

# Unravelling Hanny's Voorwerp

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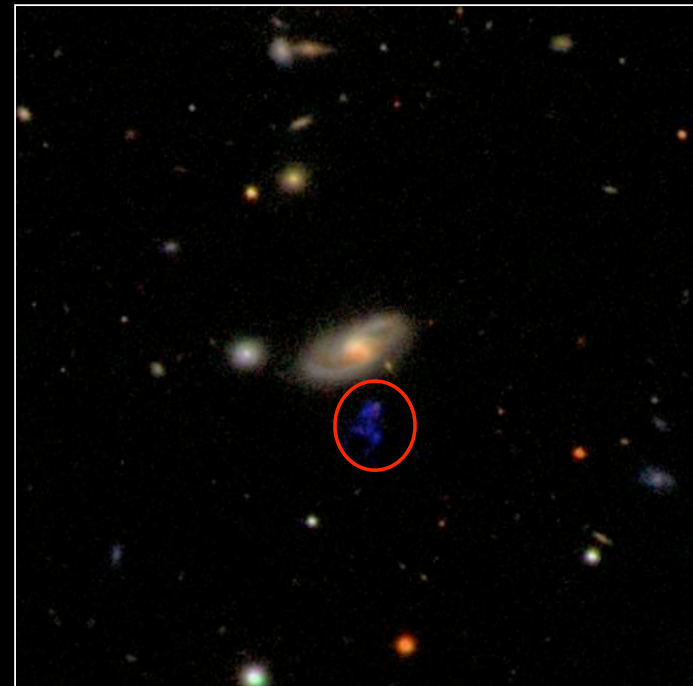
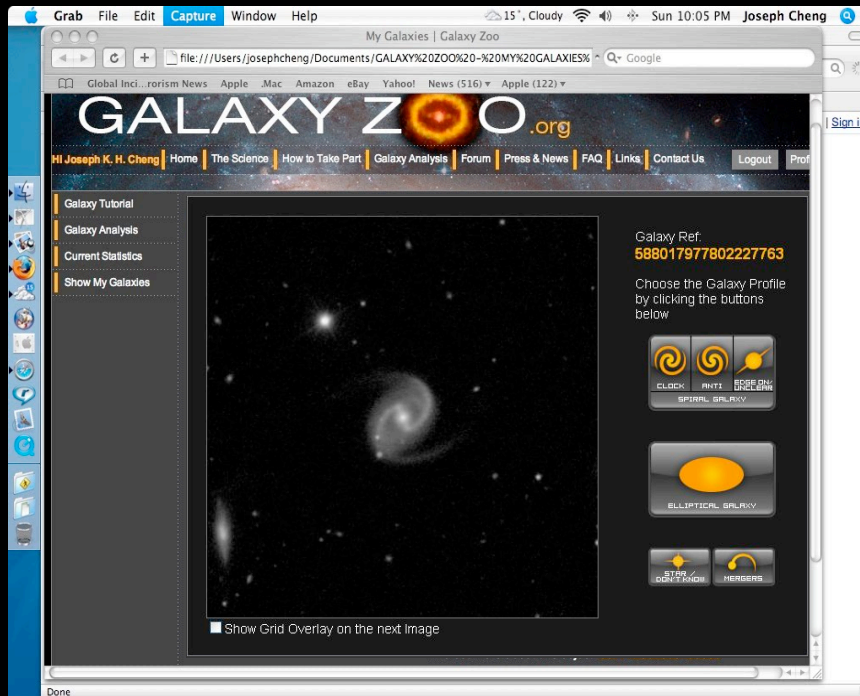


Universiteit Leiden



# “What's that blue stuff below?”

- Hanny van Arkel (Dutch school teacher) discovered "Hanny's Voorwerp<sup>1</sup>" via the GalaxyZoo project:

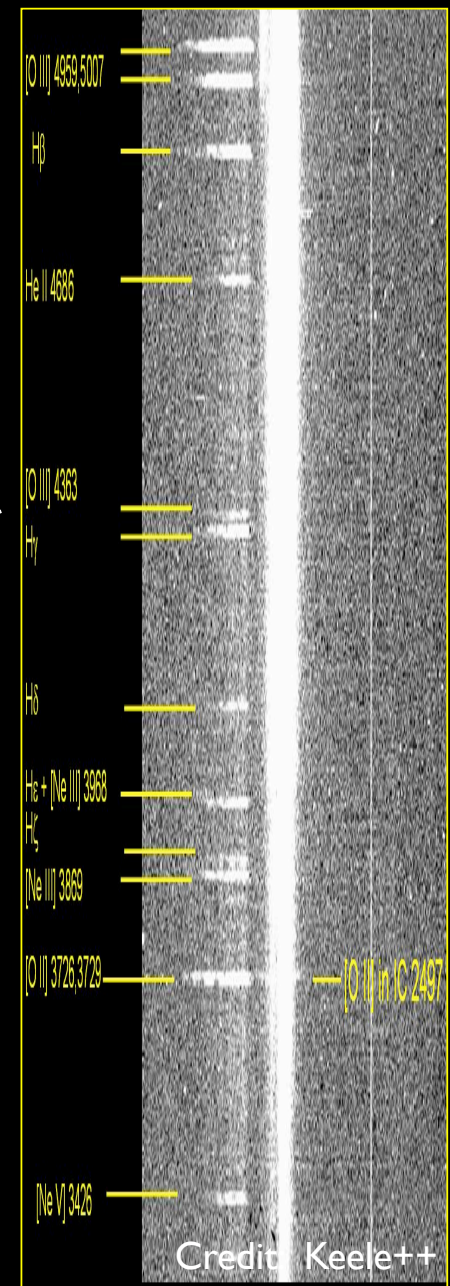


<sup>1</sup>voorwerp = "object" in dutch

IC2497 ( $V_{\text{sys}} \sim 15056 \text{ km/s}$ )

Highly ionised  
 $T \sim 15000\text{-}20000 \text{ K}$

Credit: WHT (g,r,i) image, Jarvis++

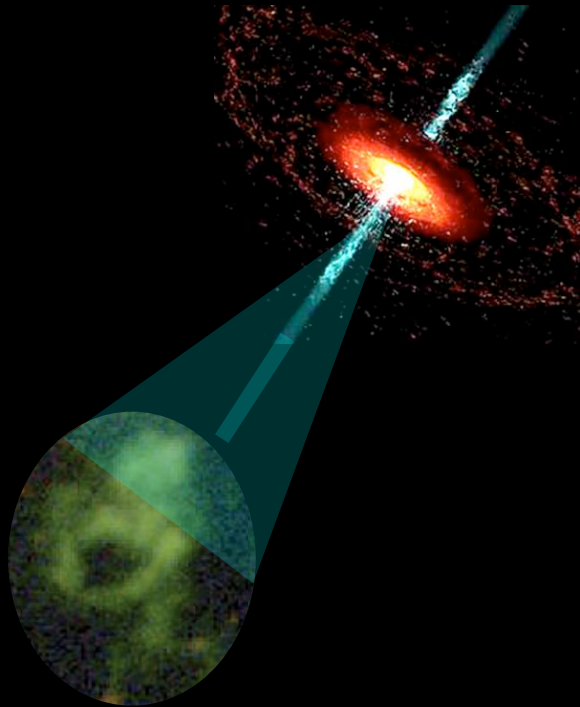


# What's the big deal?

- Huge Galaxy-sized ionised nebula - where did that come from!
- What is the source of ionisation ?
  - no stars in nebula,
  - only weak liner spectrum of galaxy IC2497,
  - no x-ray detection of IC2497 (SWIFT).

- Lintott et al. (2009) suggest IC2497 is a dead quasar, recently turned-off => Voorwerp is the first example of a *quasar light-echo*.

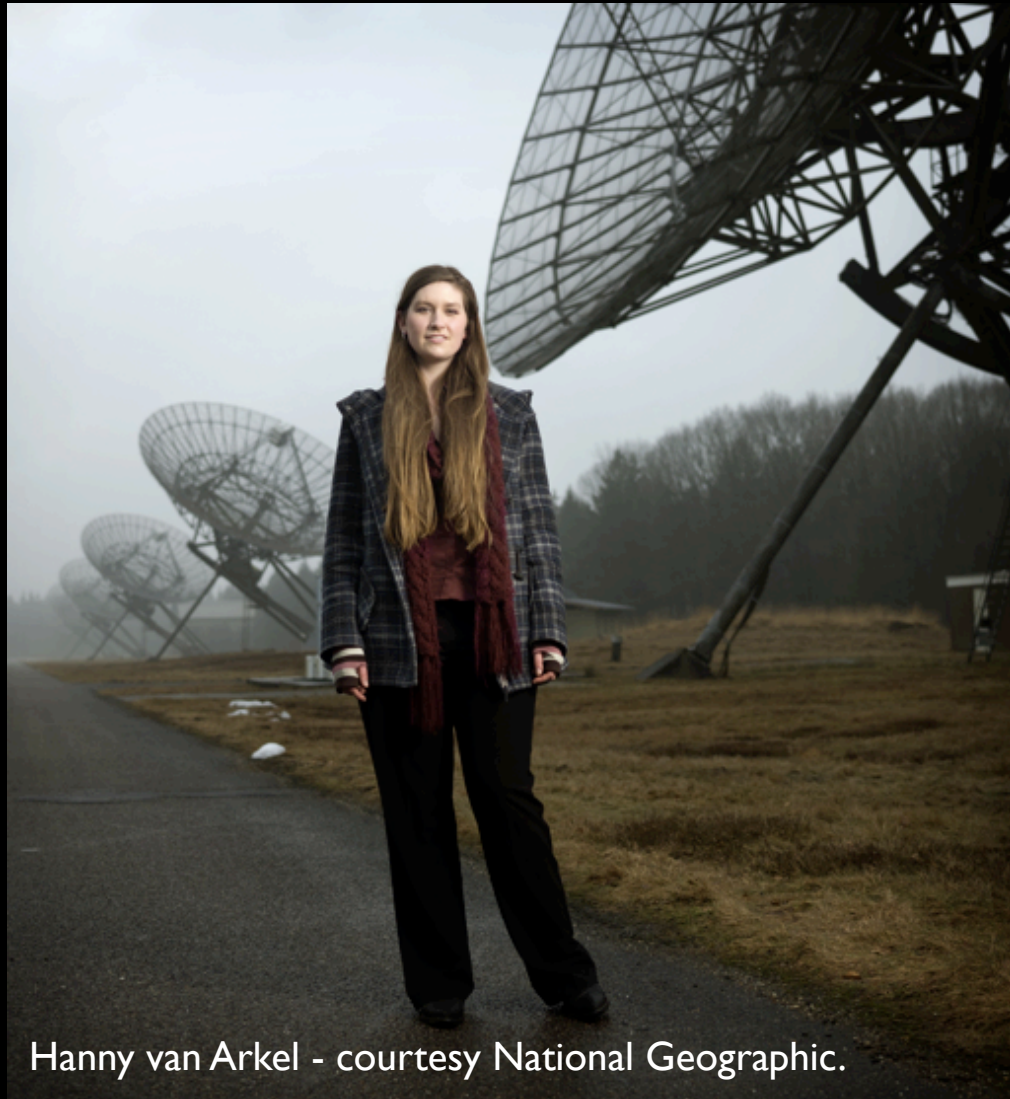
~ 50000 yr ago



- Lintott et al. suggest IC2497 is a dead quasar, recently turned-off, Voorwerp is the first example of a *quasar light-echo*.



Hanny van Arkel "citizen scientist", international celebrity, honorary ASTRON affiliation!



Hanny van Arkel - courtesy National Geographic.

**de Volkskrant** powered by Google

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**'Astronomen hebben zo iets nog nooit gezien'**

Jochien Lybaert  
gepubliceerd op 31 juli 2008 02:45, bijgewerkt op 23:37

Amsterdam - In september is Hanny van Arkel, een 26-jarige onderwijeres uit Haarlem, te zien in het BSC-programma Sky at Night. Ze vertelt een vreemde verhaal in een voor sterrenkundigen. Astronomen staan voor een raadsel.

**BBC NEWS** Watch ONE-MINUTE WORLD NEWS

Have last updated: at 22:23 GMT, Tuesday, 5 August 2008 23:23 UK.  
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**Teacher finds new cosmic object**

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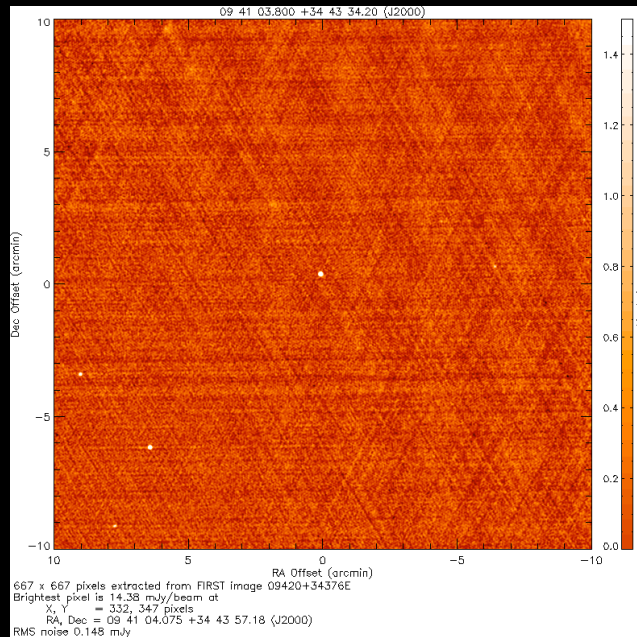
updated 11:19 a.m. EDT, Thu August 7, 2008

**Armchair astronomer finds 'cosmic ghost'**

Hanny van Arkel was poring over photos of galaxies on the Internet last August when she stumbled across a strange object: a bright, gaseous mass with a gaping hole in its middle. Van Arkel is a schoolteacher in the Netherlands, not an astronomer. But her find - what some are calling a "cosmic ghost" - has captivated astronomers. [Full story](#)

and I mailed the Zookeepers, the team.

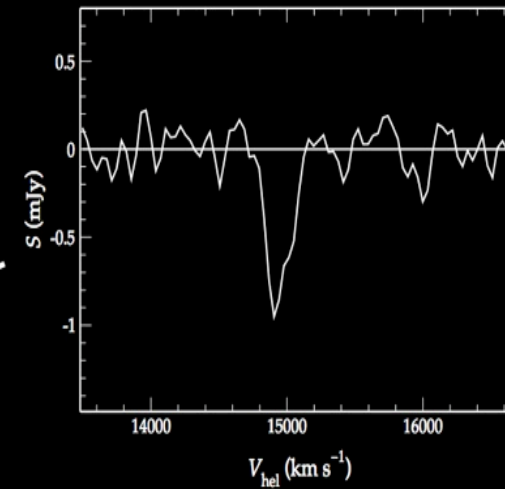
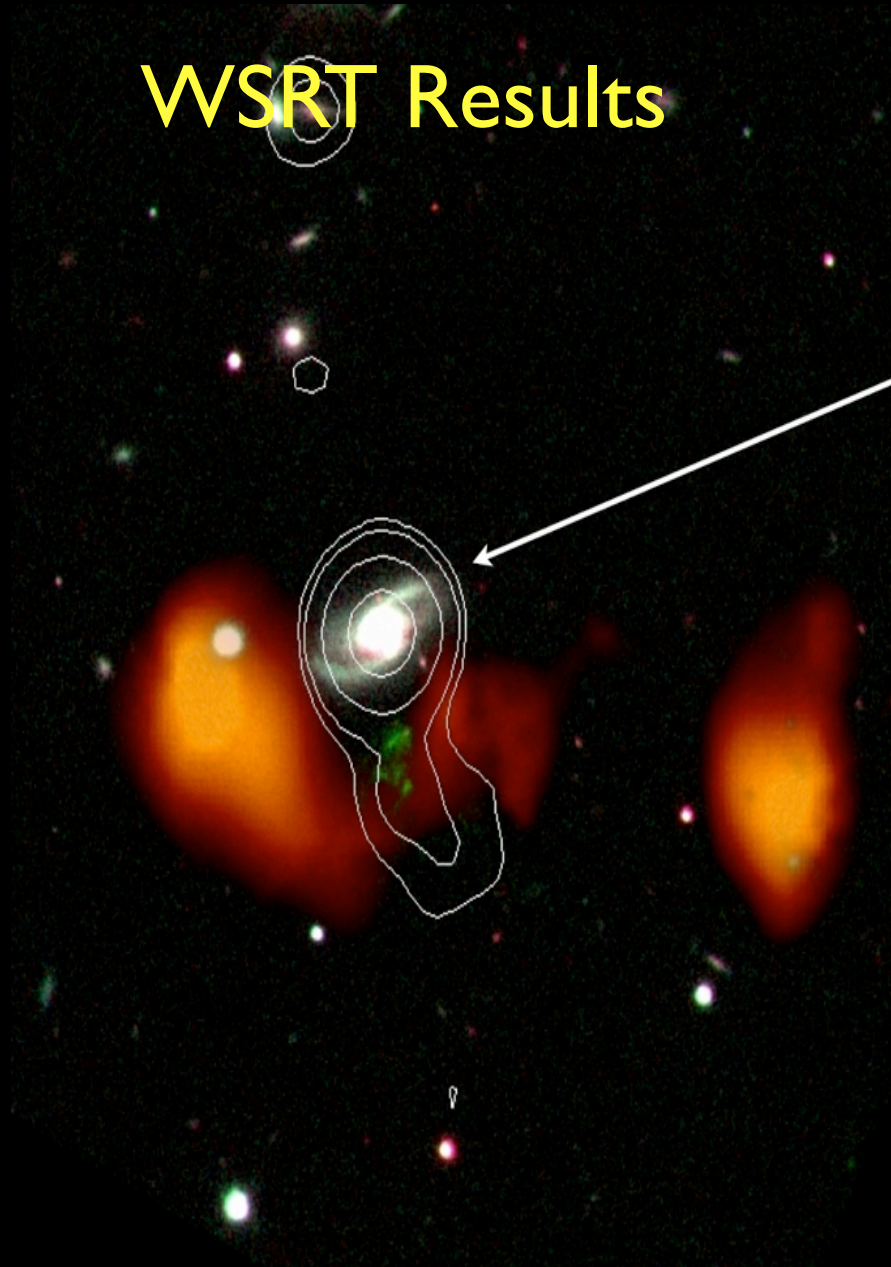
- Interview with Chris Lintott was broadcast on the "Jodcast" ca. 2008?  
==> sceptical of quasar light-echo hypothesis.
- IC2497 - detected in VLA FIRST survey  $S_{\text{tot}} \sim 17$  mJy.



Requested radio obs:

- WSRT 20 & 6cm continuum
- WSRT 21cm spectral-line
- MERLIN 18 & 6cm
- e-VLBI 18cm

# WSRT Results

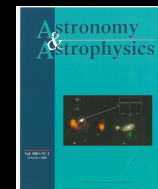


Continuum "jet" (contours) in the direction of the Voorwerp!

Massive gas cloud complex  $> 100$  kpc across  $\sim 8 \times 10^9 M_{\text{sun}}$  in the vicinity of IC2497++.

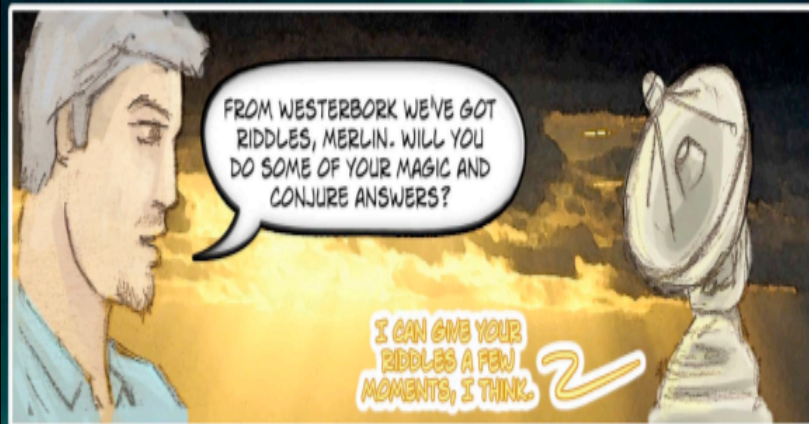
HI absorption against IC2497,  $\Rightarrow 2 \times 10^{21} (T_s/100) \text{ f}^{-1} \text{ atoms cm}^{-2}$

Jozsa, Garrett, Oosterloo et al. 2009



# NASA sponsored Voorwerp Comic:

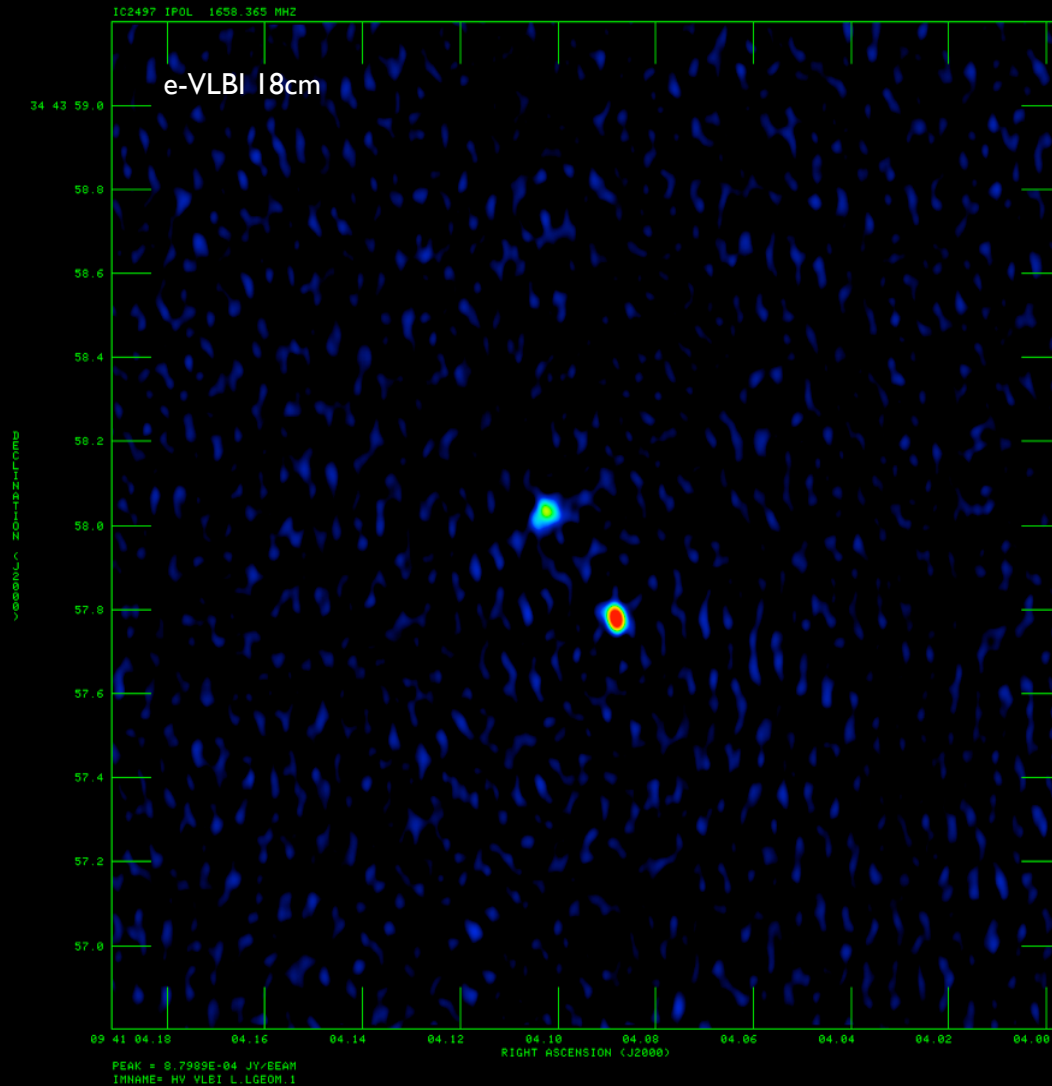




e-VLBI is great (data on demand) - thank-you!



# e-VLBI 18cm, 1 Gbps Results: Galaxy IC2497



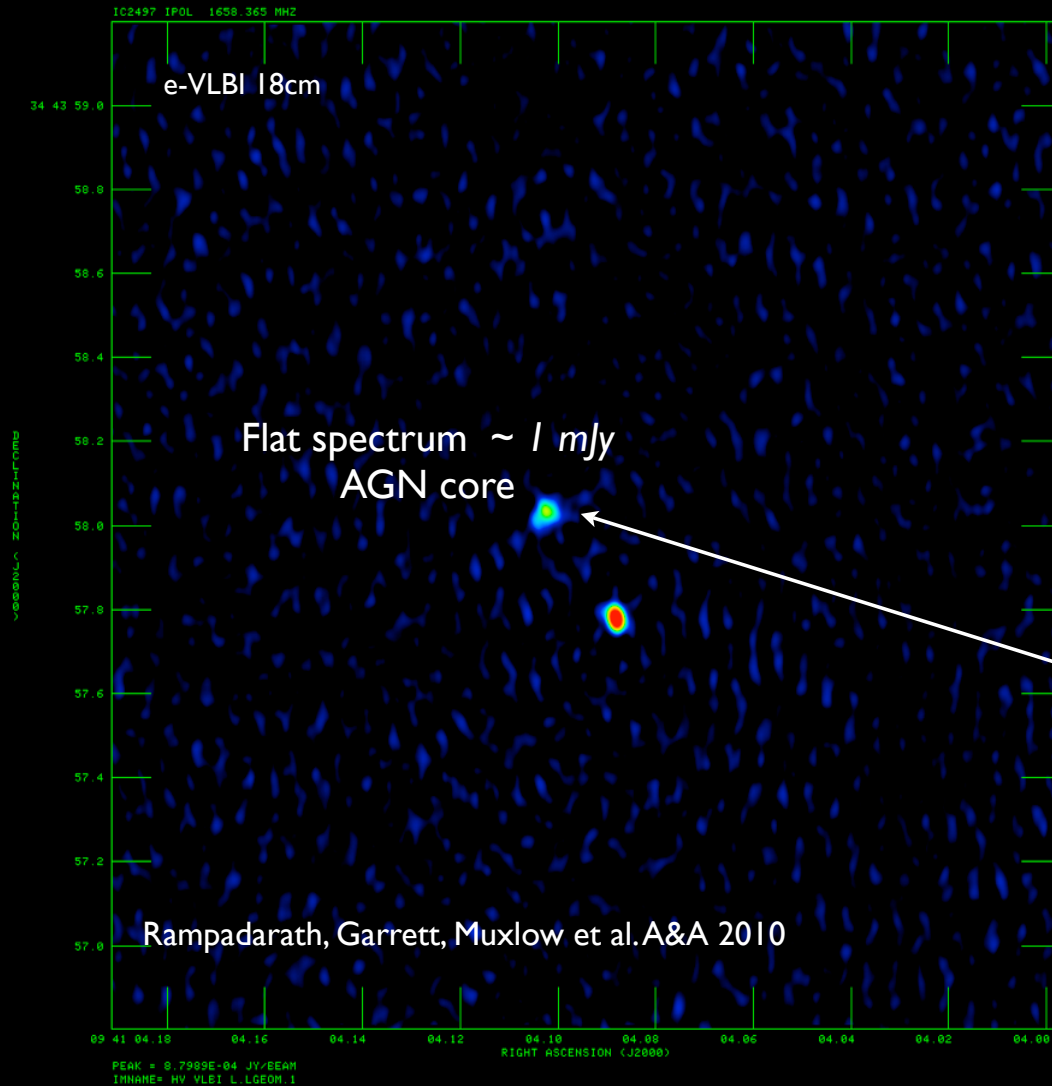
Two components,  
interpreted as core-jet  
(hot-spot).

$T_b > \text{few} \times 10^5$  Kelvin

=> evidence for  
(obscured) AGN  
activity in IC2497

Can't rule-out  
possible SNe/SNRs  
but unlikely?

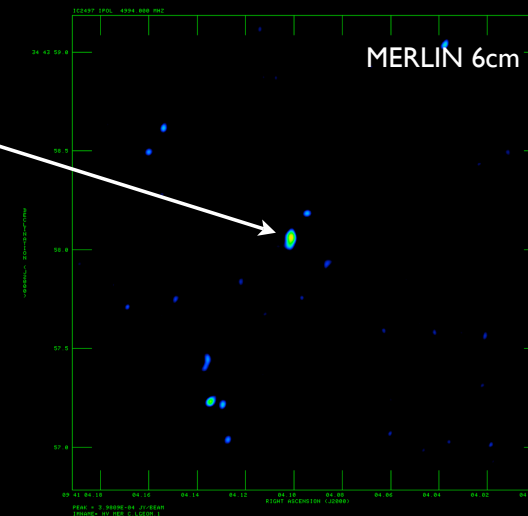
# e-VLBI 18cm/ MERLIN 6cm Results



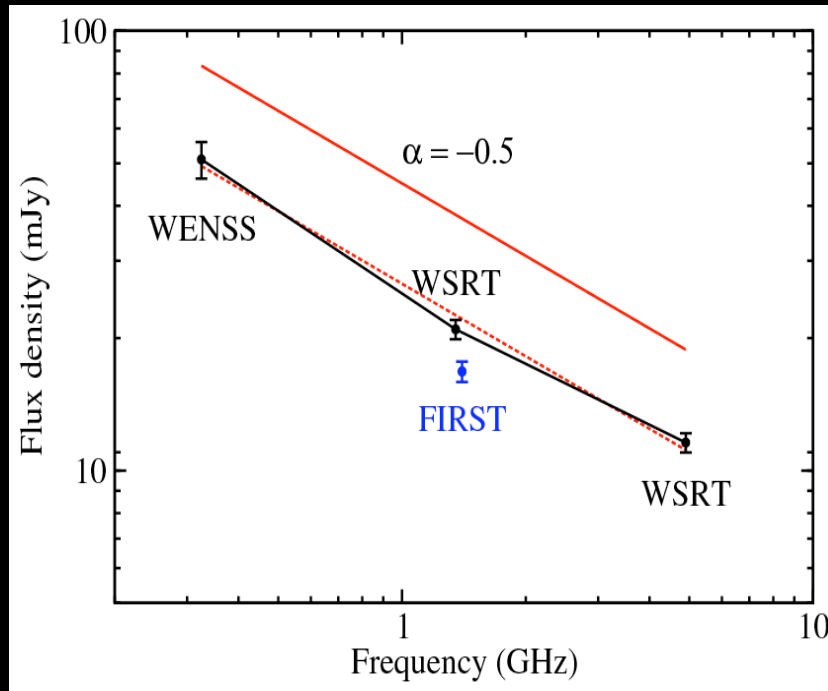
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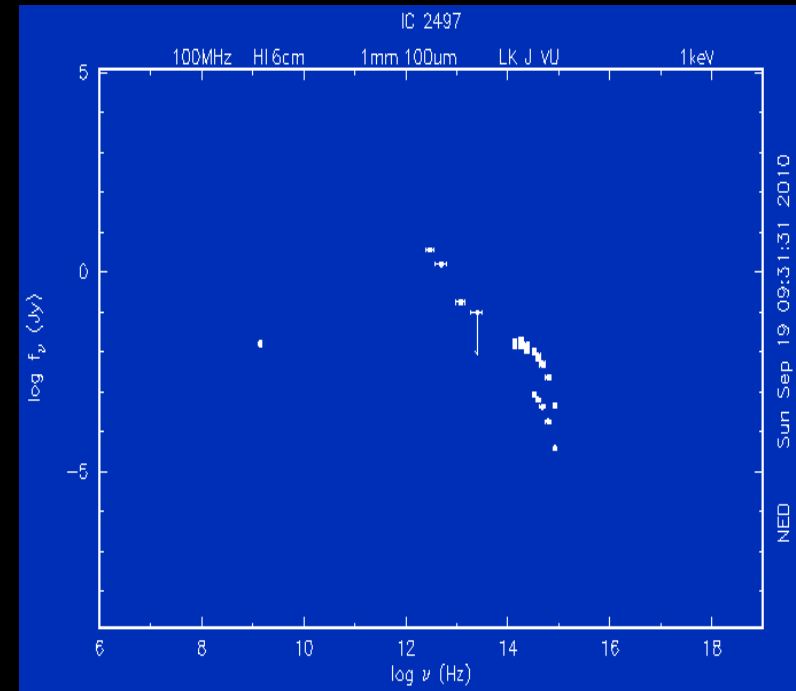
# BUT most of the radio emission == Star formation



IC2497 Spectral index  $\sim -0.55$

IC2497 radio power  $\sim 1 \times 10^{23} \text{ W/Hz}$

VLBI recovers only 10% of WSRT emission

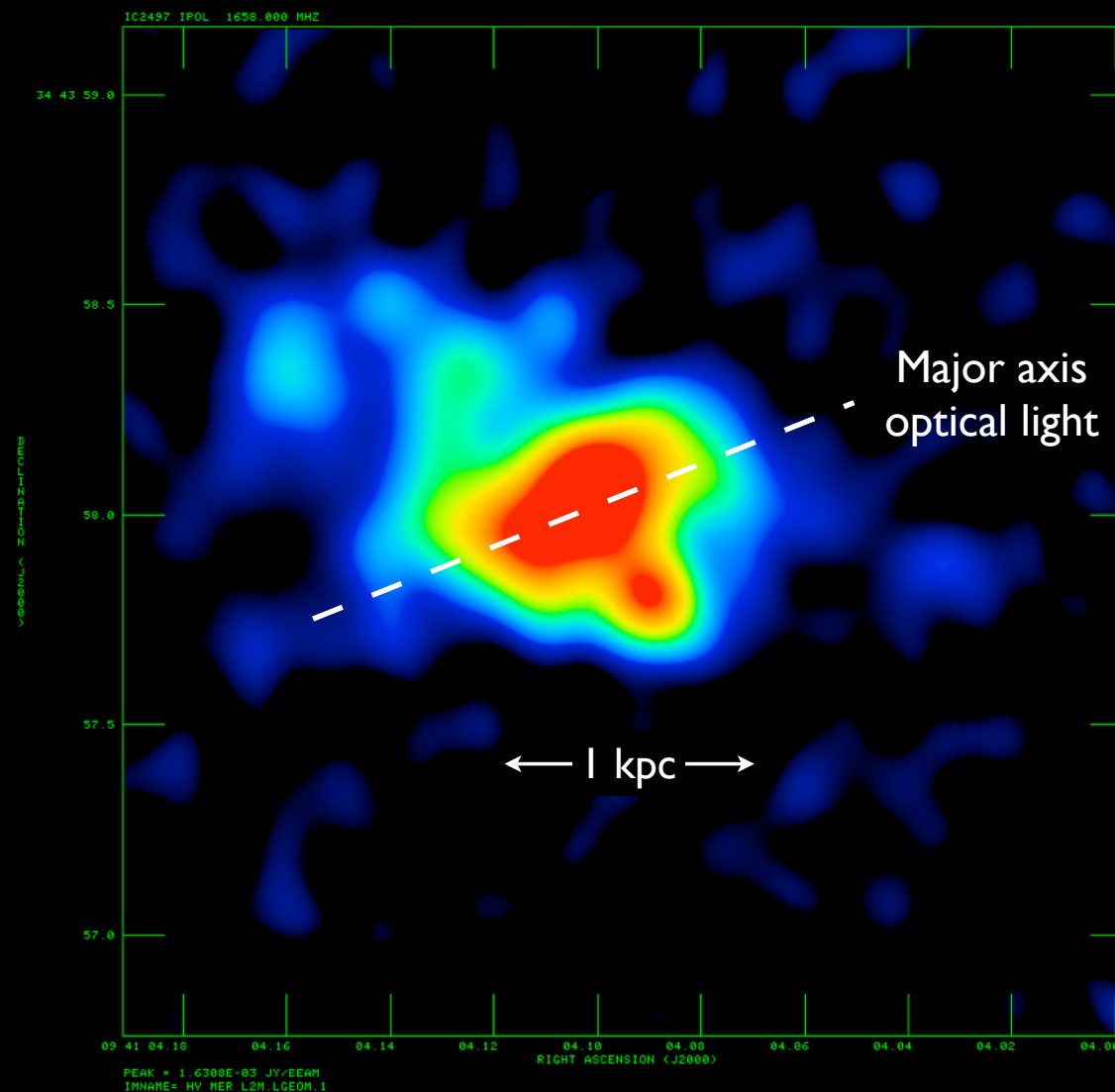


IRAS - 3.6 & 1.6 Jy (100, 60 um resp.)

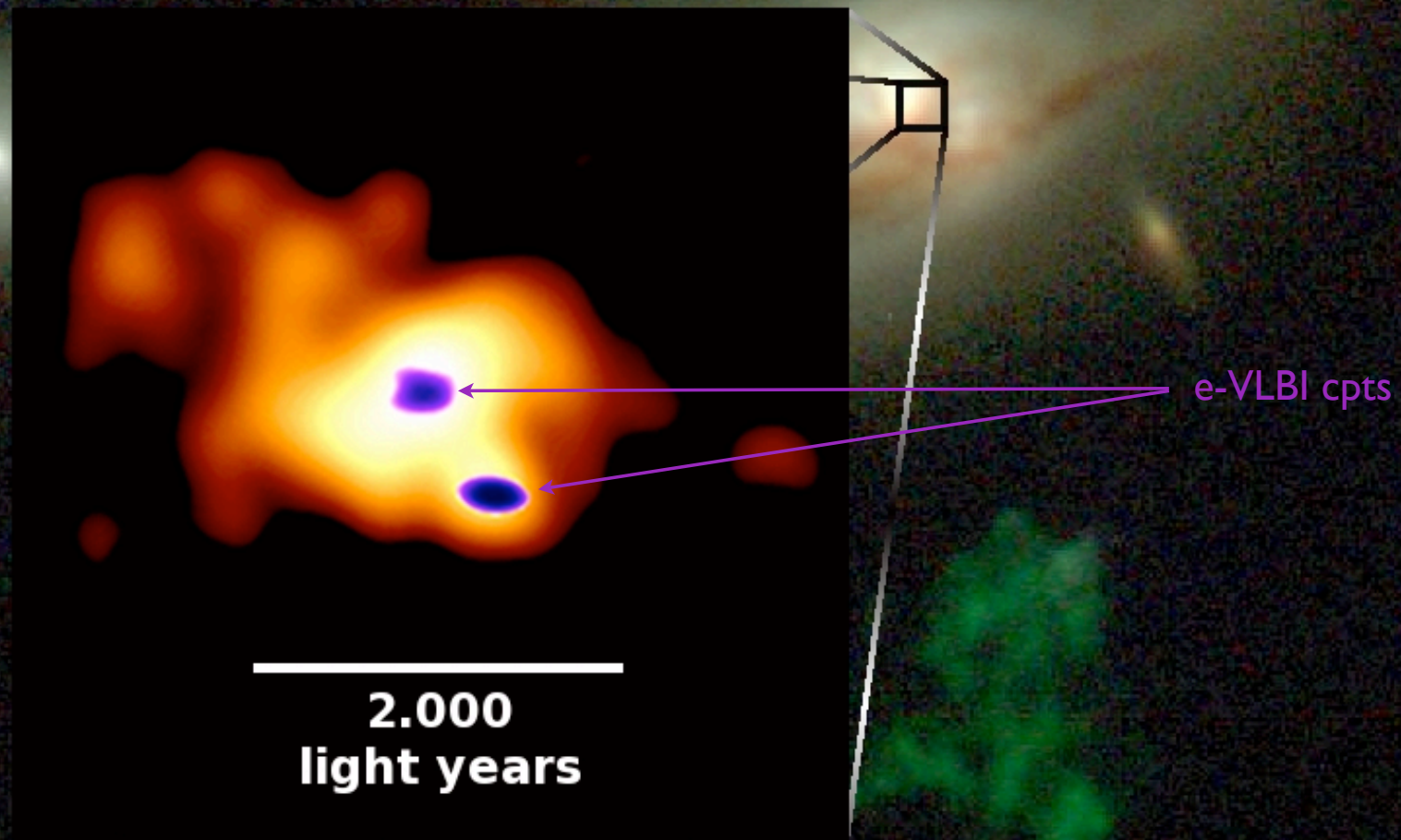
$\Rightarrow q = 2.1$

$\Rightarrow \text{Total SFR} \sim 100 M_{\text{sun}}/\text{yr}$

## *Nuclear Starburst revealed by MERLIN (18 cm)*

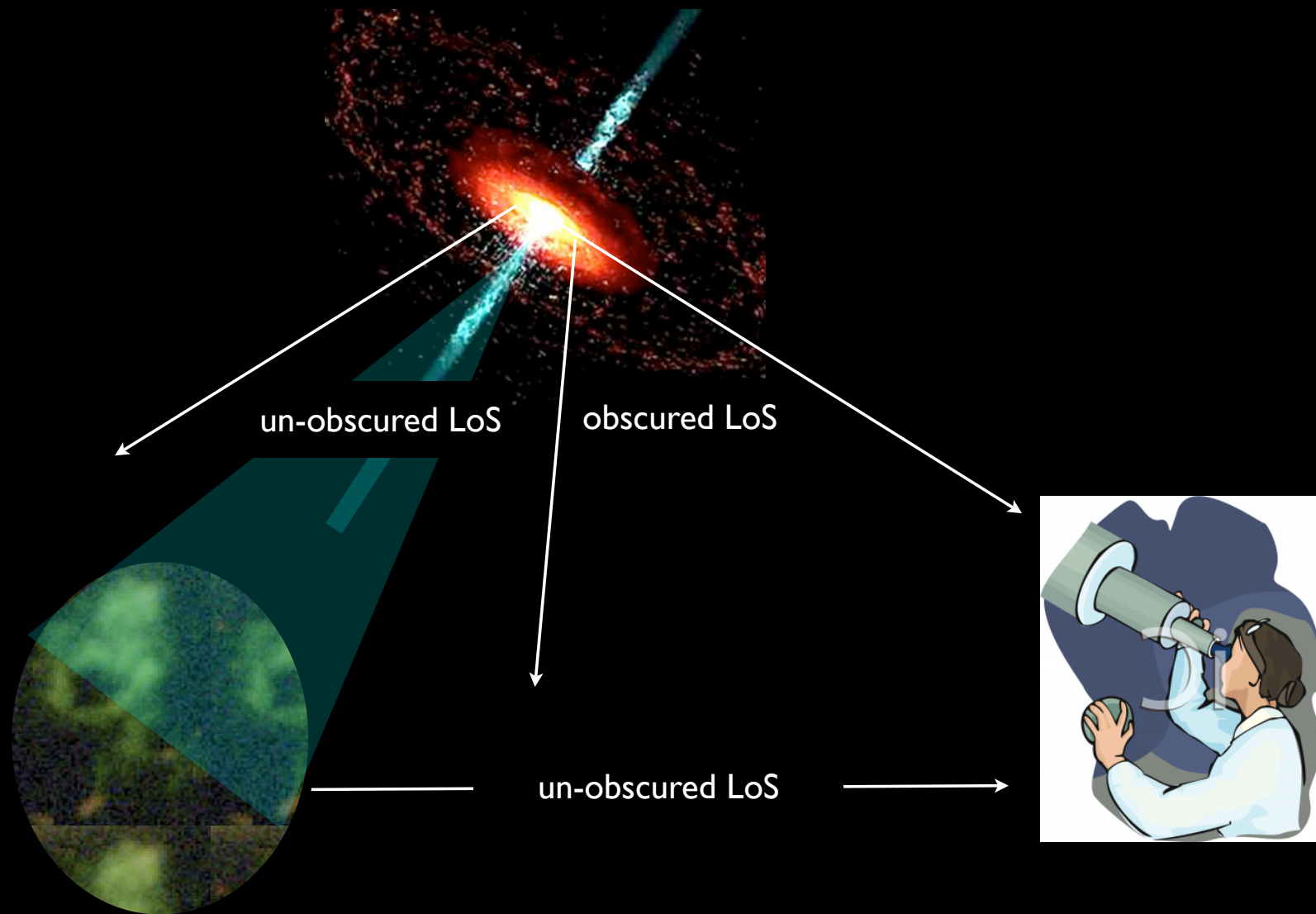


Also revealed in the MERLIN 18 cm image



## So what is our take on all of this?

- Quasar light-echo still seems unlikely.
- More likely (?):
  - IC 2497 is heavily obscured AGN (compton thick?),
  - Voorwerp is part of a massive complex of neutral gas surrounding IC 2497, arising via past galaxy-galaxy interactions,
  - AGN generates a cone of radiation that illuminates part of the gas cloud (the Voorwerp).



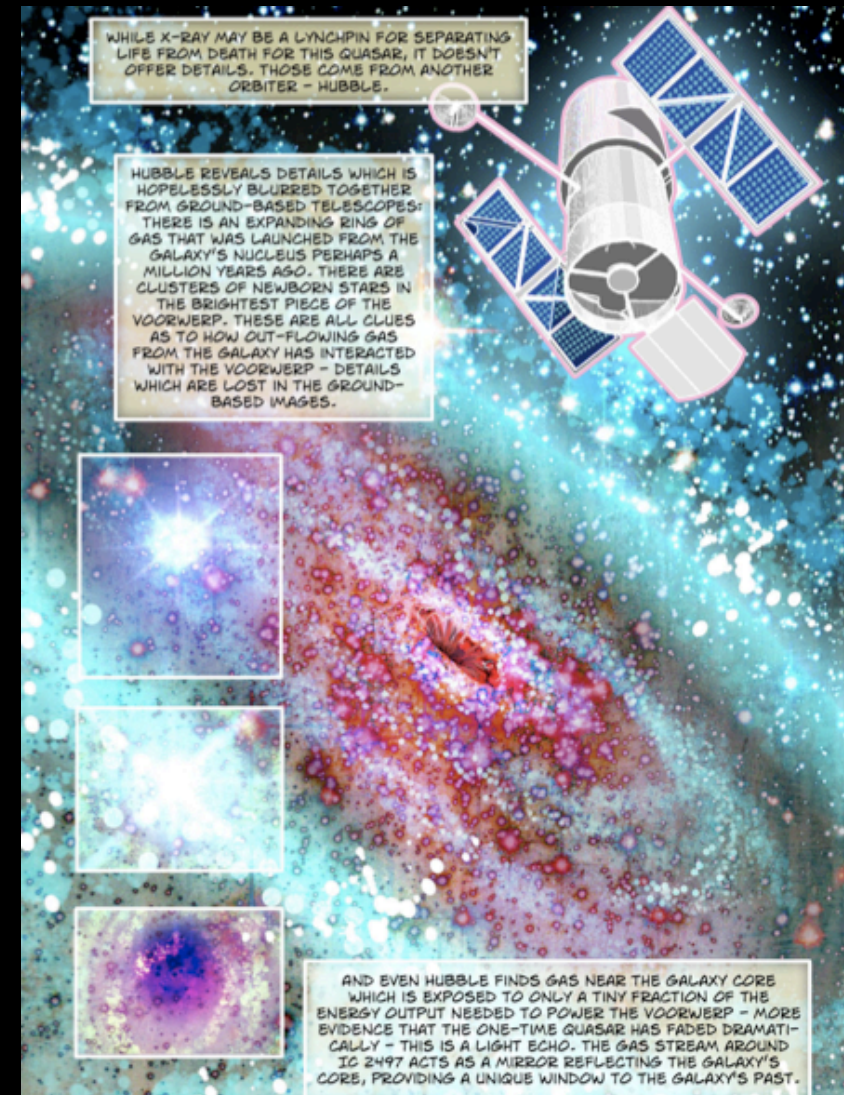
To be continued...

HST observations in April

Data being analysed...

Apparently HST observations  
lend support to Quasar light-  
echo hypothesis.

STAY  
TUNED!



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support to Quasar  
light-echo hypothesis.