Собственные движения спектрально выделенных структур в направленном потоке Хербига-Аро HH 83

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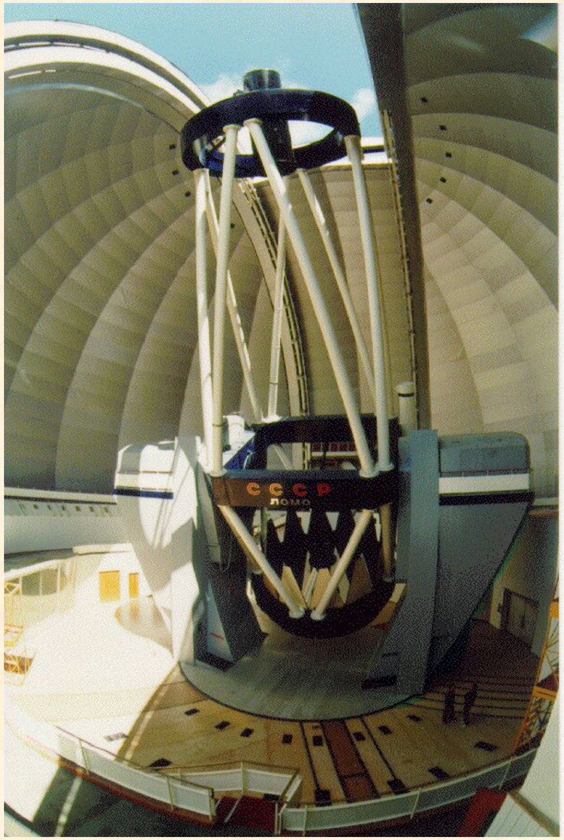
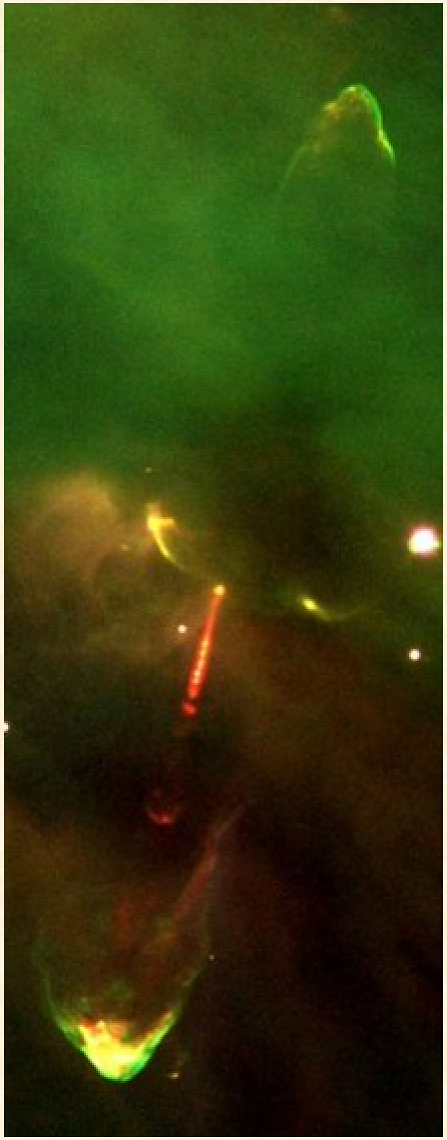
Observations were carried out in two epochs (2002 – 2017) on the 6m telescope with SCORPIO & SCORPIO2 cameras in scanning Fabry-Perot mode. First epoch with FP 501 and in second epoch – FP 751 near H⌈ .





HH 34
“Grand design jet”

Characteristic morphology of HH flow; bipolar nature, with knotty narrow jet, association with fan shape reflection nebulae. HH34 was discovered in 1974 (Herbig) and the jet in 1986 (Reipurth).

Proper motion of Herbig-Haro objects and jets

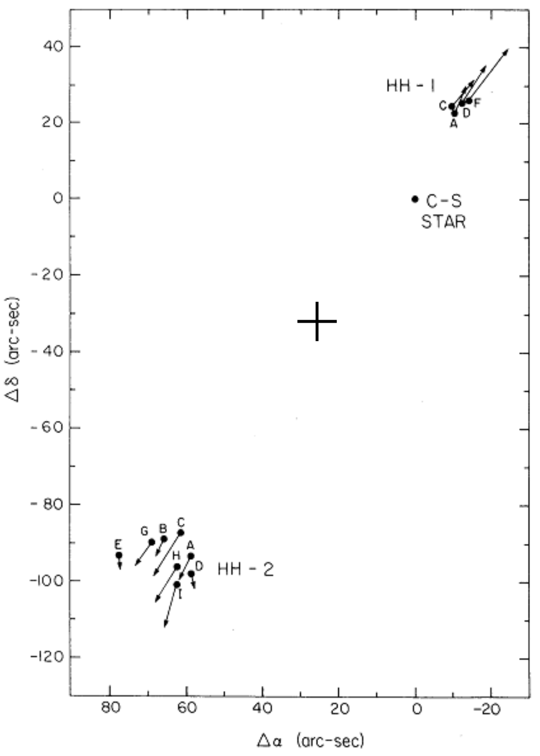
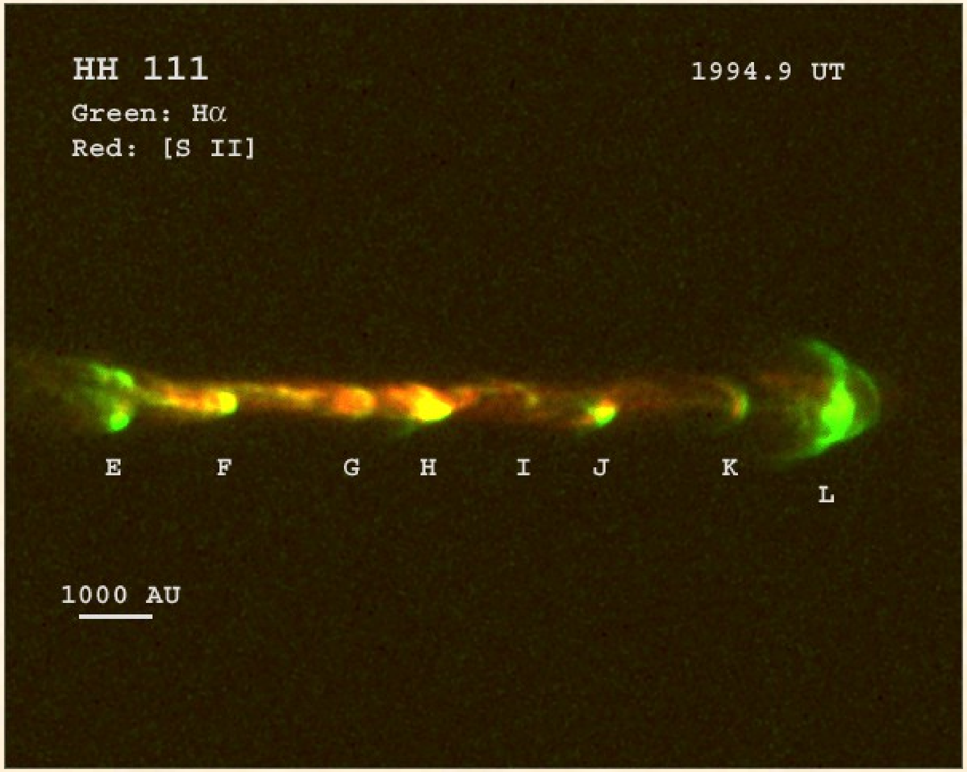


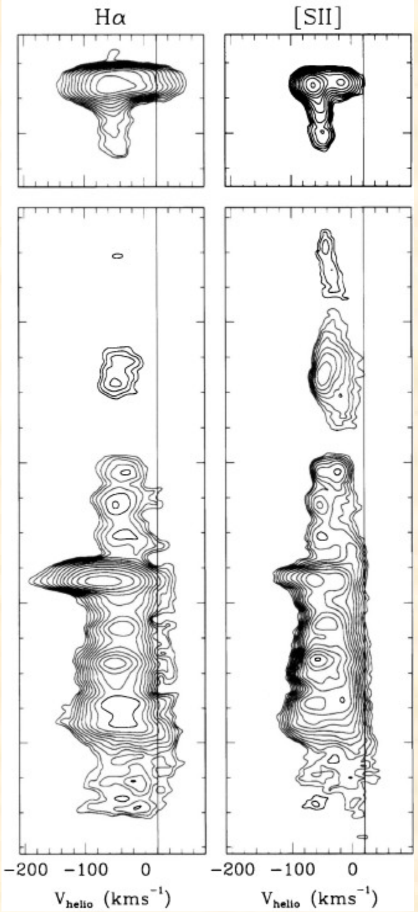
FIG. 7. The positions of HH 1, HH 2, and the Cohen-Schwartz star on the plane of the sky (for epoch 1968.0). The arrows indicate the shift in 100 yr due to proper motion. At a distance of 460 pc, 10 arcsec is equivalent to 2.23×10^{-2} pc. For HH 2A, the position is for A′ although the motion vector is for A. The motion of the C-S star is too small to show on this scale. The internal motions in HH 1 and HH 2 are displayed at larger scale in Figs. 8 and 9.

Herbig & Jones, 1981

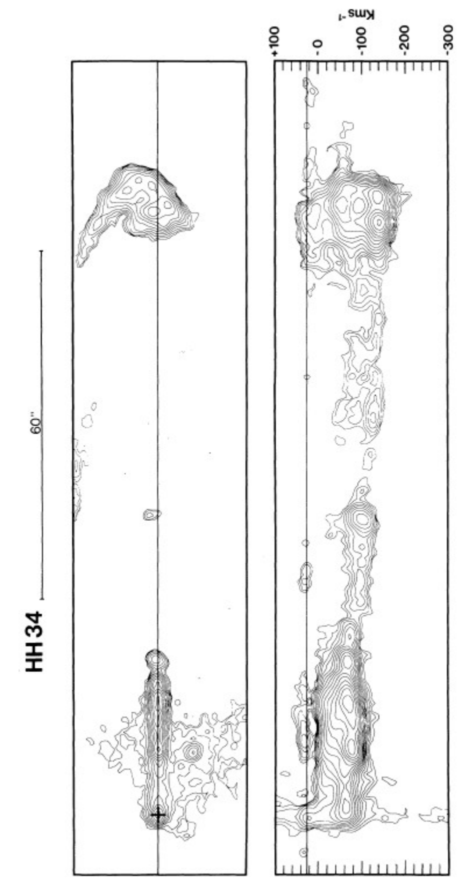


Hartigan et al. 2001

Position velocity diagrams



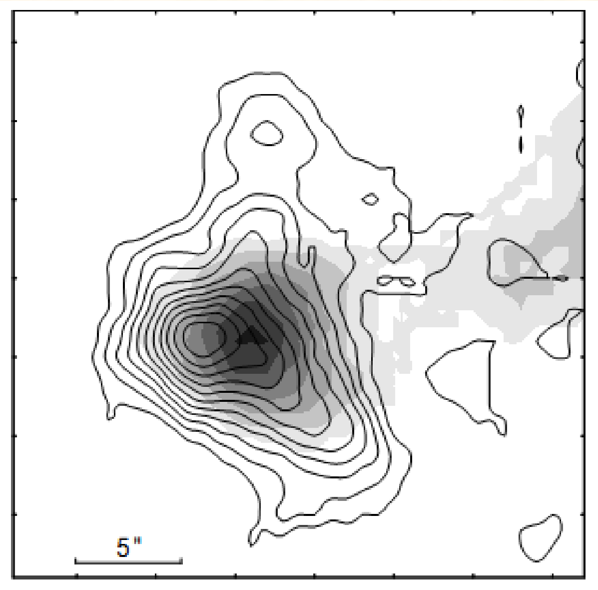
HH 111 (Reipurth et al. 1997)



HH 34 (Reipurth 1989)

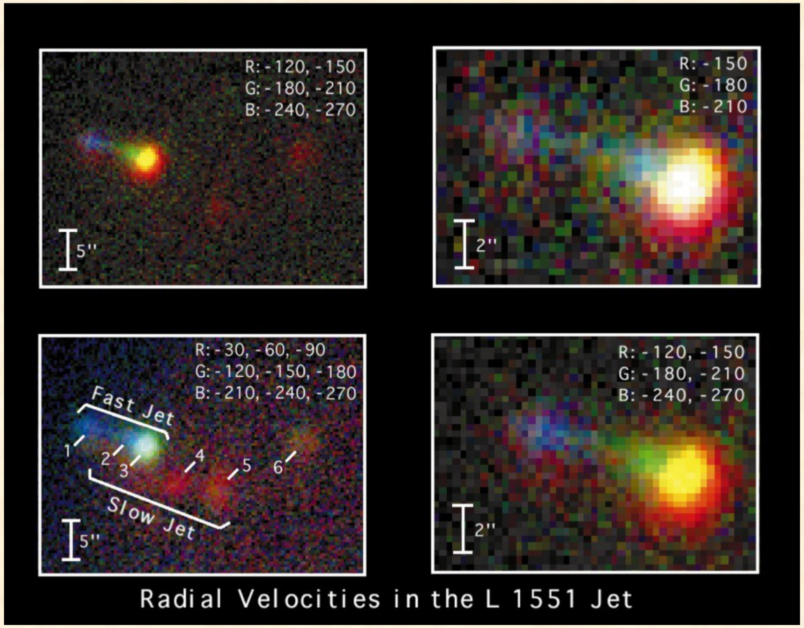
Spectra-imagery of working surfaces

HH 7



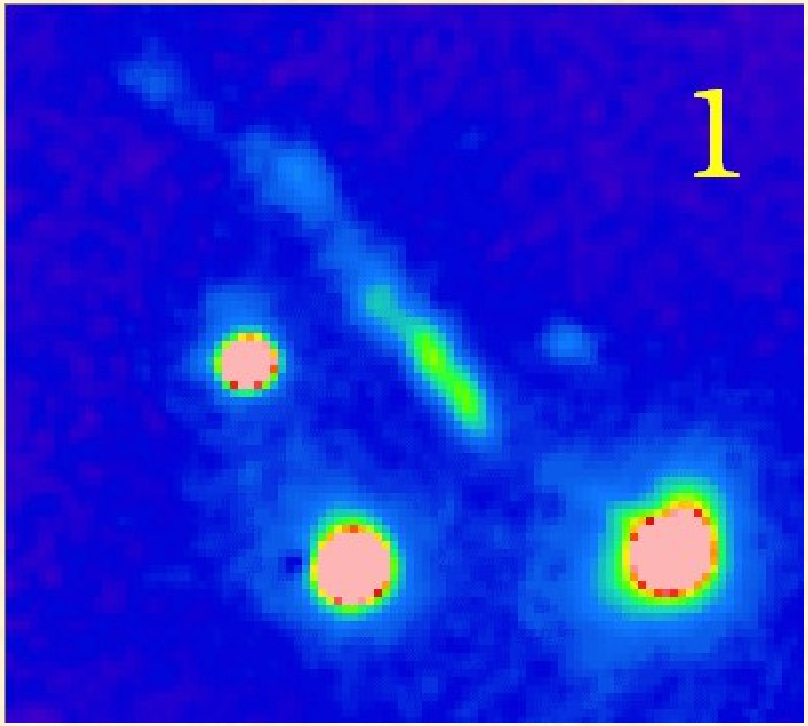
Superposition of two monochromatic images of HH 7 corresponding to velocities of −125 km s^{-1} (gray scale) and −18 km s^{-1}(isolines) (Movsessian, Magakian, Amram, Boulesteix, Gach 2000).

HH 154



From Hartigan at al. 2000

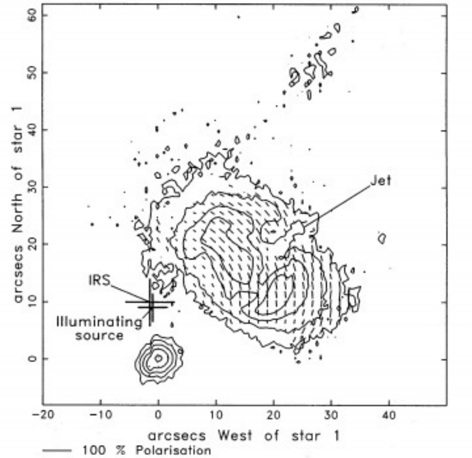
HL Tau jet

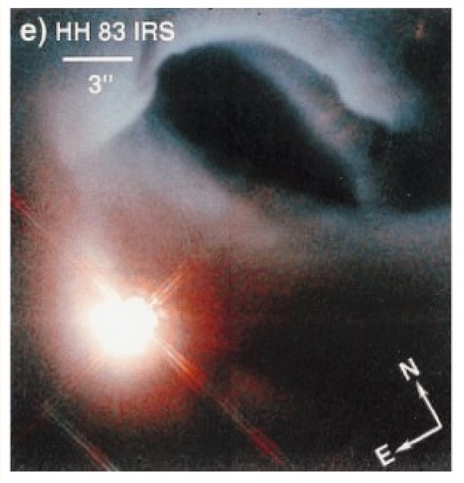


Channel movie of HL Tau jet, obtained with scanning Fabry-Perot interferometry. The radial velocity for the start channel is – 200 km s^{-1} and for the last one is 0 km s^{-1}.

HH 83

HH 83 jet is emerging from a cavity illuminated by the embedded IRAS source 05311-0631 (Reipurth 1989)
A poorly collimated molecular outflow has been studied by Bally, Castets, & Duvert (1994)

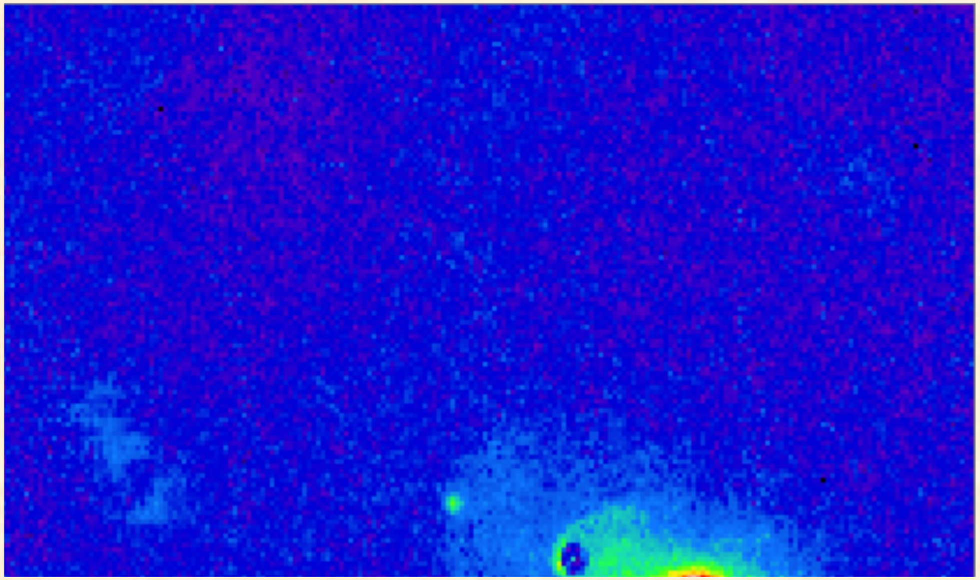




Hubble space telescope NICMOS image of HH83 source and cavity walls

HH 83 observations with FP in 2002

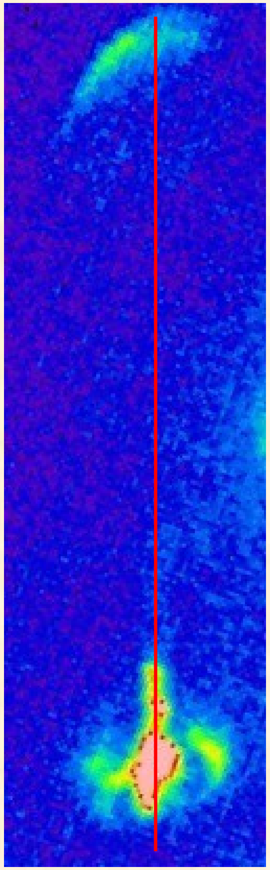
(Movsessian et al., 2009)

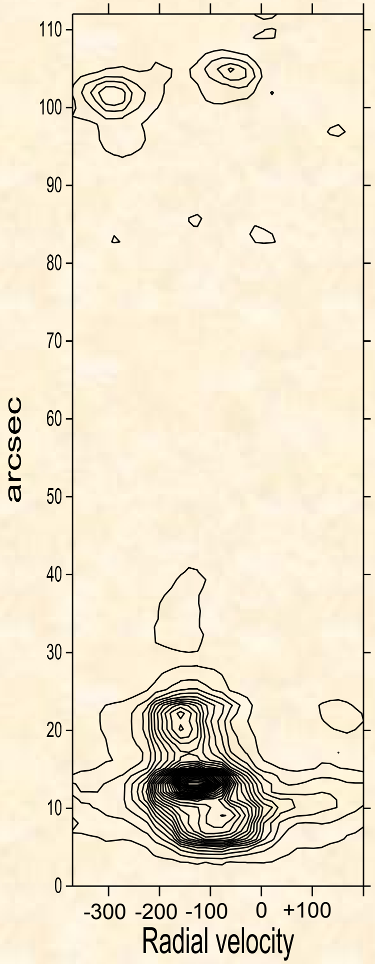


Channel movie of HH 83 jet and it’s working surface. Radial velocity for the start channel is -370 km/s and for the last one is 0 km/s.

The jet itself does not show strong changes in morphology except of the acceleration effect. Situation is reverse in terminal shock region, which is split into two structures - narrow bow and knotty filament with velocity separation of about 250 km s^{-1}.

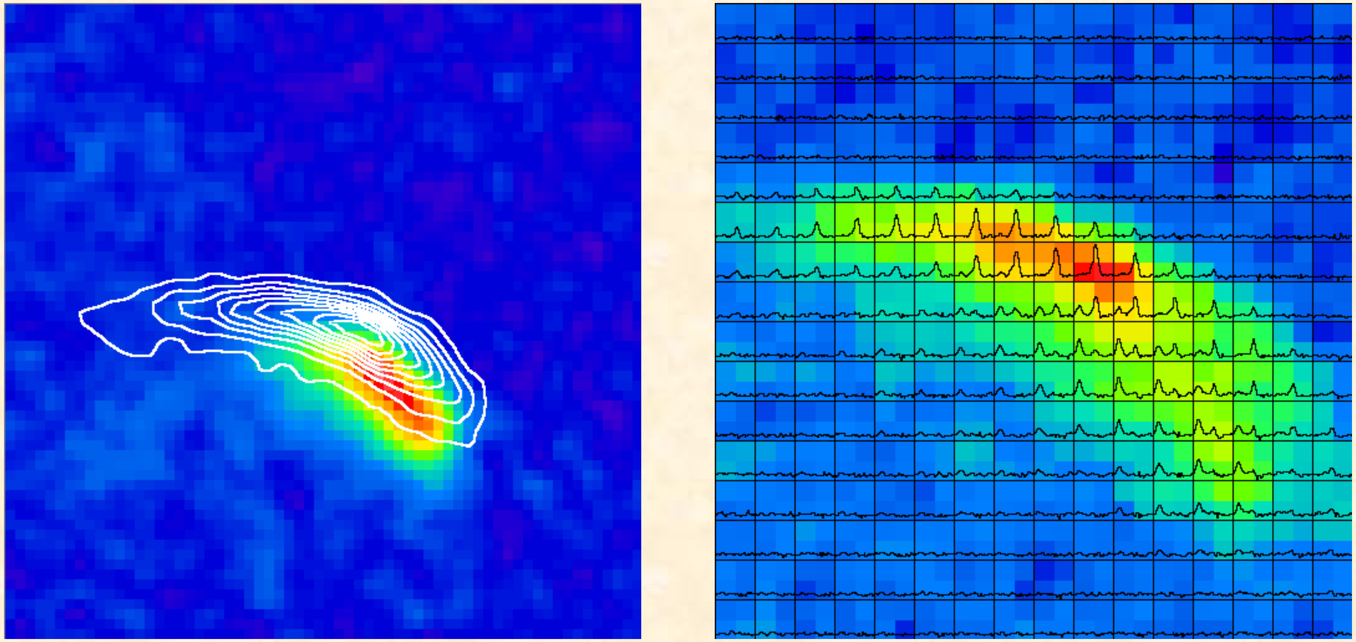
Velocity field of HH 83 outflow system





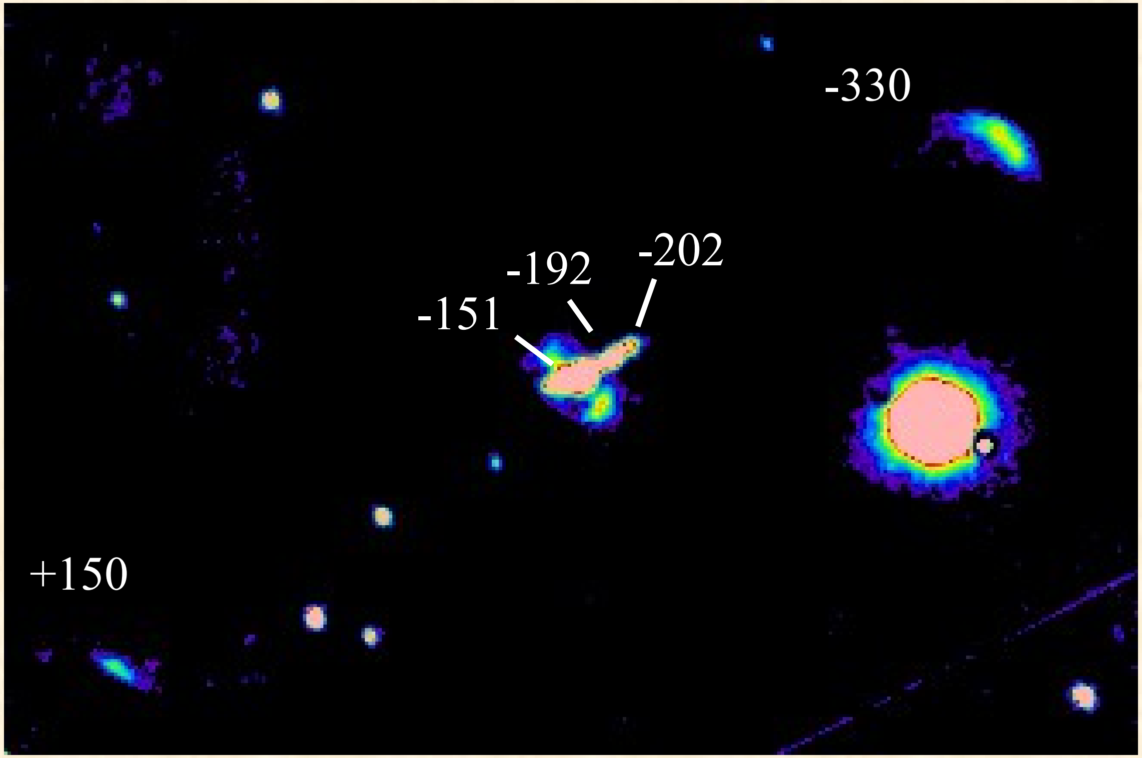
Velocity field in the jet of HH 83 is in good accordance with long-slit data presented in (Reipurth, 1989) where the strong increase of velocity by the distance from the source was discovered. It should be emphasized, that the extrapolation of the jet velocity up to the terminal shock region reaches the high velocity structure (Mach disk), which indicates the increase of flow velocity until the terminal shock region (Movsessian et al., 2009). Continuation of this tendency in such a large distance, in our opinon, strongly supports the idea of time-dependent outflow, suggested in (Reipurth, 1989).

High & low velocity structures in the working surface of HH 83



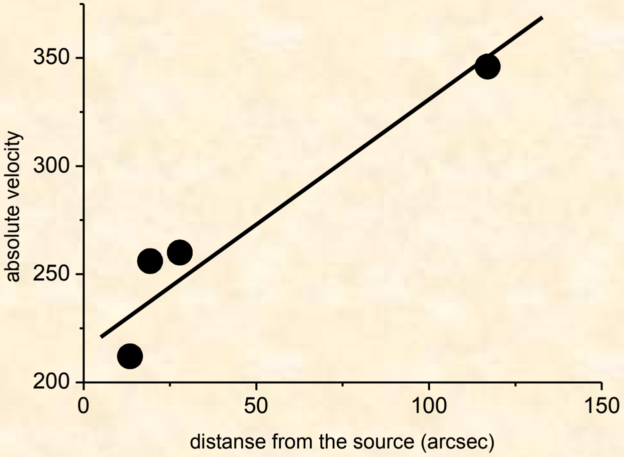
The working surface of the HH83 outflow, split into high-velocity −325 kms^{-1} (color scale) and low-velocity −58 km s^{-1} (contoured) structures (Movsessian, Magakian, Moiseev, Smith, 2009).

HH 83 observations with FP in 2017

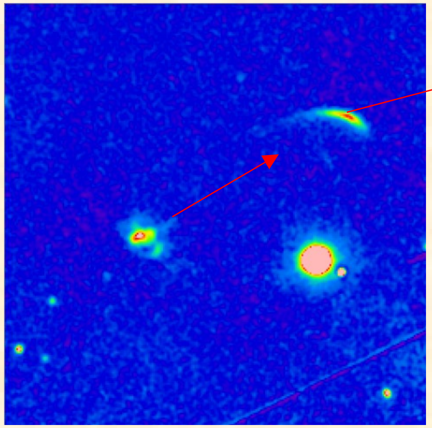


Radial and tangential velocities in the various structures in HH 83

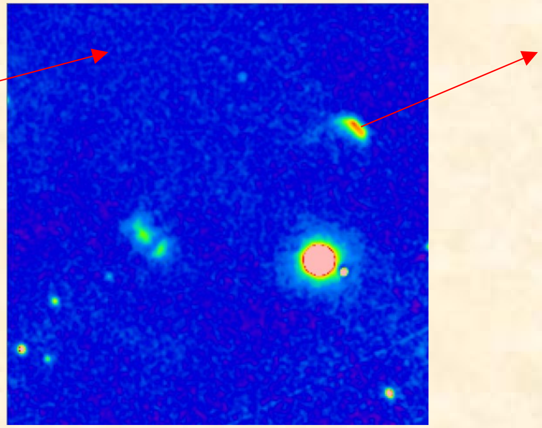
Knot	Distance (arcsec)	V*tan* (km /s)	PA (deg)	V*r* (km/s)	V*abs* (km/s)
A	13,5	150 ± 35	40	-150	212
B	19,3	170 ± 38	48	-192	256
C	27,8	165 ± 40	42	-202	260
WS *high vel.*	117,0	150 ± 40	24	-330	362
WS *low vel.*	119,4	160 ± 45	21	-50	



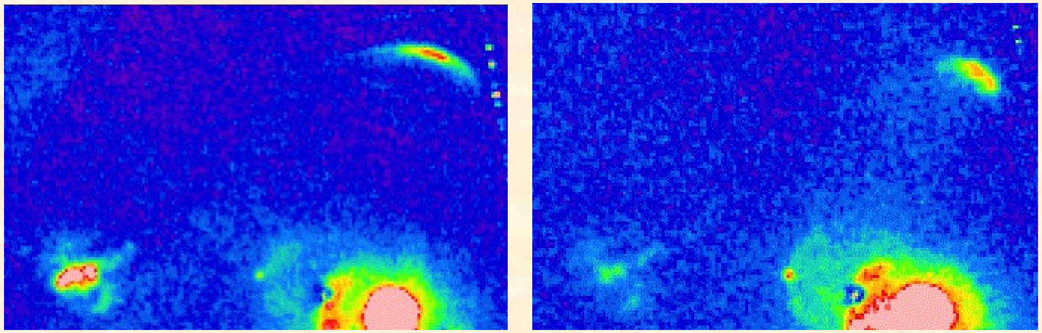
Proper motions of spectrally selected structures in HH 83 outflow system



Vr=70 km/s



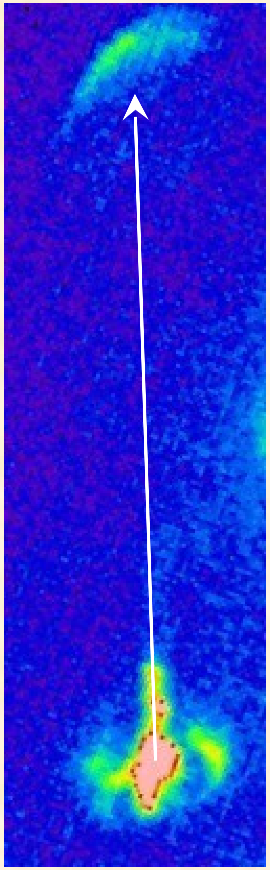
Vr=300 km/s



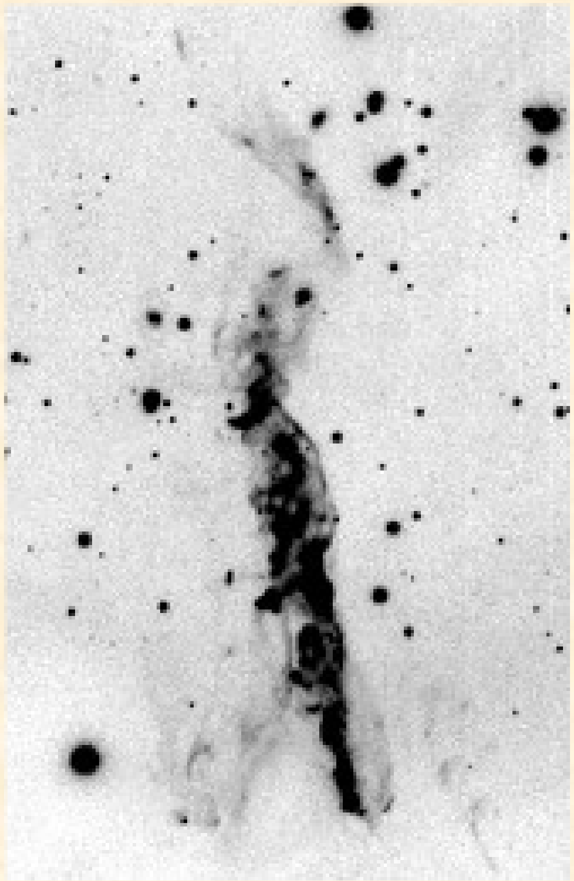
Proper motion values represents the pattern speed of the structures in HH flows (V_t=$V_{pattern}$Cos[ ) and the radial velocities – flow speed (i.e. speed of emitting gas, Vr=V_{flow}Cos[ ).

In the case when we observe supersonic bullet we have two distinct structures, first the shocked gas of the bullet itself and second the shocked gas of ambient medium excited by leading supersonic shock wave.

Jet - dense molecular cloud core collision

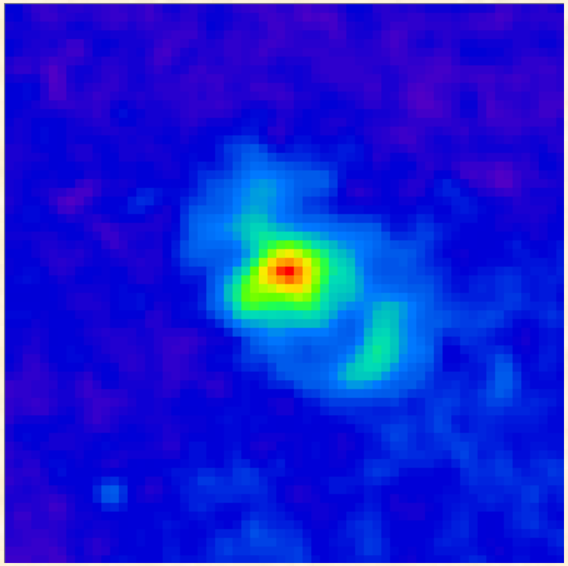


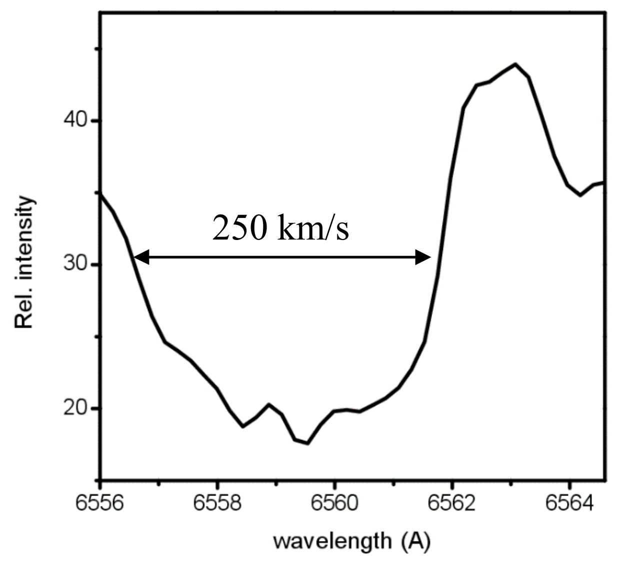
HH 83



HH 110 (Reipurth et al., 1996)

H⌈ profile in the reflected light from the source of HH 83





H⌈ profile shows wide absorption component
with faint blue-shifted component typical for FUors

Conclusion

Fabry-Perot spectra-imagery allows to separate various morphological structures with different radial velocities.

- We revealed the bipolar structure of HH 83 outflow system
- In HH 83 outflow radial velocities increase with the distance from the source as in case of HH 34
- In the working surface of HH83 we could separate two structures with strongly different radial velocities
- Second epoch Fabri-Perot observation of HH 83 give us possibility to measure PM of spectrally separated structures
- PM of high and low radial velocity structures have the same values
- Absolut velocities as well as increase with the distance from the source
- H⌈ profile in the reflected light from the source of HH 83 is typical for FUors, and the burst of the source was about 1000yr ago according to kinematical age of the working surface

Спасибо за внимание!