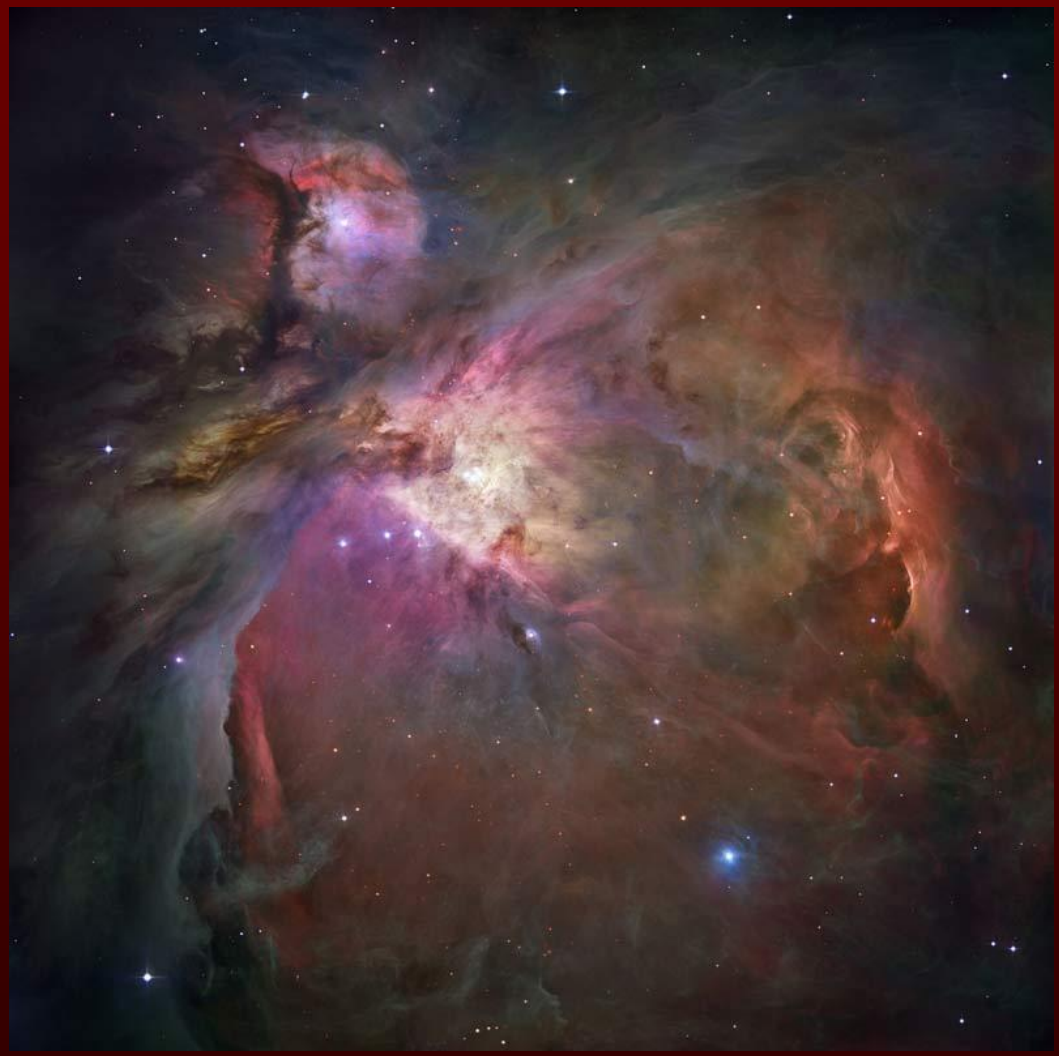
8 CHRISTIANI HVGENII

Phæno-menon in Orione novum.

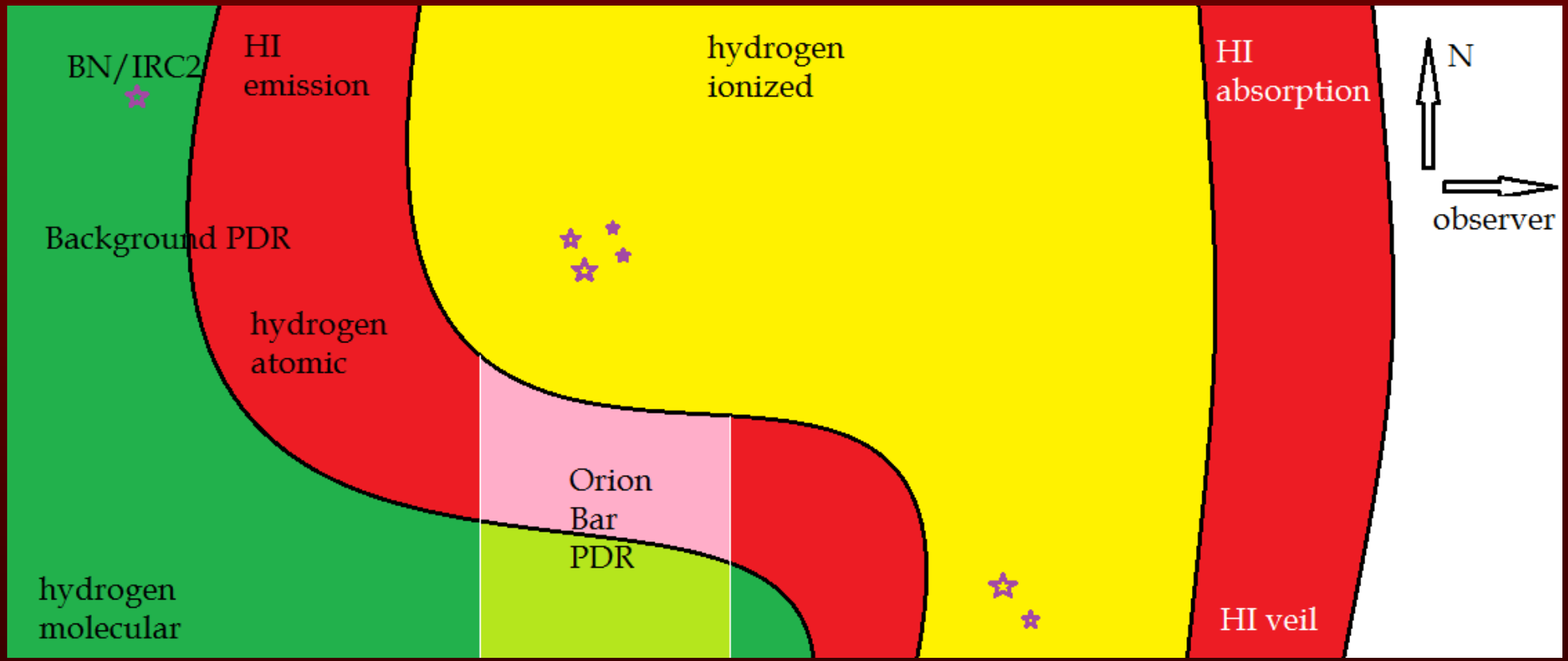
Unum verò circa fixas phænomenon relatu dignum occurrit, à nemine hucuſque, quod ſciam, animadverſum, nec quidem niſi grandibus hiſce teleſcopijs rectè obſervandum. In Orionis enſe tres ſtellæ ab Aſtronomis reponuntur inter ſe proximæ. Harum mediam Anno 1656 fortè per tubum inſpicienti mihi, pro ſtella una duodecim (quod quidem minimè novum) ſeſe obtulerunt; eo poſitu quem ſubjecta figura expreſſimus.

Ex his autem tres illæ pene inter ſe contiguæ, cumque his aliæ quatuor, velut trans nebulam lucebant, ita ut ſpatium circa ipſas, qua forma hîc conſpicitur, multo illuſtrius appareret reliquo omni cælo; quod cum apprimè ſerenum eſſet ac cerneretur nigerrimum, velut hiatu quodam inter-

The Huygens Region and the Veil



Field guide to HI associated with Orion A



Concise history of HI interferometry of the Orion Nebula

- 1972: Parkes Interferometer: main HI absorption systems
- 1978: Owens Valley: first imaging of HI absorption
- 1989: VLA-D: HI absorption Zeeman imaging
- 1989, 1990: VLA-C: high-res HI absorption mapping
- 2011: VLA/EVLA-B+C: high-resolution HI absorption + emission mapping

Radhakrishnan, Brooks, Goss, Murray & Schwarz ApJS 24, 1

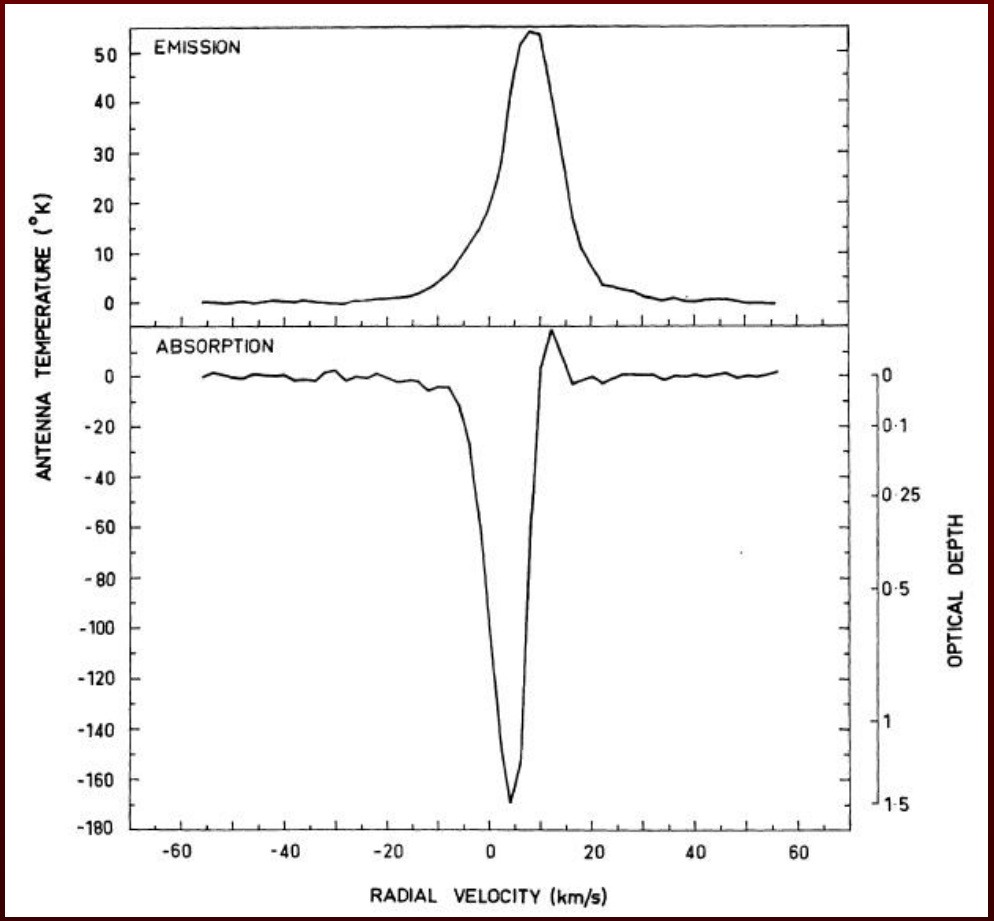
Lockhart & Goss A&A 67, 355

Troland, Heiles & Goss ApJ 337, 342

Van der Werf & Goss A&A 224, 209; ApJ 364, 157

Van der Werf, Goss & O'Dell to be resubmitted

HI spectra of Orion A



(Radhakrishnan *et al.* 1972)

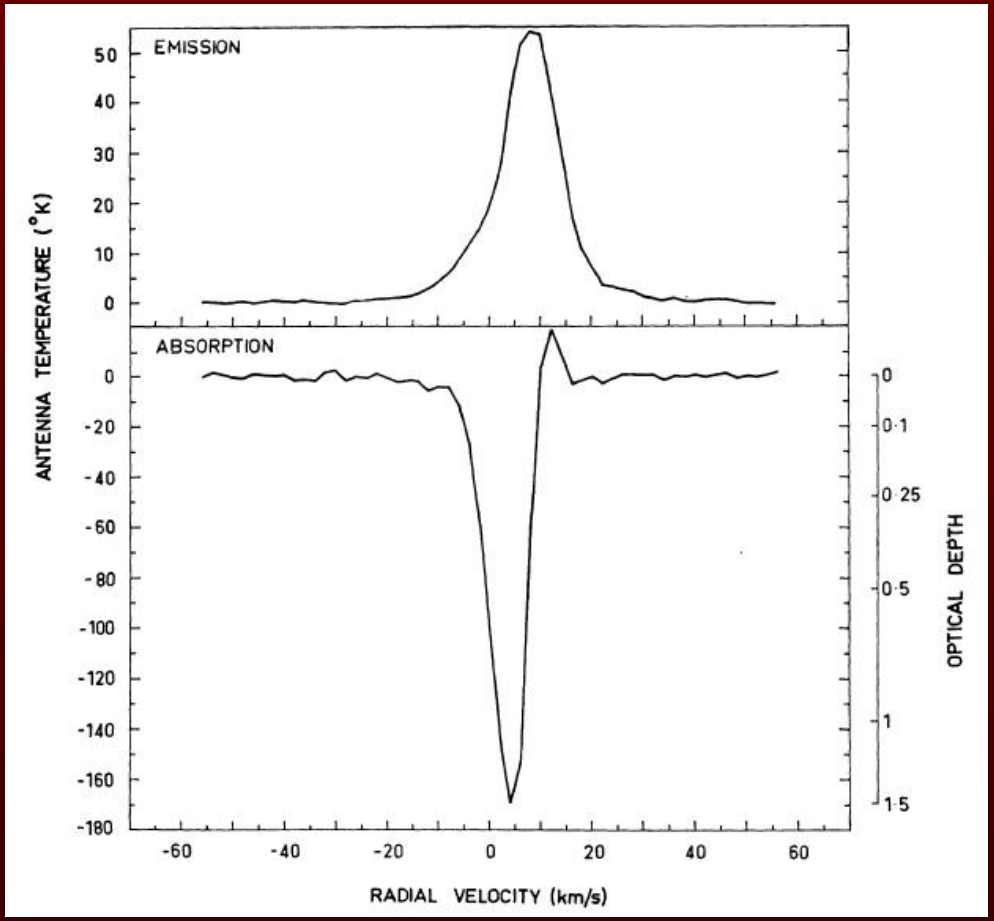
There is a large-scale foreground HI absorption feature: the Veil of Orion.

NB: velocity offset between emission and absorption

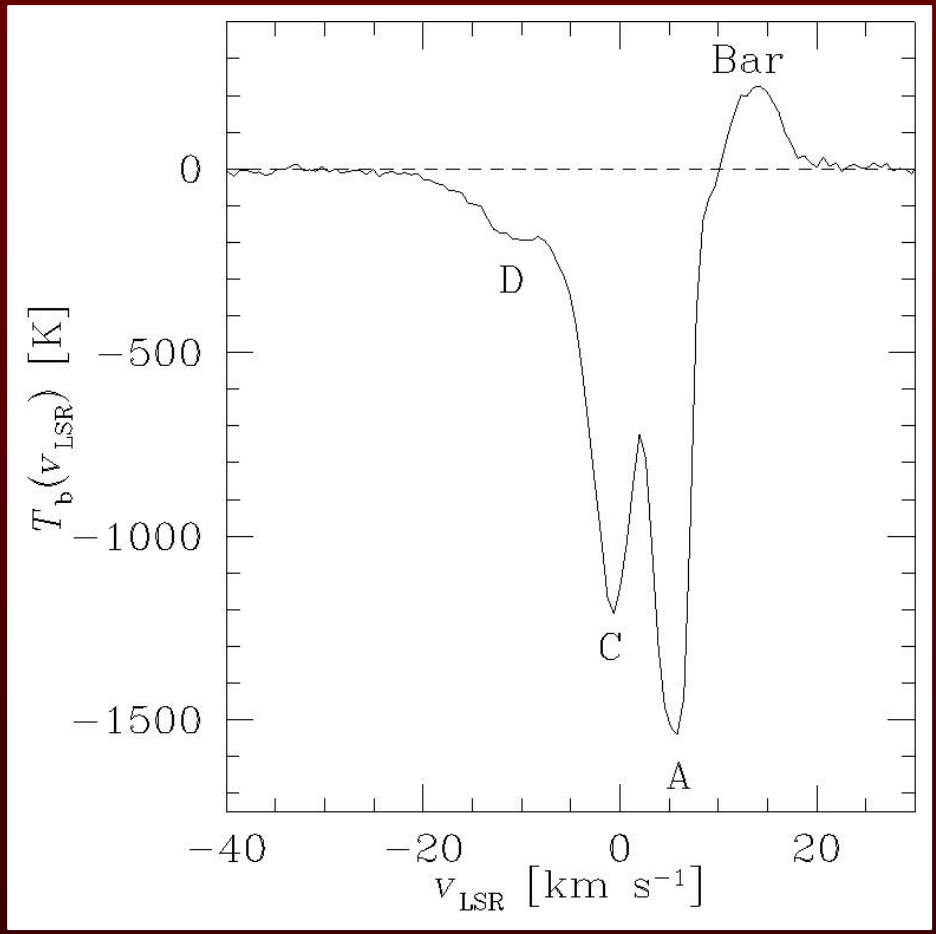
New HI data...

- VLA C-array + EVLA/VLA B-array
- Resolution 6″ ⇒ compare to optical data
- Velocity coverage –42 → +27 km/s v_{LSR}
- Shows absorption and emission
- Remember: background molecular cloud: v_{LSR} = 10 km/s
  ionized gas: v_{LSR} = –2 km/s
  veil: v_{LSR} = 2→7 km/s

HI emission!



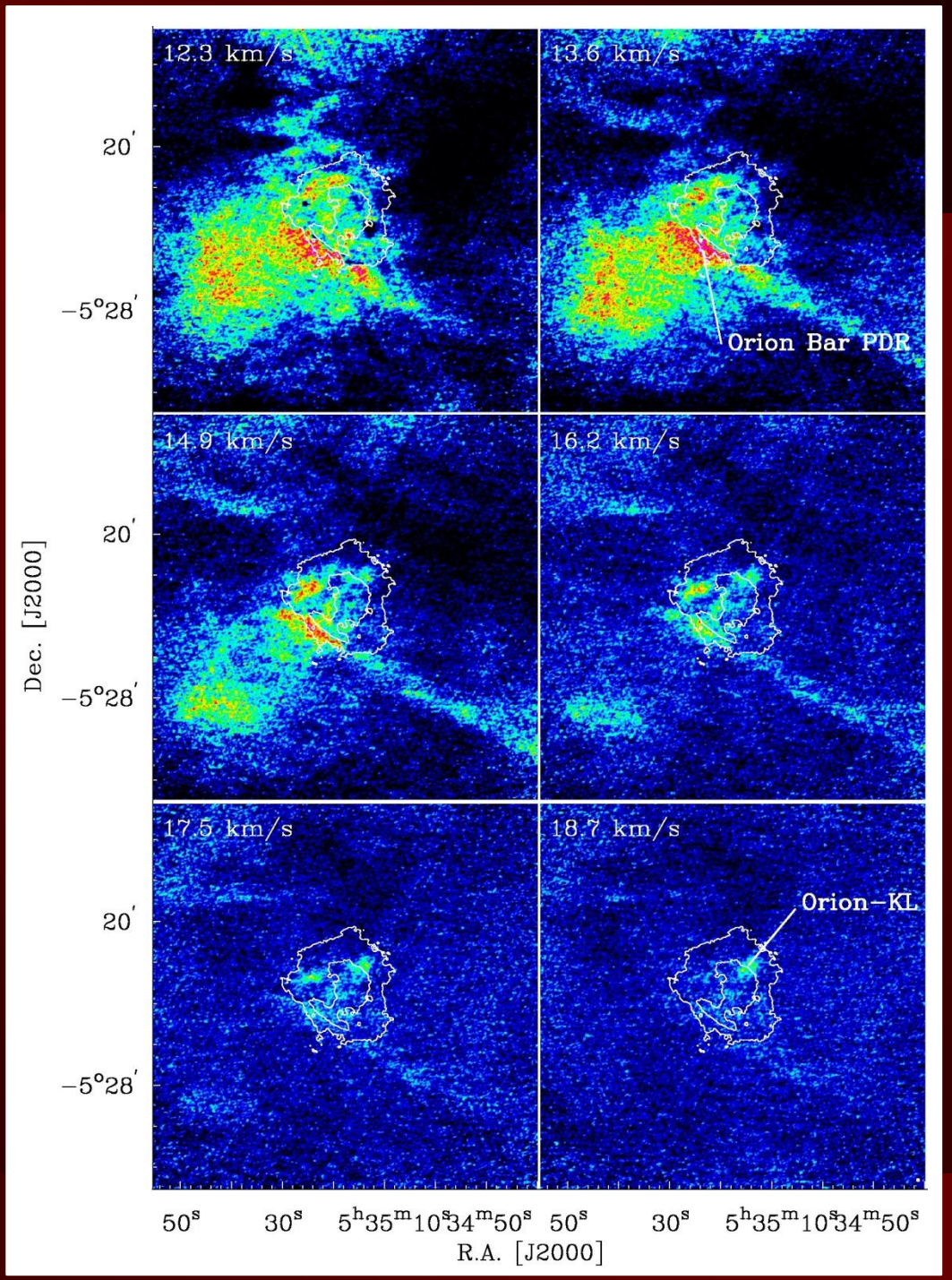
(Radhakrishnan *et al.* 1972)



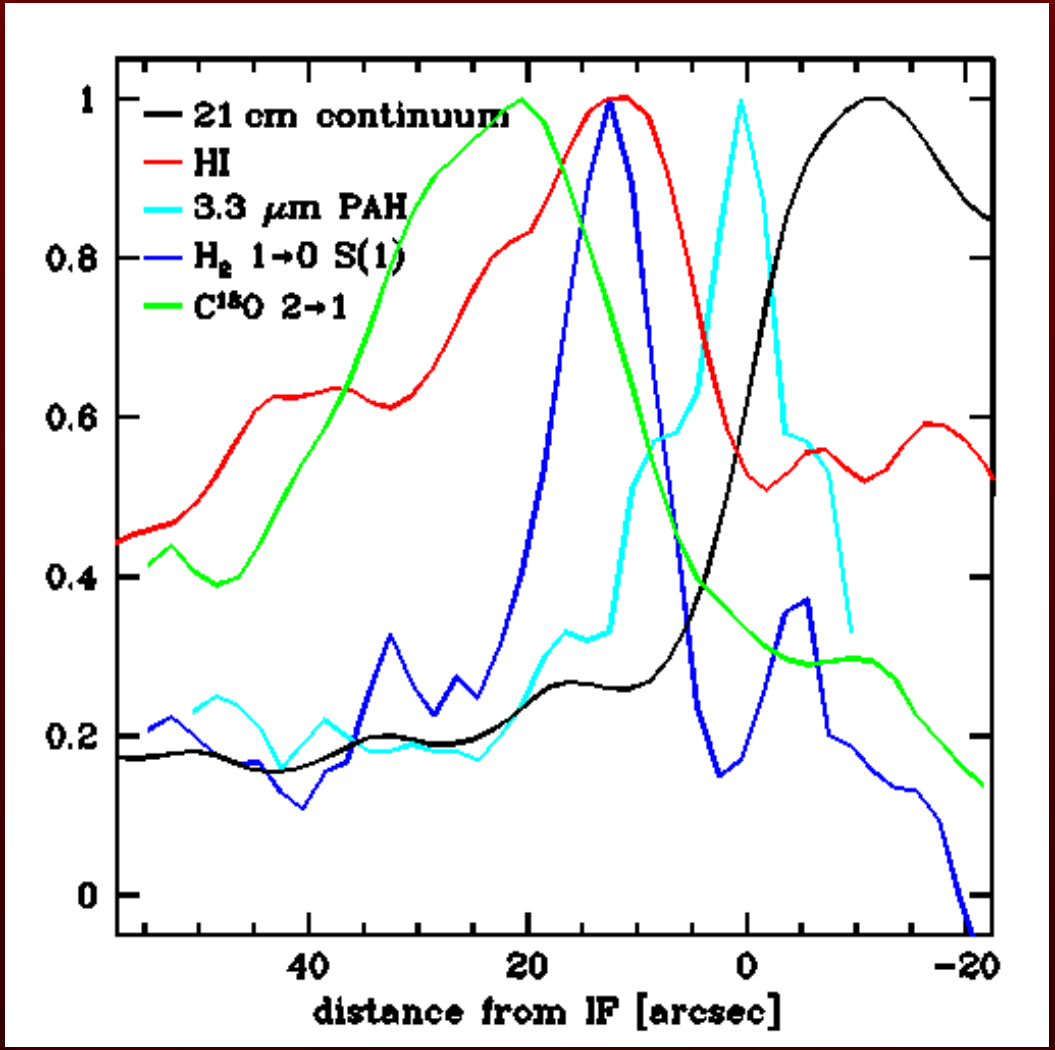
(vdW, Goss & O'Dell 2011)

HI emission images

- Bar + extension
- Extended emission
- high-velocity features

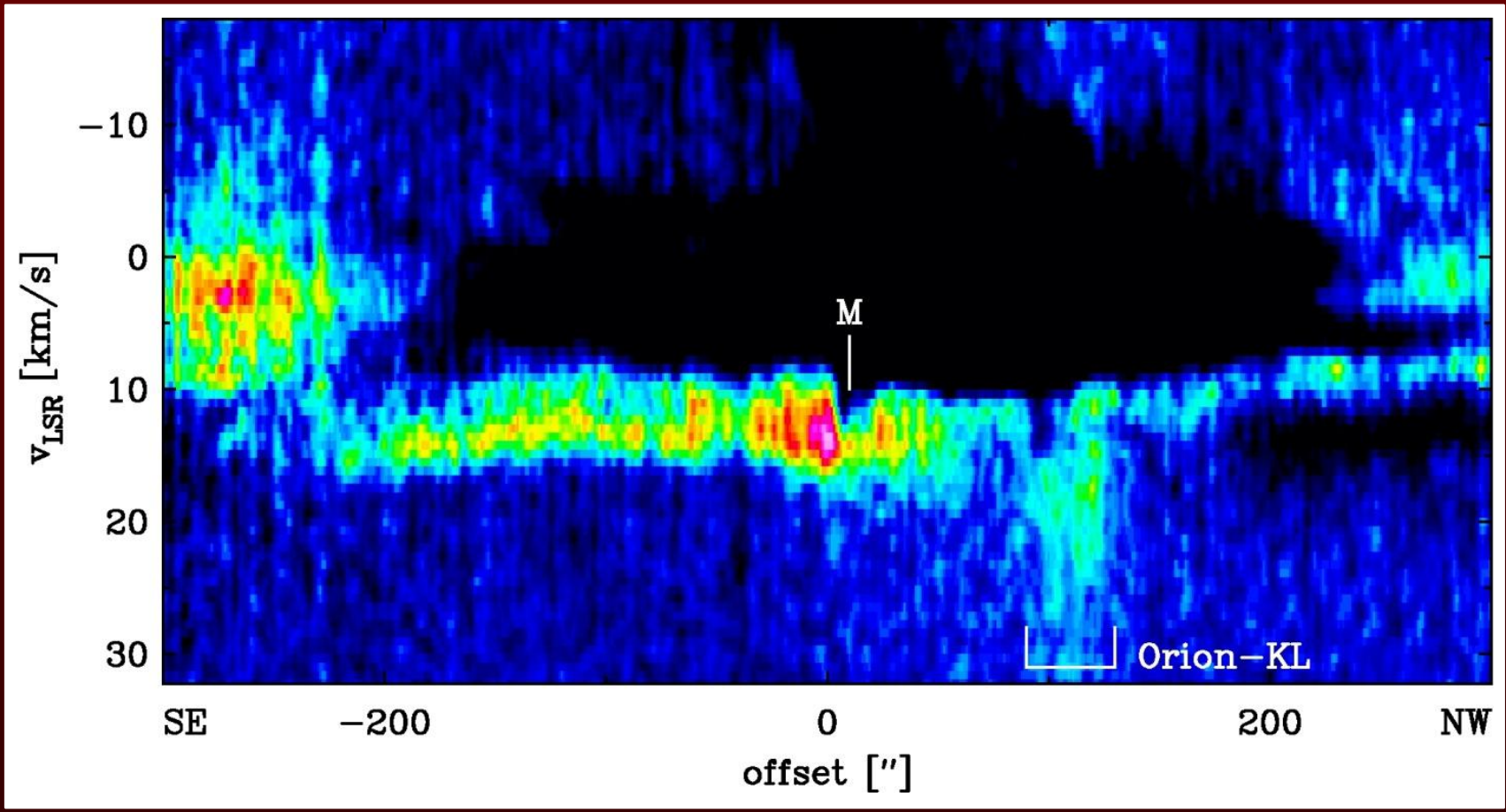


HI in the Orion Bar PDR

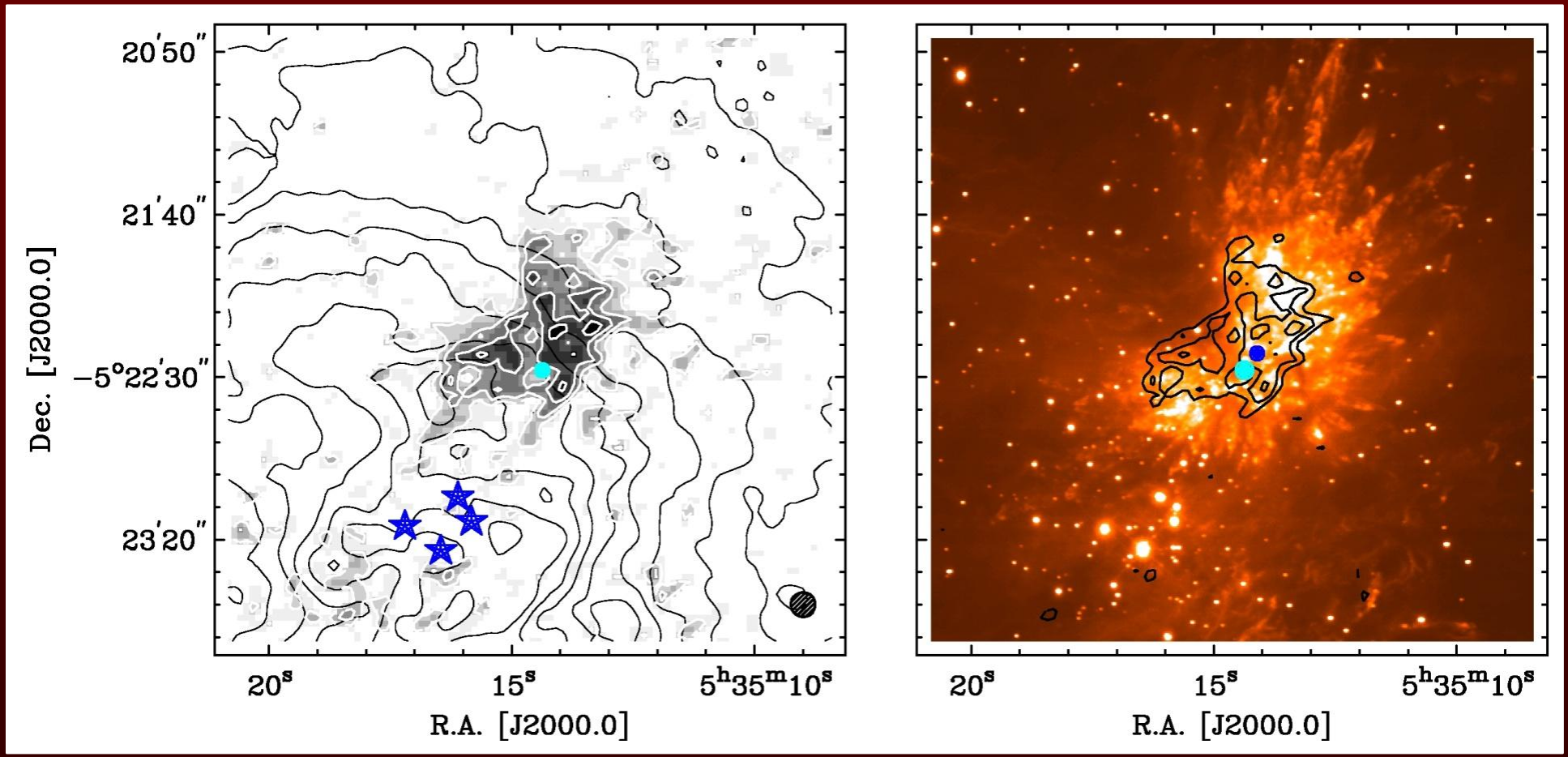


- HI located between CO and ionized gas
- HI peak matches H_2 vibrational line emission peak
- At HI peak, only few % of H_2 photodissociated ⇒ PDR = Photon-Dominated Region
- HI temperature at surface ~500 K

HI in the Orion Bar PDR and Orion-KL



HI in the BN/KL outflow region



New HI data: HI absorption

- VLA C-array + EVLA/VLA B-array
- Resolution 6″ ⇒ compare to optical data
- Velocity coverage –42 → +27 km/s v_{LSR}
  ⇒ absorption by the Veil + high-velocity features
- Orion HI absorption: The Movie
- Remember: background molecular cloud: v=10 km/s
  ionized gas: v=–2 km/s
  veil: v=2→7 km/s

Old HI opacity spectra of Orion A

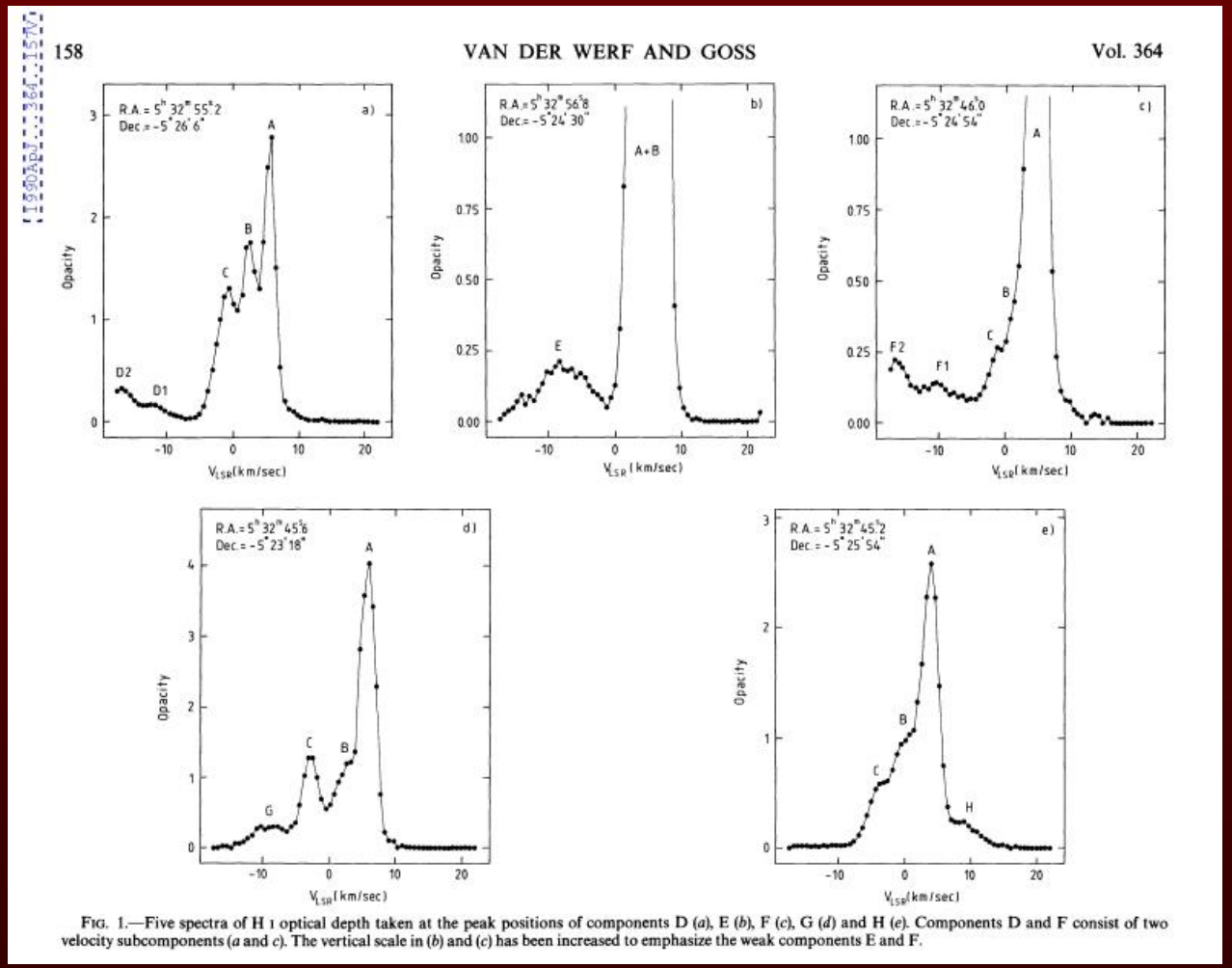
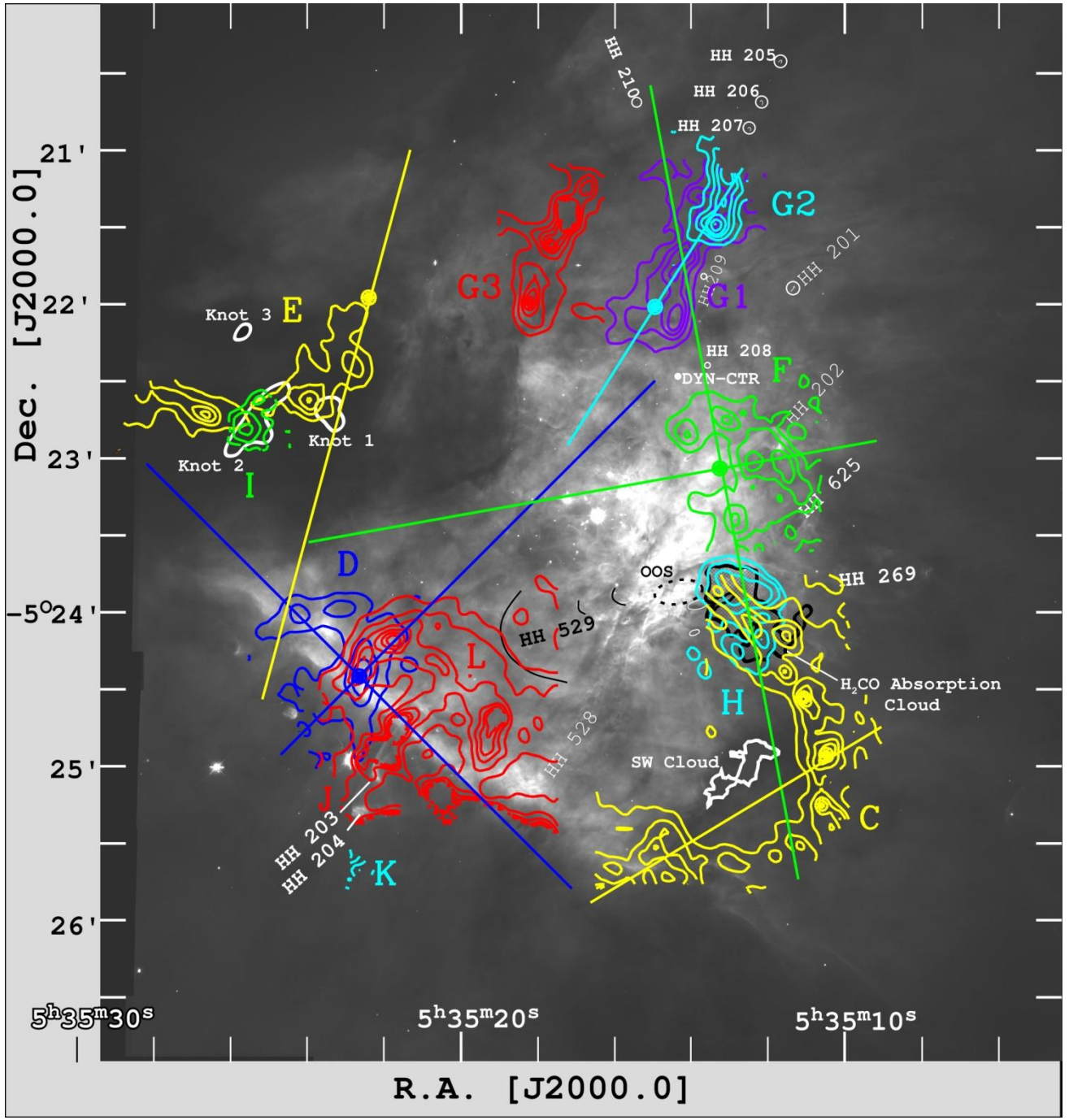


FIG. 1.—Five spectra of H I optical depth taken at the peak positions of components D (*a*), E (*b*), F (*c*), G (*d*) and H (*e*). Components D and F consist of two velocity subcomponents (*a* and *c*). The vertical scale in (*b*) and (*c*) has been increased to emphasize the weak components E and F.

(vdW & Goss 1990)

HI optical depth spectra reveal (in addition to the Veil), small-scale (sub-pc, sub-solar mass) HI absorption features, almost all blueshifted with respect to the Veil.

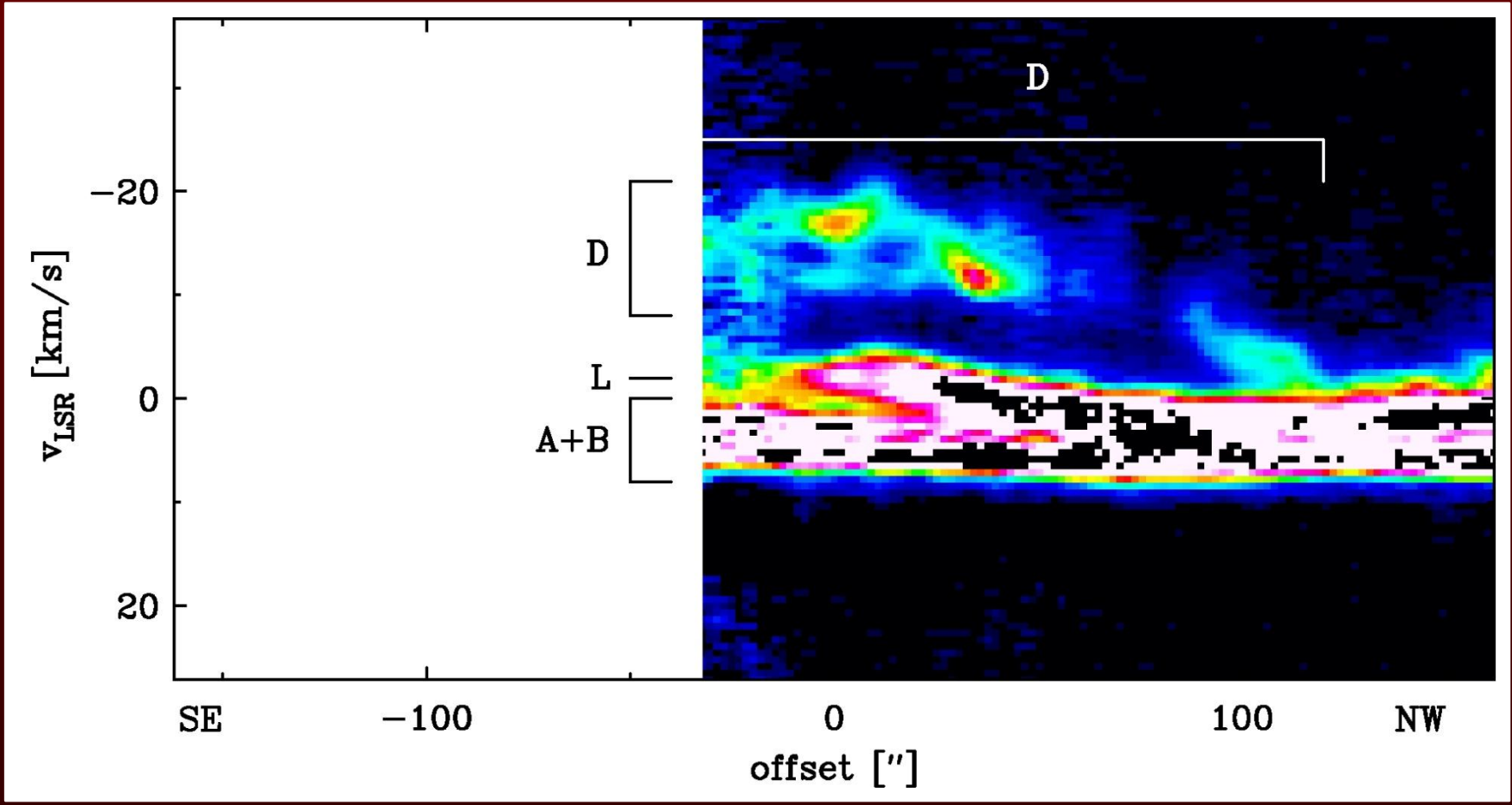
NB: several run off the velocity scale



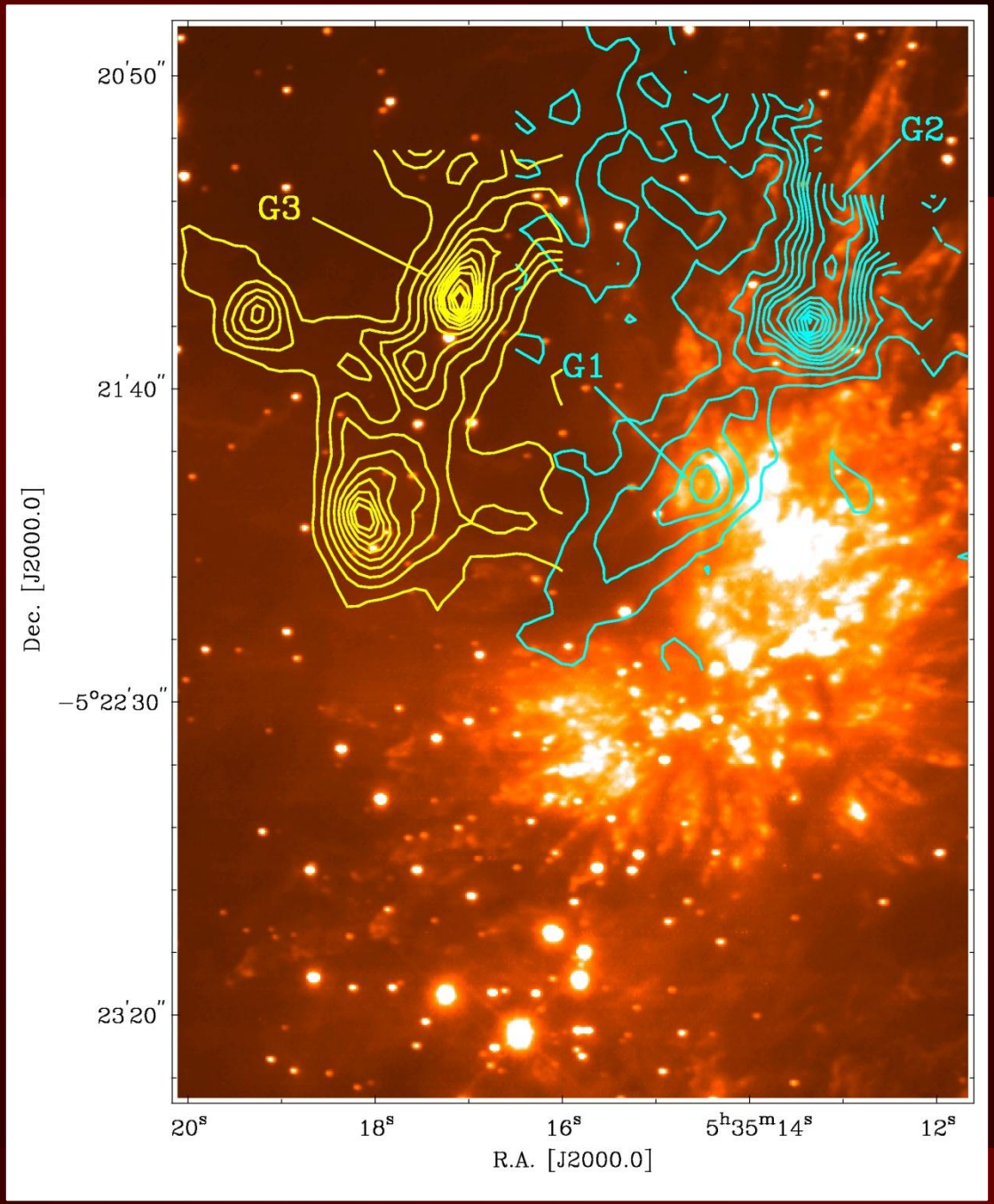
HI absorption features

Kinematics from position-velocity diagrams

Expanding shells



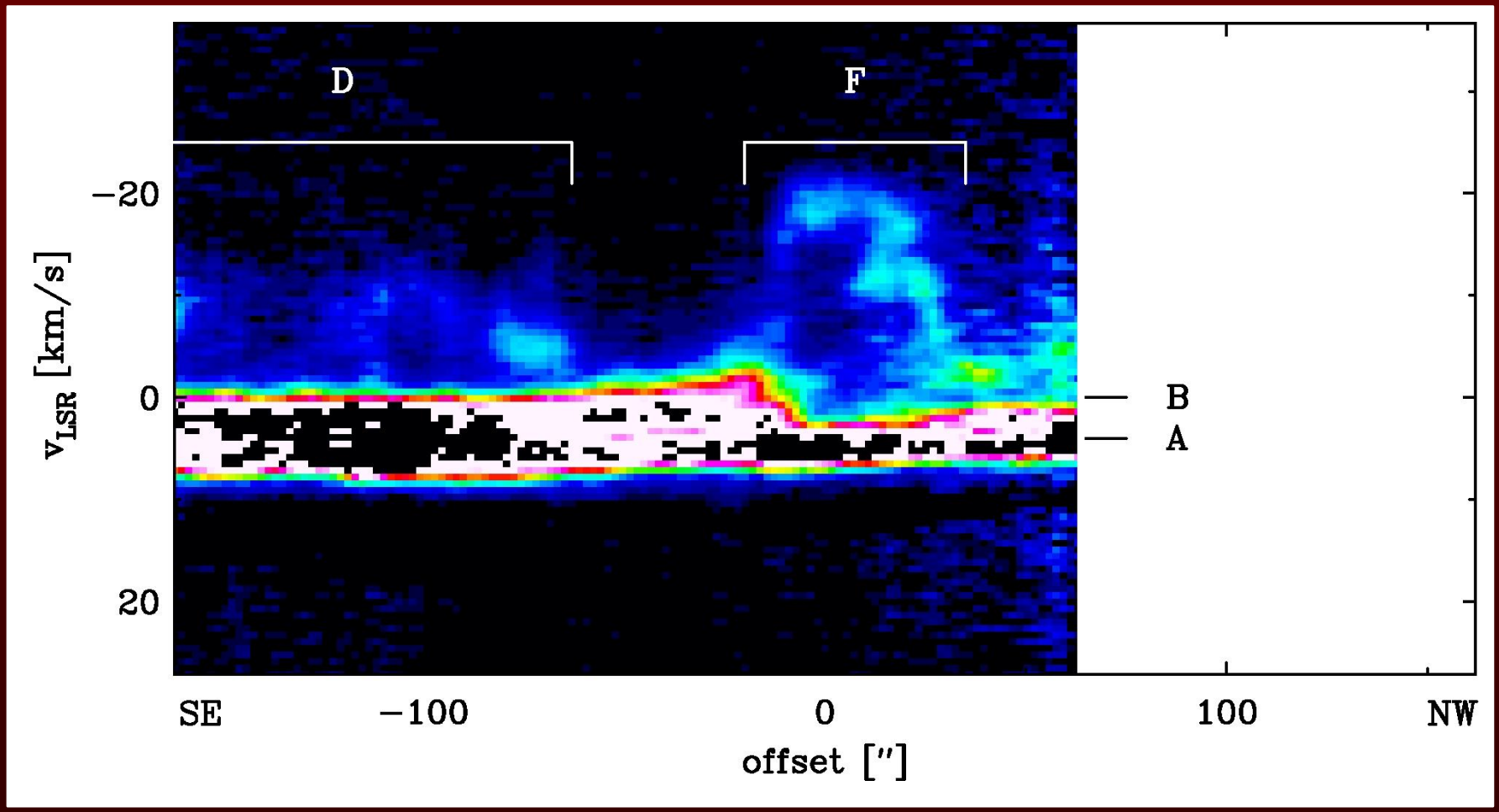
Elongated features



Inventory of features

- Expanding shells probably driven by θ^2A and B Ori (D, L)
- Elongated features associated with HH203/204 and the 1:00 H_2 finger (J, G)
- Clumps in the Dark Bay (E)
- Orion-S (H)
- Clumps near the Bright Bar (M)
- A shell-like feature associated with HH202

Connection with the Veil



Implications

- HH202 interacts with the neutral Veil. Its space motion is known and it originates close to the Orion-S region.

  ⇒ can determine distance of Veil from Orion-S: ~ 0.2pc (in any case < 0.3 pc). Distance from Trapezium probably similar.

- Note value based on modeling of UV absorption lines: >1 pc

(similar argument places Orion-KL 0.1pc behind IF)

Evolution of the Veil

- HI mass pushed by flows is small: would take ~1 Myr to destroy the entire Veil.

- Flow of ionized gas from main IF would reach and destroy Veil in ~0.2 Myr.

$\Rightarrow$ hydrodynamic evolution of HII region has more effect on neutral environment than stellar-driven flows.