A nursery of young objects: intergalactic HII regions in Stephan's Quintet

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Workshop do Milênio

- Motivation: star formation induced by galaxy collisions

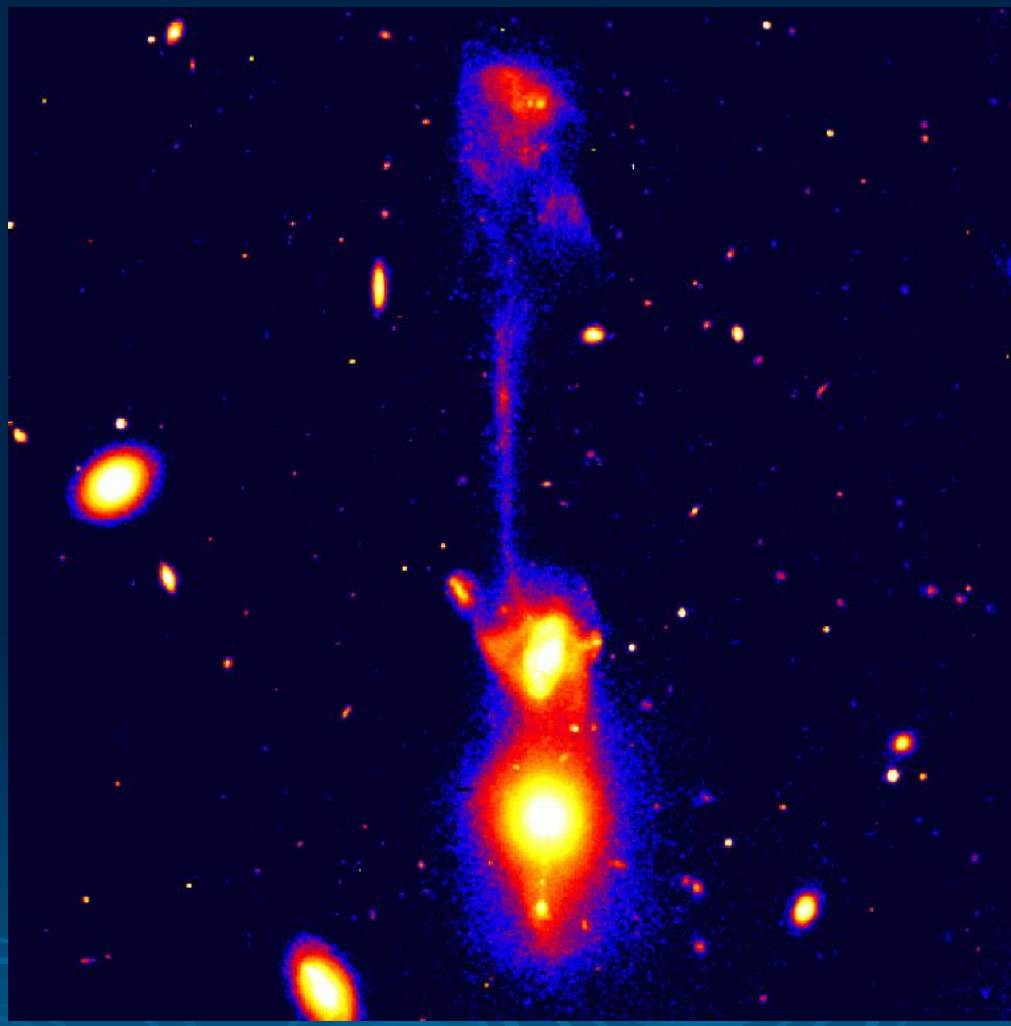
- high end of the mass spectrum: tidal dwarf galaxies (TDG)

  Ex.: Arp 105 (Duc & Mirabel 1994)

- low end of the mass spectrum: young star clusters (proto-globular clusters?)
  first identified in mergers

  Ex.: NGC3597

  (Lutz 1991)



- Natural place to look for new objects formed in galaxy collisions: compact groups

  high galaxy density; low velocity dispersion (e.g., Iglesias-Páramo & Vílchez 2001; Gallagher et al. 2001)

- Here: discovery of IHII in Stephan's Quintet

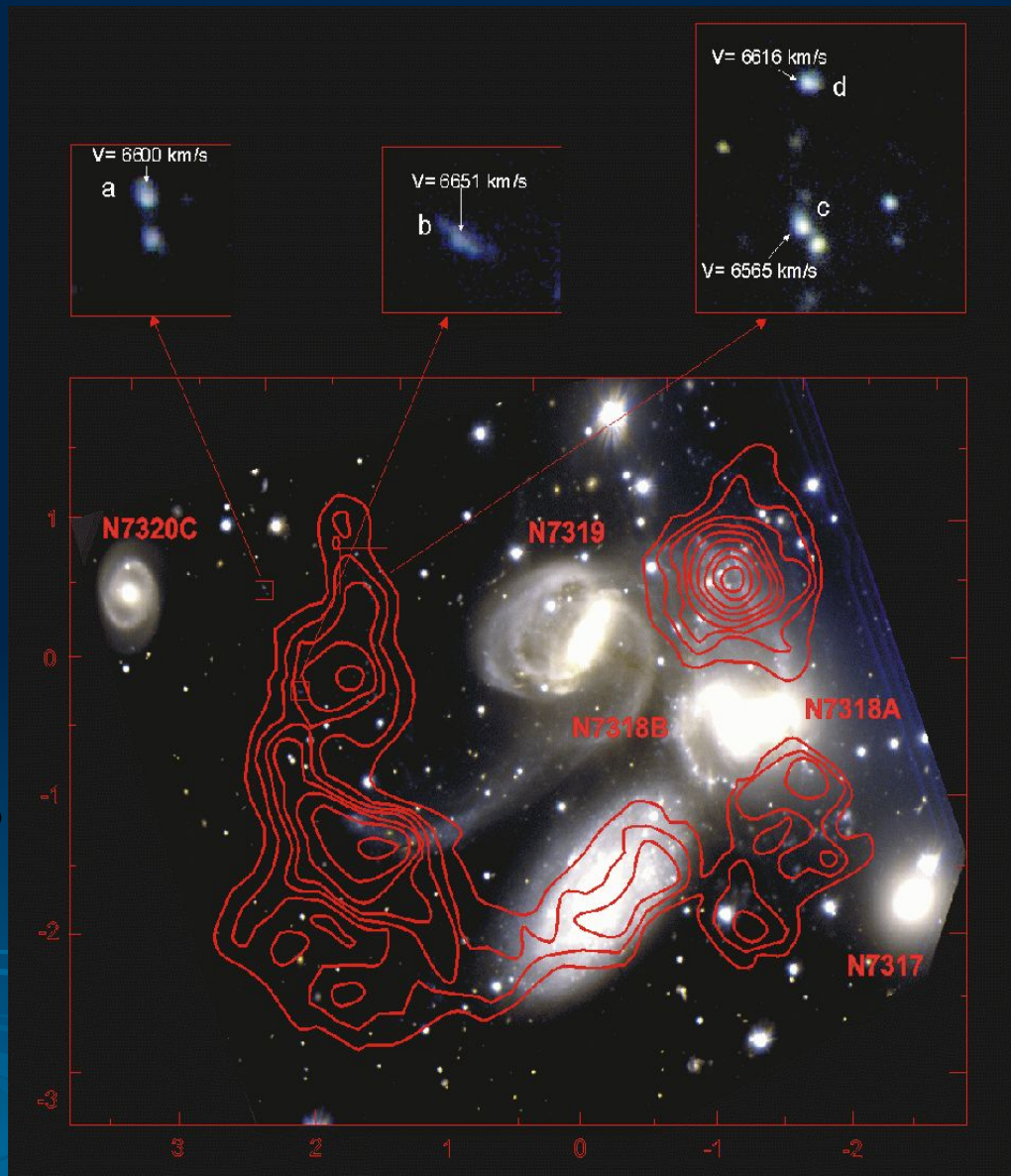
Observations aiming to identify TDG

- Gemini North
- r' and g' GMOS imaging with seeing of ~0.75"
- multislit spectroscopy: masks 1" + R400 grating -> 8A resolution, 4000-8000A coverage

Multislit spectroscopy:

- serendiptious detection of 4 HII regions on the HI tail (Williams et al. 2002)
- projected distance to the closest bright member galaxy:
  > 25pc

Intergalactic HII regions (IHII)



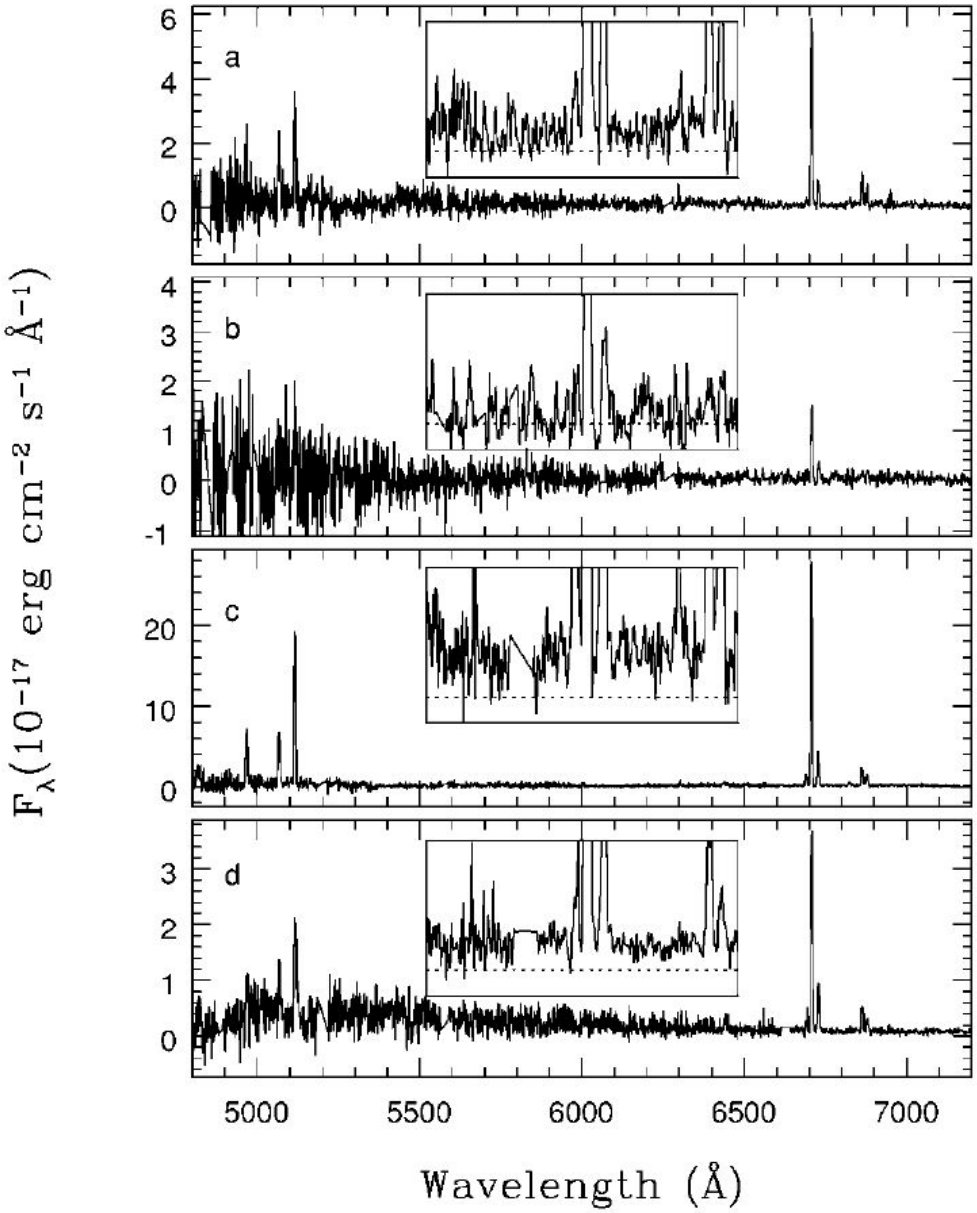


FIG. 2.—(*a–d*) Spectra of IHIIs (see Fig. 1). Each inset presents a zoom in the region from 6500 to 6900 Å. Zero flux is indicated with a dotted line, showing that the continuum in each case can be measured and averaged over many pixels.

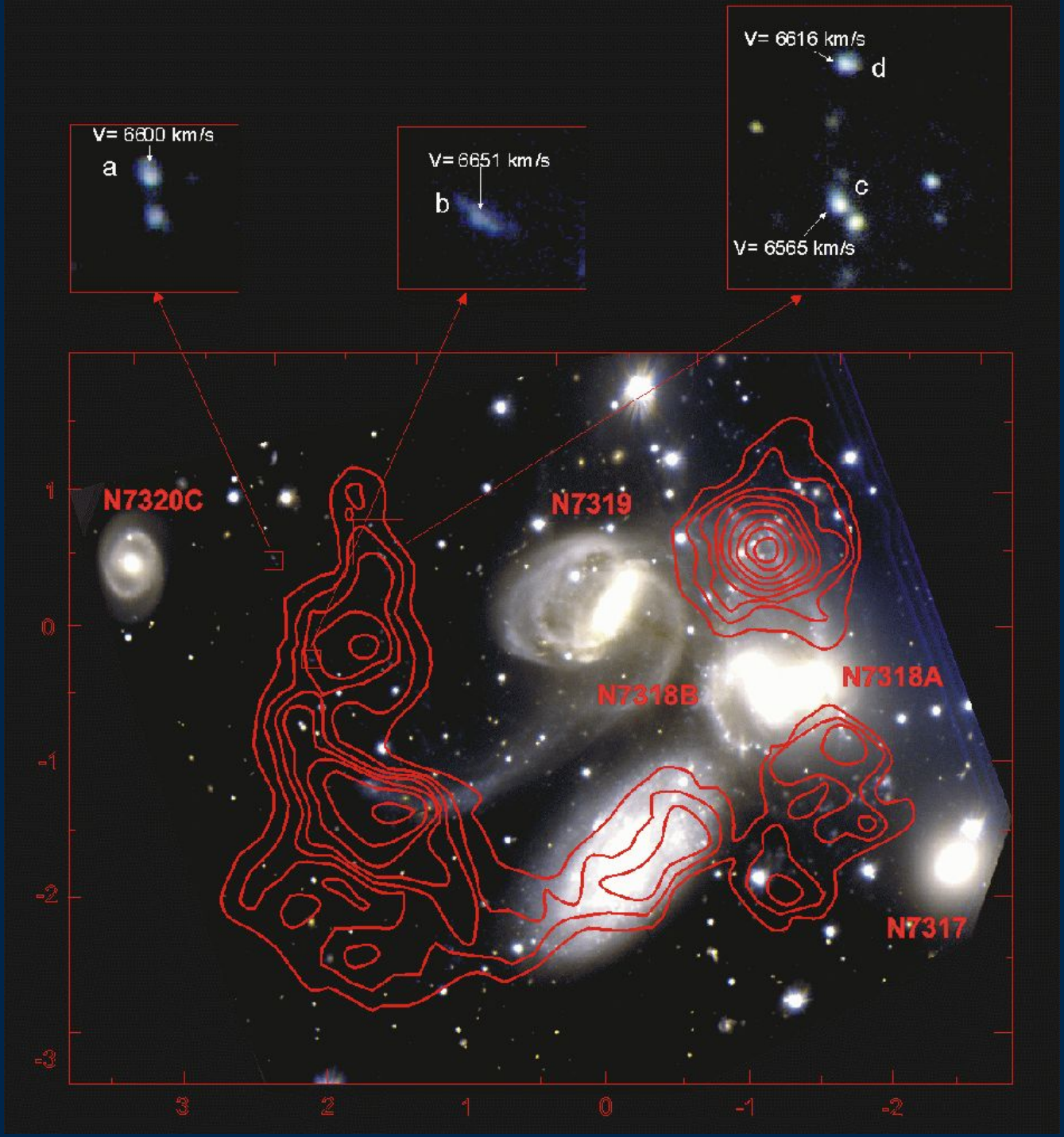

V= 6600 km/s
a
V= 6651 km/s
b
V= 6616 km/s
d
c
V= 6565 km/s
N7320C
N7319
N7318B
N7318A
N7317
1
0
-1
-2
-3
3
2
1
0
-1
-2

Table 1. Main photometric parameters and projected distances for the IHII regions

ID	B_T[(a)] mag	R_T[(a)] mag	M_B[(a)] mag	$B-R$ 0.8"/1.5"	D_{N7319}[(b)] "/kpc	D/R_{25}[(c)] N7319	D_{N7320C} "/kpc	D/R_{25} N7320C	FWHM/2[(d)] "/pc
a	23.00	22.29	-11.9	0.88/0.80	159.1/62	4.1	65.5/25	3.8	0.56/218
b	22.71	22.19	-12.1	0.70/0.62	140.4/54	3.6	93.3/36	5.4	0.83/321
c	22.32	21.68	-12.5	1.08/0.93	110.7/43	2.9	114.7/44	6.6	0.50/193
d	22.51	21.97	-12.3	0.69/0.64	118.5/46	4.1	110.8/43	6.4	0.56/217

[(a)] B_T and R_T are the total observed magnitudes (they correspond to the MAGBEST parameter given by SExtractor, Bertin and Arnout 1996). M_B is corrected for Galactic extinction only (Schlegel et al. 1998, $A_B = 0.34$ mag) assuming a distance to the group of 80 Mpc

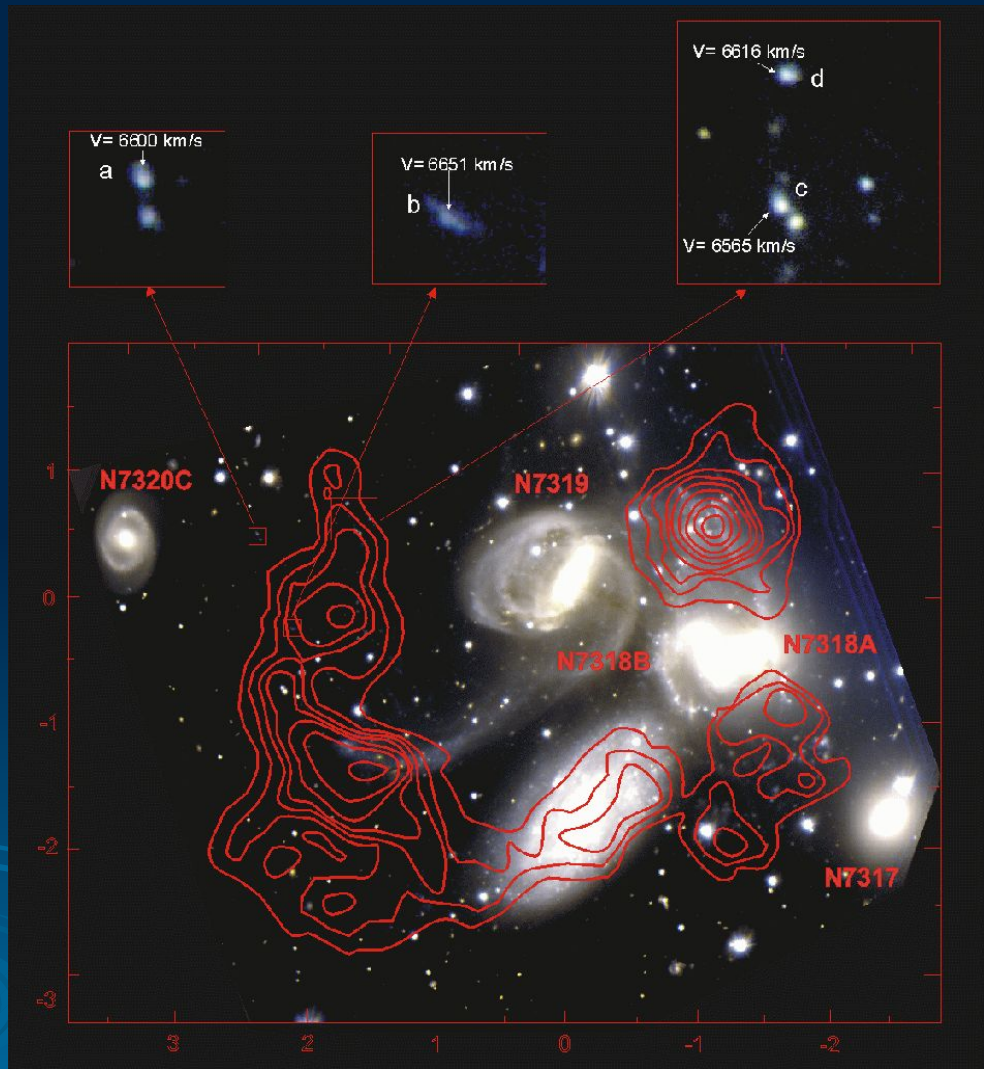
[(b)] D is the apparent distance between the IHII and the galaxy indicated.

[(c)] R_{25} is taken from the RC3 to be 38.7 arcsec for NGC 7319 and 17.3 arcsec for NGC 7320C.

[(d)] Measured in the R band by fitting a gaussian, using the task splot in IRAF.

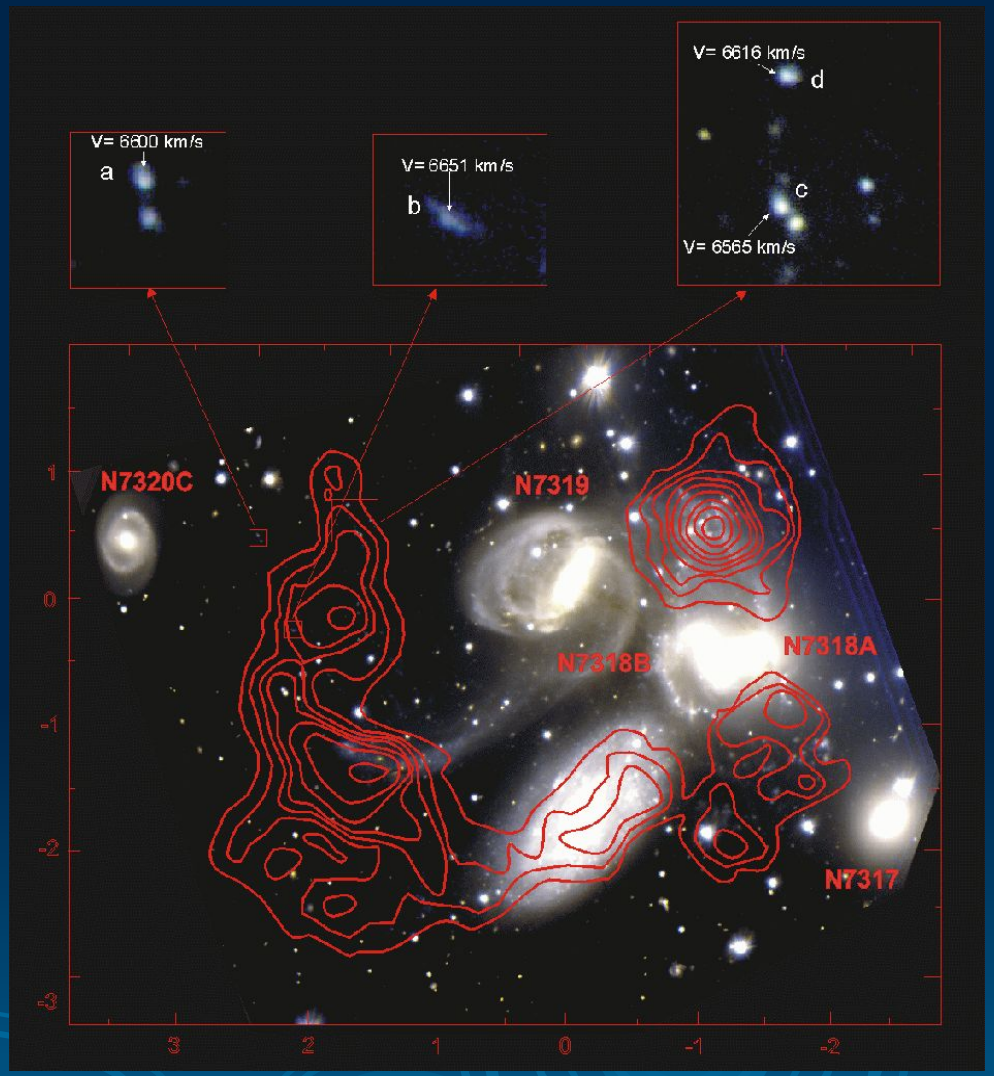
- the 4 IHII regions are resolved

- region c is listed by Gallagher et al. (2001) as a candidate stellar cluster and by Sulentic et al. (2001) as a candidate extragalactic HII region



- IHII radial velocities are within ±20 km/s of the HI velocity:

  physical association of the knots with the cloud



metallicities

- N2 calibrator (Denicoló, Terlevich & Terlevich 2002)

  [NII]λ6584/Hα
<12+log(O/H)>=8.6
(Sun: 8.8±0.1)

- object c: 8.64 ±0.25
 using [OIII]/Hβ (Edmunds & Pagel 1984): 8.4 ±0.2

→ the IHII have been formed from pre-enriched material

ages:

- Starburst99 (Leitherer et al. 1999): solar metallicity, Salpeter IMF, instantaneous burst

- ages from EW(Hα): 3.2 – 5.6 Myr

  mean: 4.6 Myr

mass:

- mass from the emission rate of ionizing fotons, $Q(H^0)$, estimated from L(Hα):

  $(2.9\pm1.4) \times 10^4 M_{sun}$
- expected number of O stars: ~20 to ~200

- mass from the luminosity of the stellar component

  R-band luminosities corrected for line-emission: $(4.5\pm2.8) \times 10^4 M_{sun}$

- Lower limits because of internal extinction

  region c: $(H\alpha/H\beta)=4.4 \rightarrow A_R \sim 1$ mag

  masses might be at least twice these values

TABLE 2

MAIN SPECTROSCOPIC PARAMETERS FOR THE IHIIs

Region	V_{helio} (km s^{-1})	[N II] λ6584/Hα	12 + log (O/H)	EW (Hα) (Å)	$L_{H\alpha}$ (10^4 $L_\odot$)	Age (Myr)	Mass (10^4 $M_\odot$)
a	6600 ± 33	0.132 ± 0.061	8.48	508 ± 25	7.8 ± 1.5	4.0	2.0
b	6651 ± 43	0.229 ± 0.194	8.65	287 ± 35	2.2 ± 1.1	5.6	1.4
c	6565 ± 19	0.219 ± 0.051	8.64	1149 ± 54	38.2 ± 7.0	3.2	4.4
d	6616 ± 36	0.155 ± 0.014	8.53	297 ± 14	5.6 ± 1.0	5.6	3.6

other examples of similar phenomena

- Gerhard et al. (2002): Virgo cluster

  $M \sim 10^3\ M_{sun}$ $d_{proj} \sim 18$ kpc to NGC4388

- Gavazzi et al. (2003): dwarf/HII galaxies in a group falling in the cluster A1367

  $M = 10^7 - 10^{12}\ M_{sun}$

  near bright galaxies

- Summary of the IHII characteristics:

1- compact (except for region b) but resolved

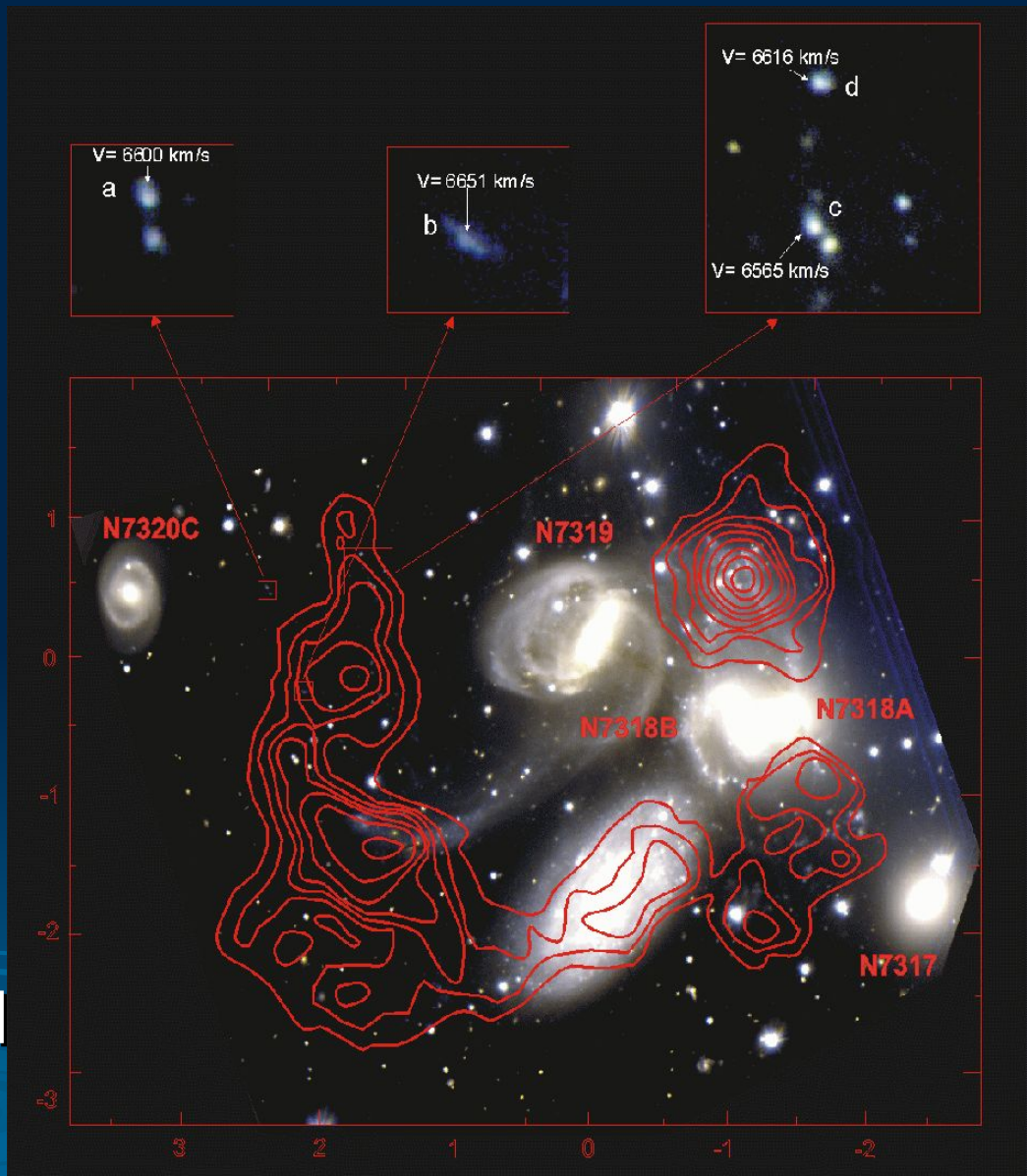
2- high metallicities (~60% solar)

3- masses of the order of 10^4 M_{sun}

4- ages ranging from 3.2 to 5.6 Myr

5- located far from bright galaxies

6- coincide in location and velocity with the HI tail



What is the origin of the IHII in Stephan's Quintet?

- were they removed from some galaxy?

typical ejection velocities ~200-300 km/s

$T_{eject} > 10^8$ yr

Ages: a few Myr

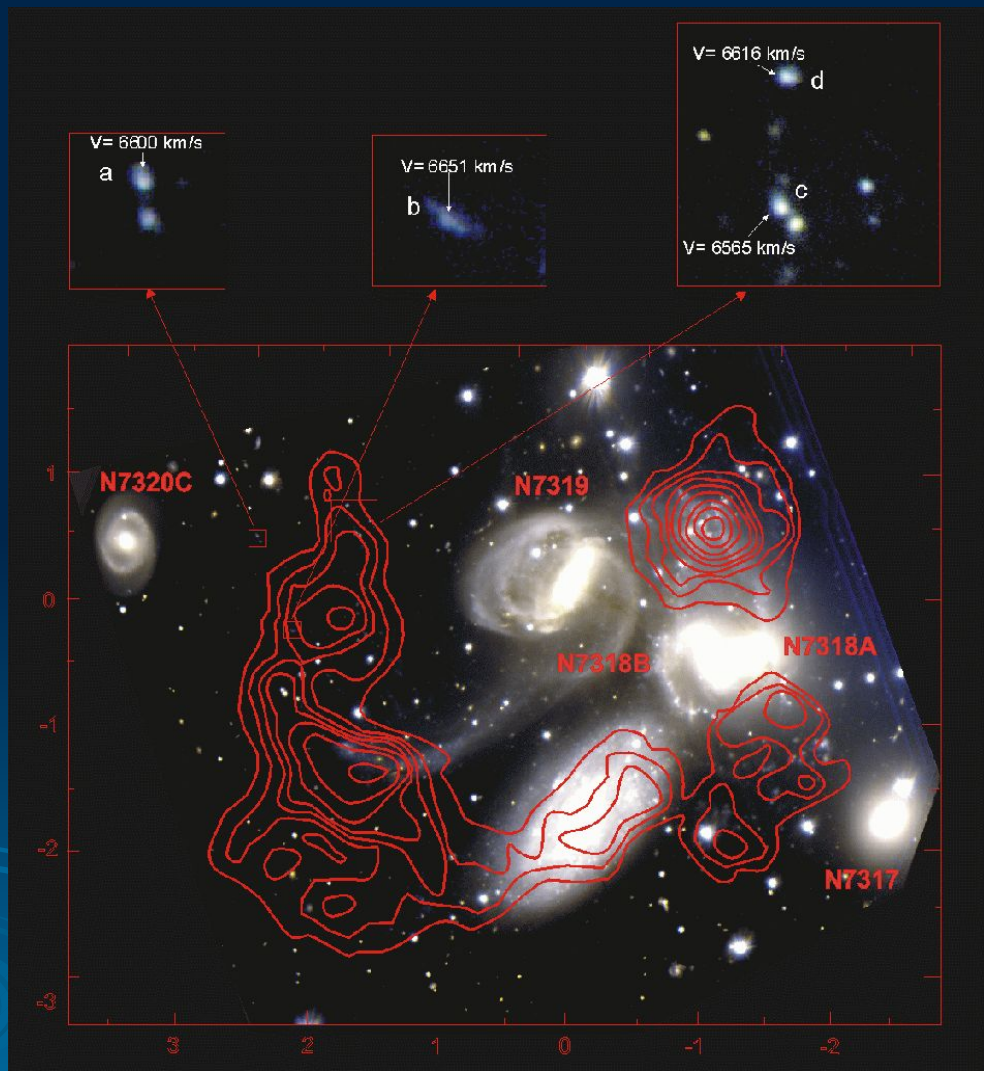
- probably they were formed where they are observed

origins…

→ tidal interactions?

→ interactions with a hot intergalactic medium?

→ …?



some questions…

- role of the IHII in the pollution of the intergalactic medium?
- how common the IHII are?