Imaging the jets of the naked quasar

Dániel Molnár

PhD student
University of Sussex

M. T. Sargent, D. Elbaz

National Astronomy Meeting

07. 07. 2015.

Outline

- What we know about HE0450-2958 so far
- New JVLA observations
- Discussion and summary

HE0450-2958

- double optical system (Magain et al. 2005): QSO and companion galaxy
- low redshift (z = 0.2864)

Hypotheses

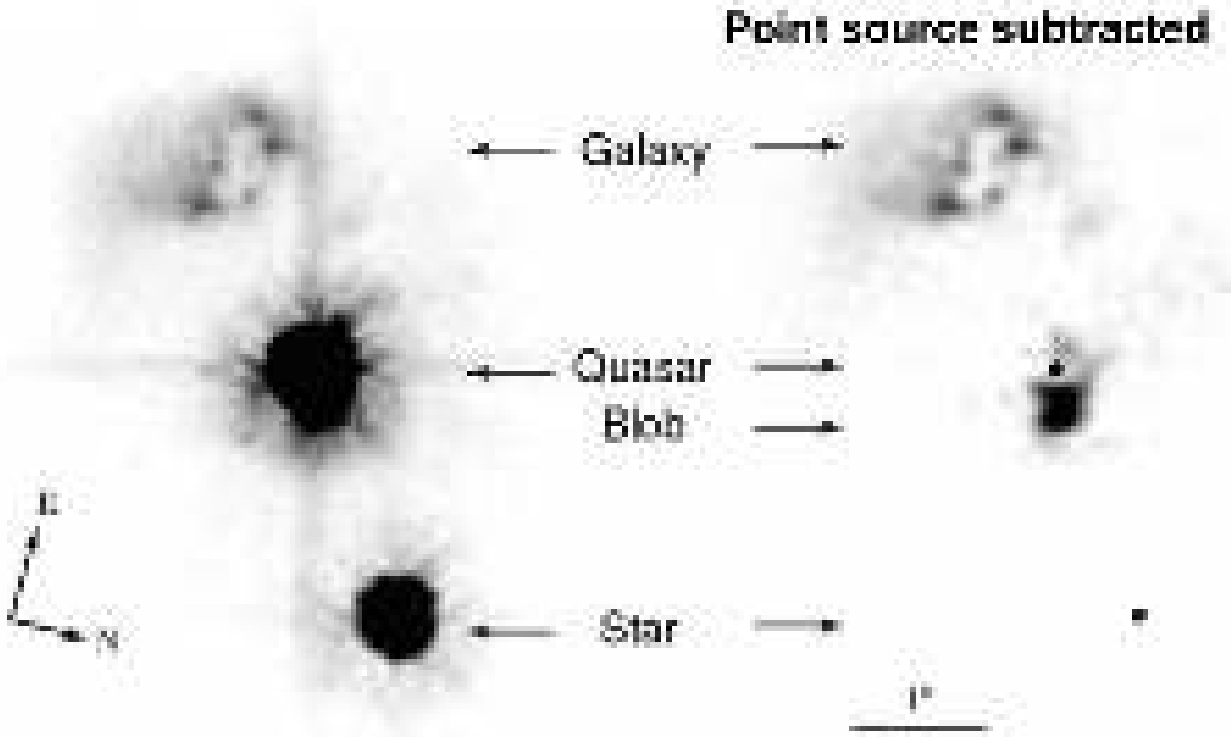
- naked quasar
- merger of a massive galaxy and a dwarf with an AGN (Papadopoulos et al. 2008)
  - specific merger phase caught in the act?
- quasar-jet-induced star formation (Elbaz et al., 2009)
  - positive AGN feedback?
- highly asymmetric host with an offset active nucleus (Letawe & Magain 2010)
  - multiple black hole interaction, gravitational wave physics

HE0450-2958

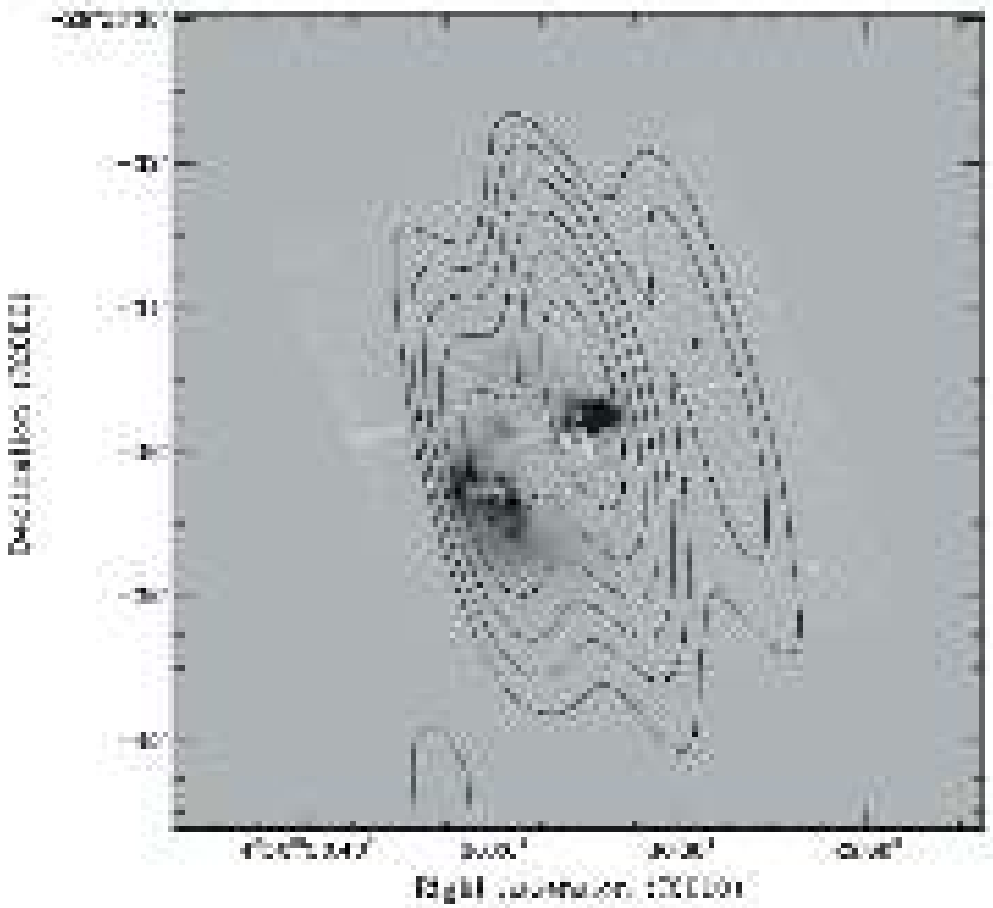
- double optical system (Magain et al. 2005): QSO and companion galaxy
- low redshift ($z = 0.2864$)

Hypotheses

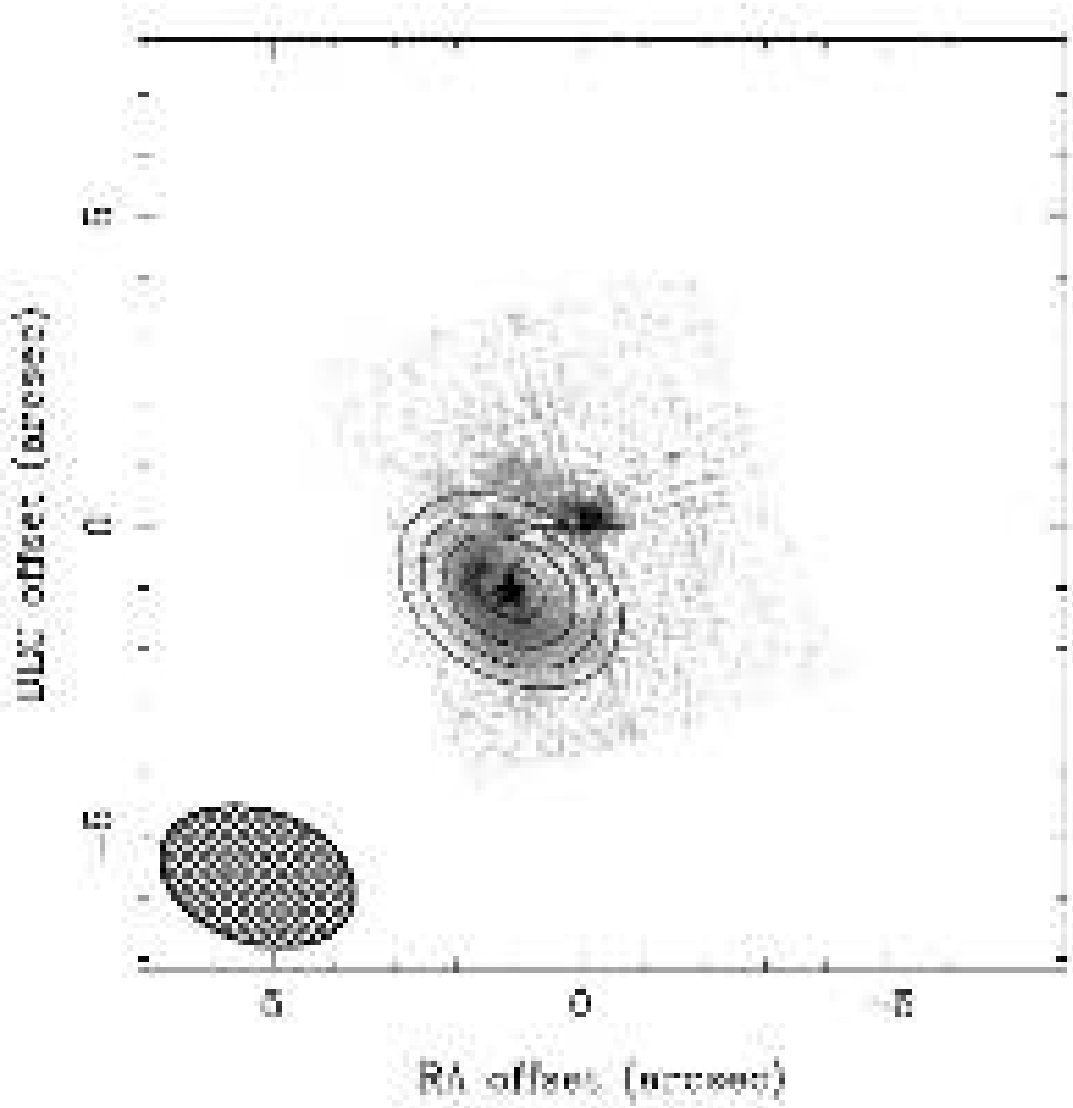
- naked quasar
- merger of a massive galaxy and a dwarf with an AGN (Papadopoulos et al. 2008)
  - specific merger phase caught in the act?
- quasar-jet-induced star formation (Elbaz et al., 2009)
  - positive AGN feedback?
- highly asymmetric host with an offset active nucleus (Letawe & Magain 2010)
  - multiple black hole interaction, gravitational wave physics



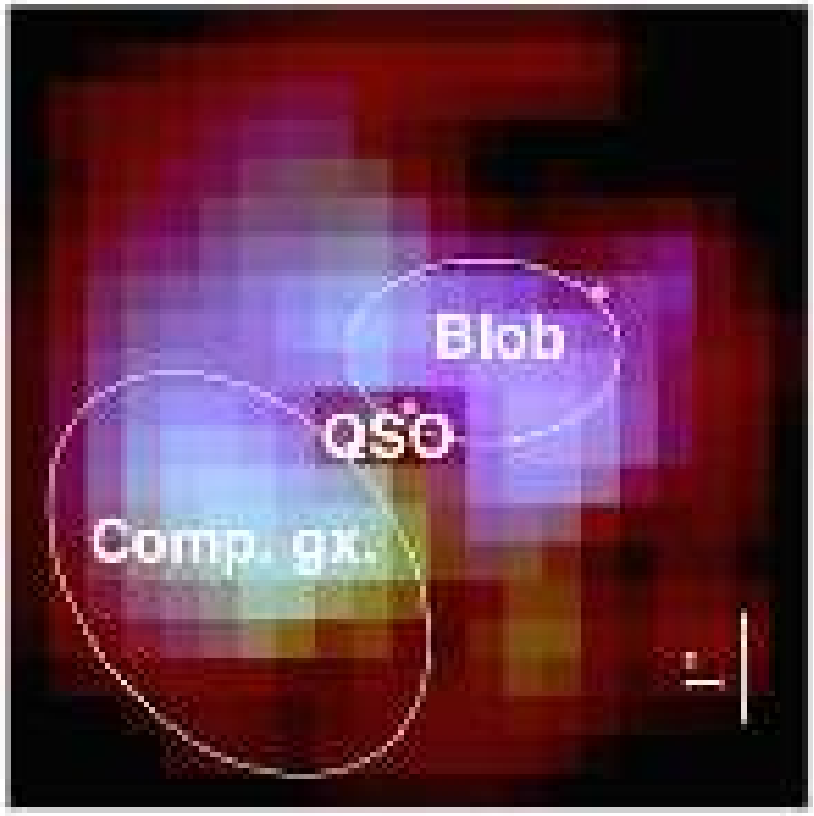
HST image: QSO and companion galaxy (with a foreground star). After PSF deconvolution the “blob“ appears. Host galaxy is not detected. Is it a truly naked quasar? Or it has an undermassive host? Or the blob is an offset host galaxy?
Image is from Magain et al. 2005..

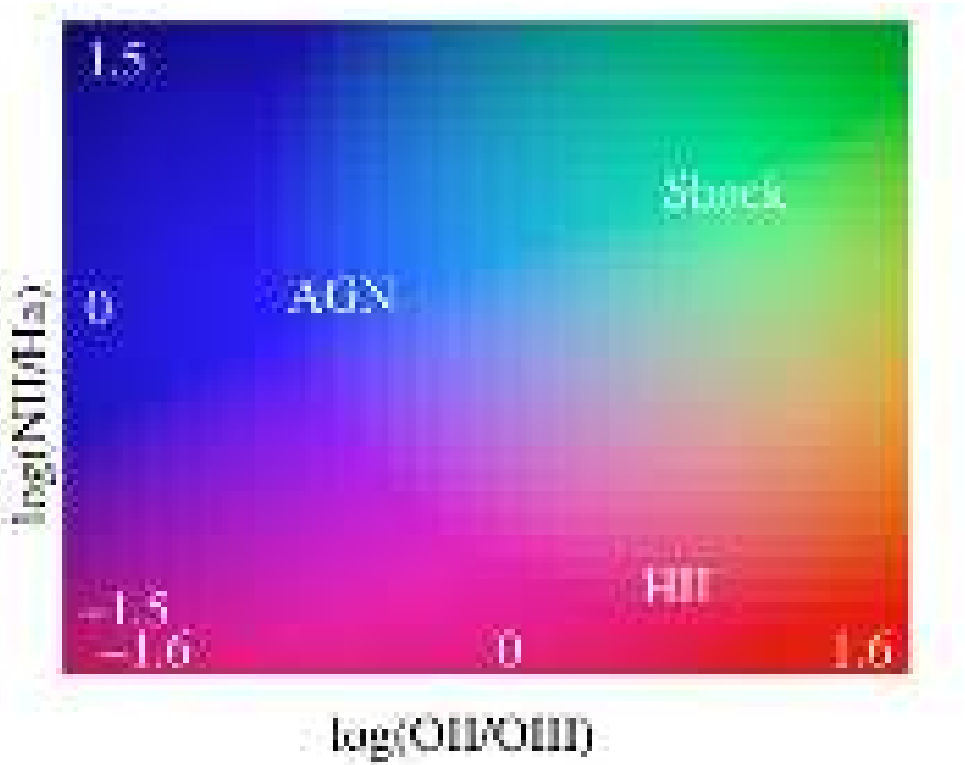


Triple radio morphology. Right hand faint, low resolution source is not associated with any background/foreground source -> QSO has a radio jet? Left-hand lobe has emission from the companion galaxy and jet as well. Jet might be aligned to the galaxy - jet-induced star formation?



CO emission coming from the companion galaxy. Source: Papadopoulos et al., 2008





HE0450-2958 is probably embedded in ionized gas. AGN ionizes the blob.
Figure from Letawe et al. 2008.

observations from 2011 Sep - 2012 Sep (PI.: M. Sargent)

Obs.	ν (GHz)	$\theta x \theta$ (“ x “)	σ_{rms} (μJy beam^{-1})	improvement
VLA	1.5	6 x 4	-	
JVLA	1.5	2.64 x 0.84	32	3x / -
ATCA	6.2	5.68 x 1.95	40	
JVLA	5	0.93 x 0.37	11	5.6x / 3.6x
ATCA	8.6	4.07 x 1.25	50	
JVLA	8.4	1.02 x 0.75	19	2.6x / 2.6x

- data reduction with NRAO CASA pipeline
- imaging with CASA's CLEAN task in MS-MFS mode & Briggs-weighting

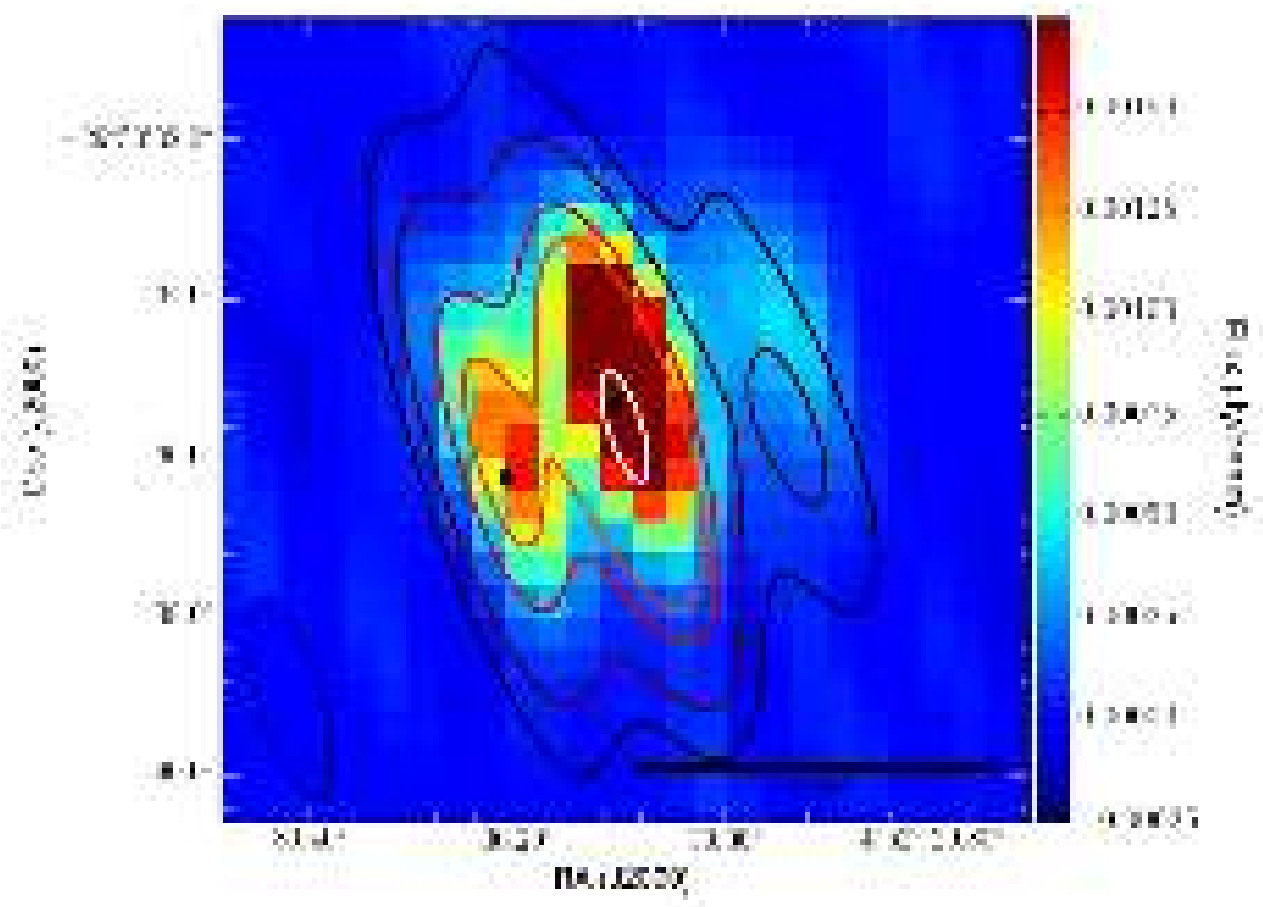


Figure: JVLA 1.5 GHz images with A array configrations. Triple radio configuration is recovered as was seen before in higher frequencies. 6 GHz overlaid contour is from Feain et al. 2007.

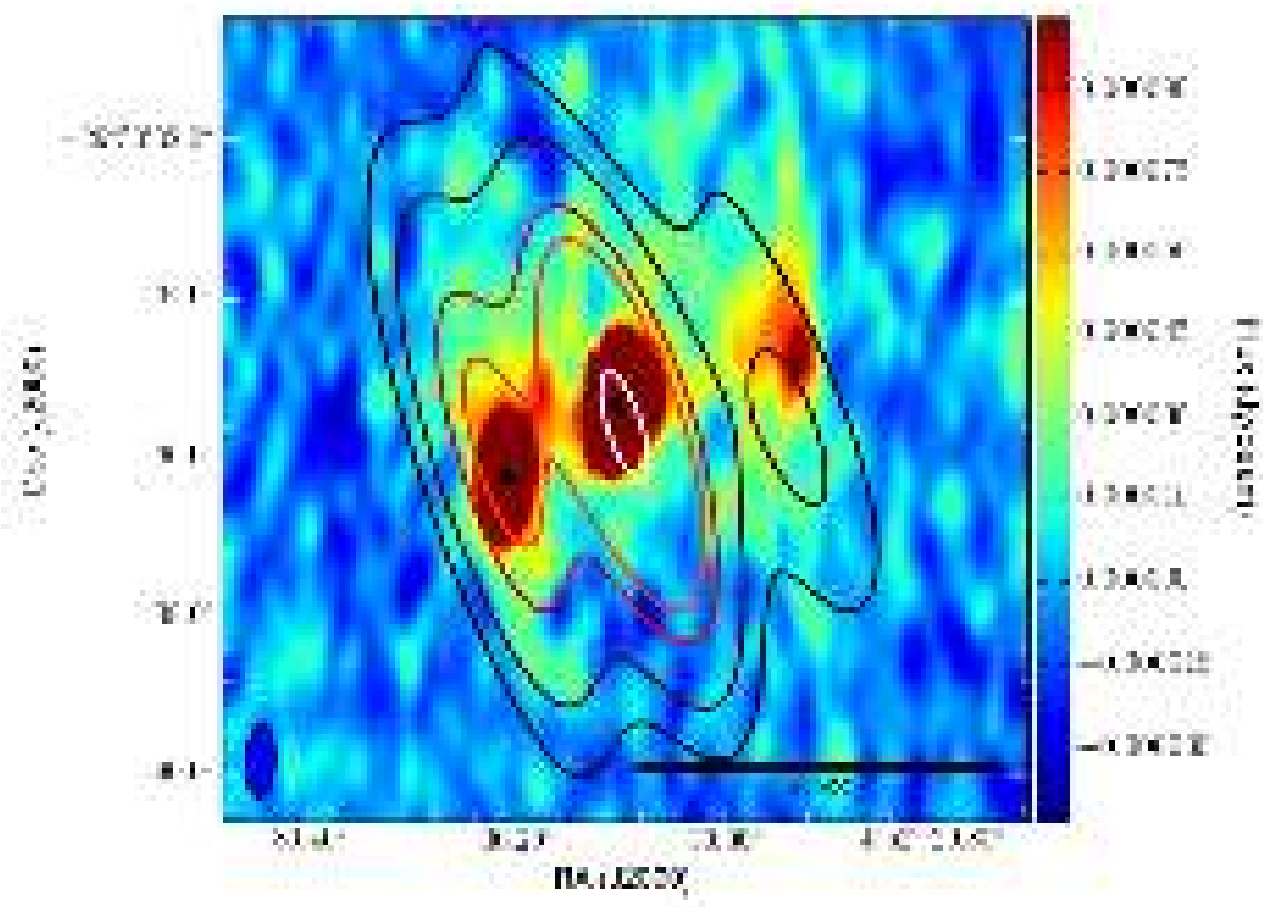


Figure: JVLA 5 GHz image with point sources. QSO+galaxy surrounded by ionized gas. Previously tentantatively observed lobe is detected. 6 GHz overlaid contour is from Feain et al. 2007.

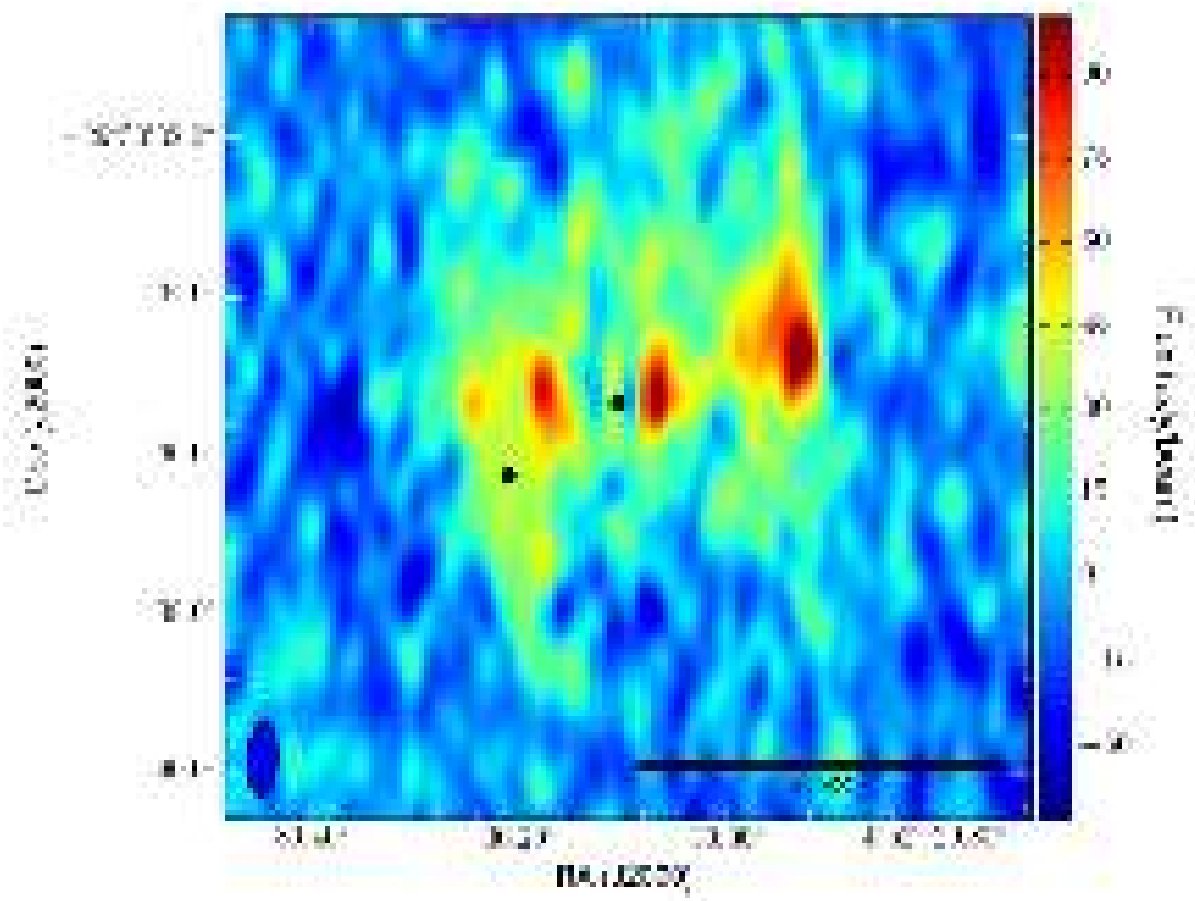


Figure: JVLA 5 GHz image without point sources. The blob is detected in radio. Other blobs appear along the radio axis. Outflow pinpointed to the northern part of the companion galaxy.

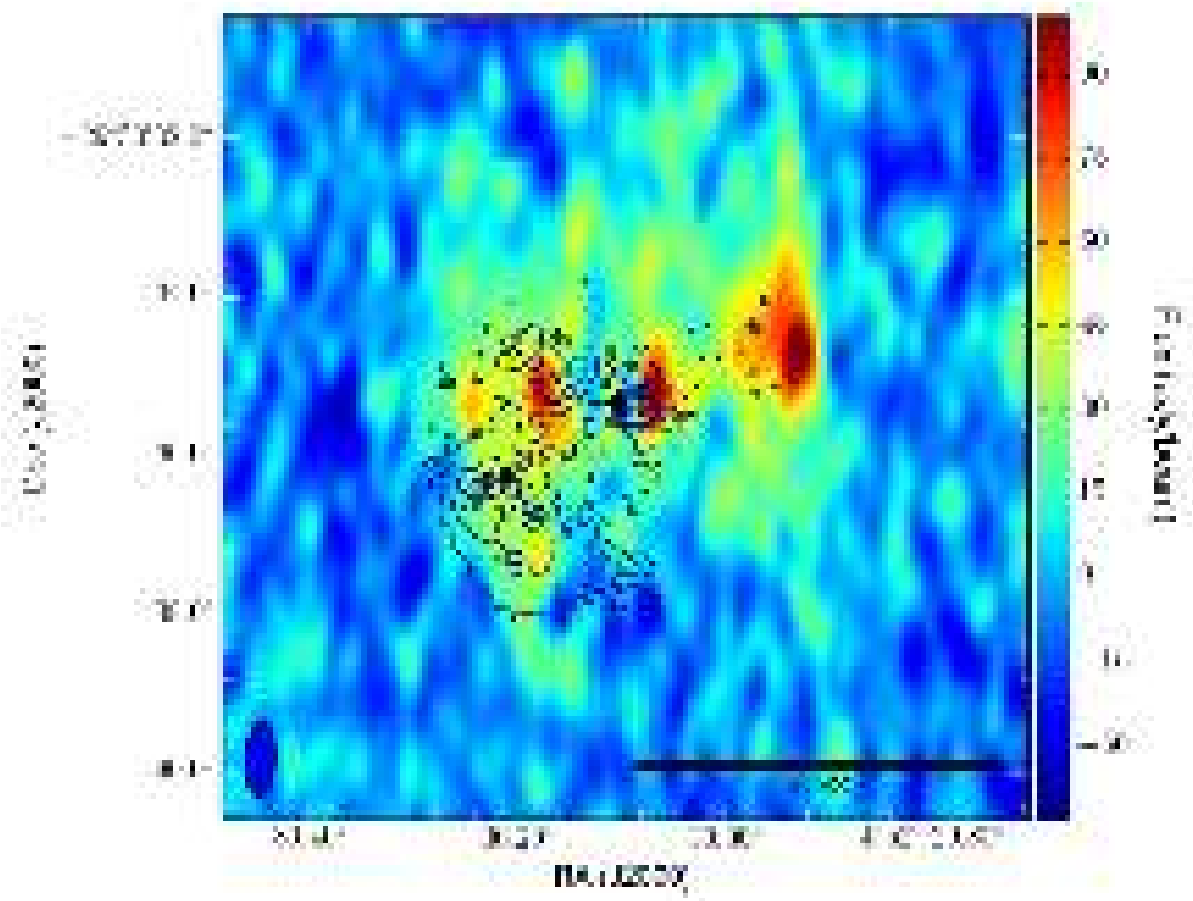


Figure: JVLA 5 GHz image without point sources. Optical overlaid contour is from Magain et al. 2005. Star formation is pinpointed to the dust obscured part of the companion galaxy.

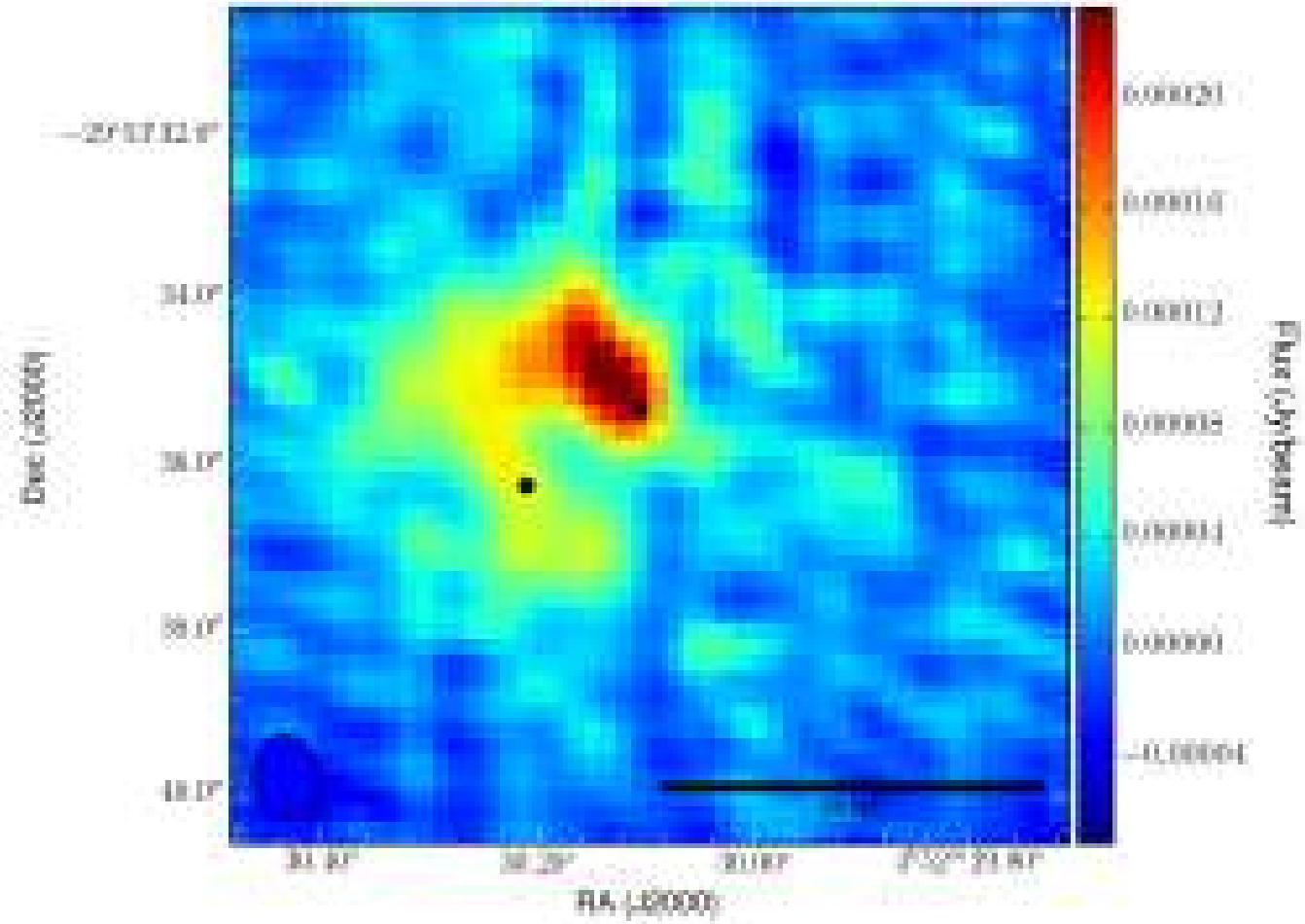


Figure: JVLA 8.4 GHz image. Completely different morphology than in lower frequencies. Overlaid contour is from the JVLA 6 GHz image with point sources.

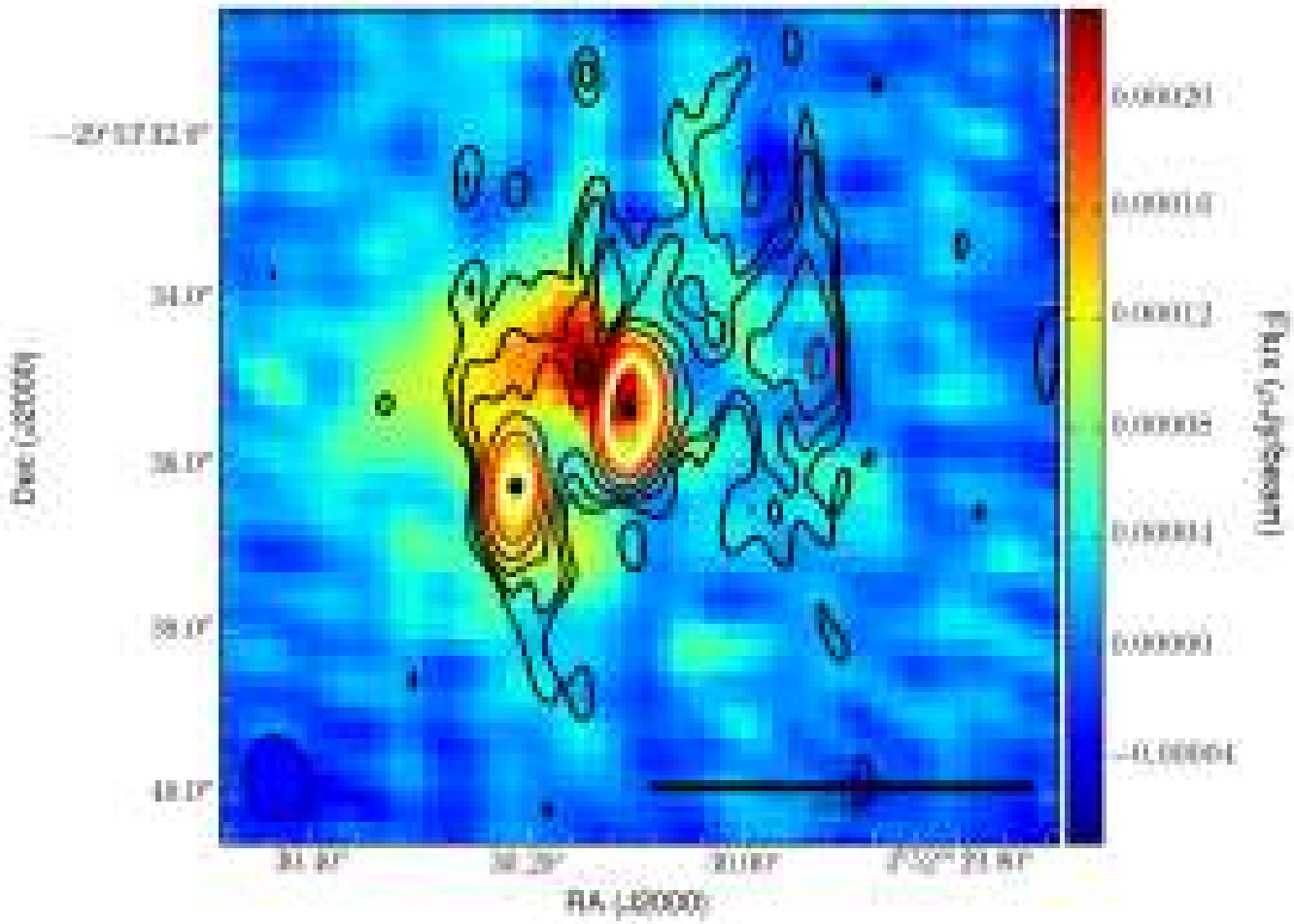


Figure: JVLA 8.4 GHz image. Overlaid contour is from the JVLA 6 GHz image with point sources.

Conclusions

- linear structrue: possibly outflow/jet, first time imaged in high-resolution - jet-induced star formation is still a valid hypothesis
- "blob": detected in NIR, MIR, radio, on the radio axis - part of the outflow? offset host?
- $\sim$ 20 kpc diffuse radio halo - flat spectrum - photoionized gas by the QSO (agrees with optical em. line ratios) -> truly naked QSO?
- star formation in the comp. galaxy concentrated in the dust obscured nucleus
- comp. galaxy's radio emission can be attributed only to star formation, consistent with SFR derived from IR data ($\approx 210\ M_{\odot}\ \mathrm{year}^{-1}$)
- 8.4 GHz images show completely different morphology