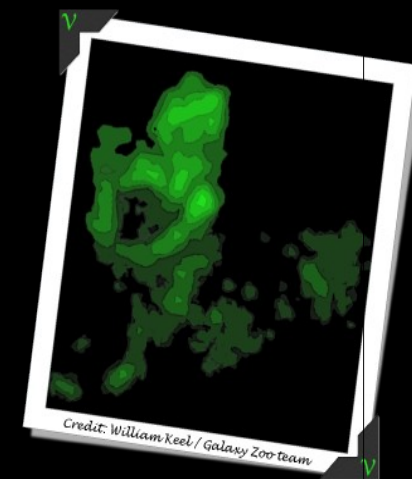




*Hanny's Voorwerp:
Evidence of AGN activity and a nuclear starburst
in the central regions of IC 2497*

Hayden Rampadarath
JBCA, University of Manchester
(JIVE & Leiden)

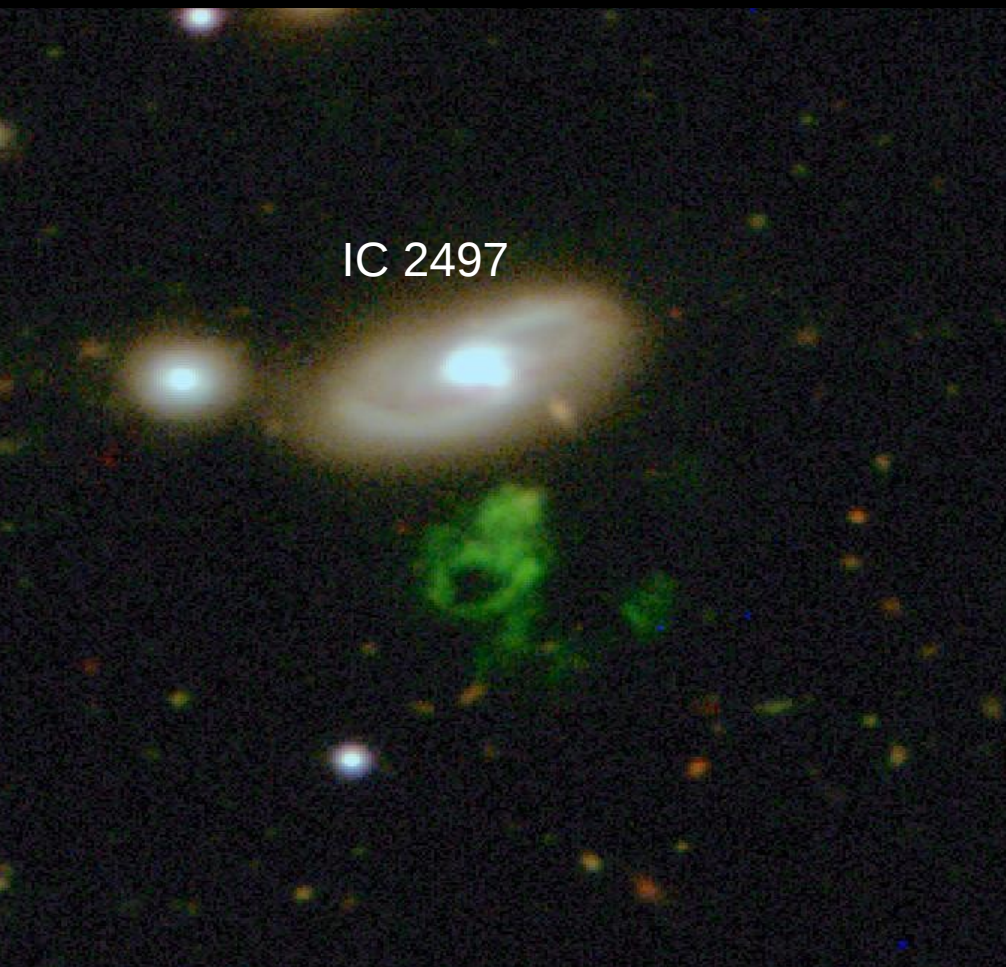


Prof. Michael Garrett (ASTRON/Leiden/Swinburne), Guyla Jozsa (ASTRON), Tom Oosterloo (ASTRON), Tom Muxlow (JBCA), R. Beswick (JBCA) & Zsolt Paragi (JIVE)

Outline

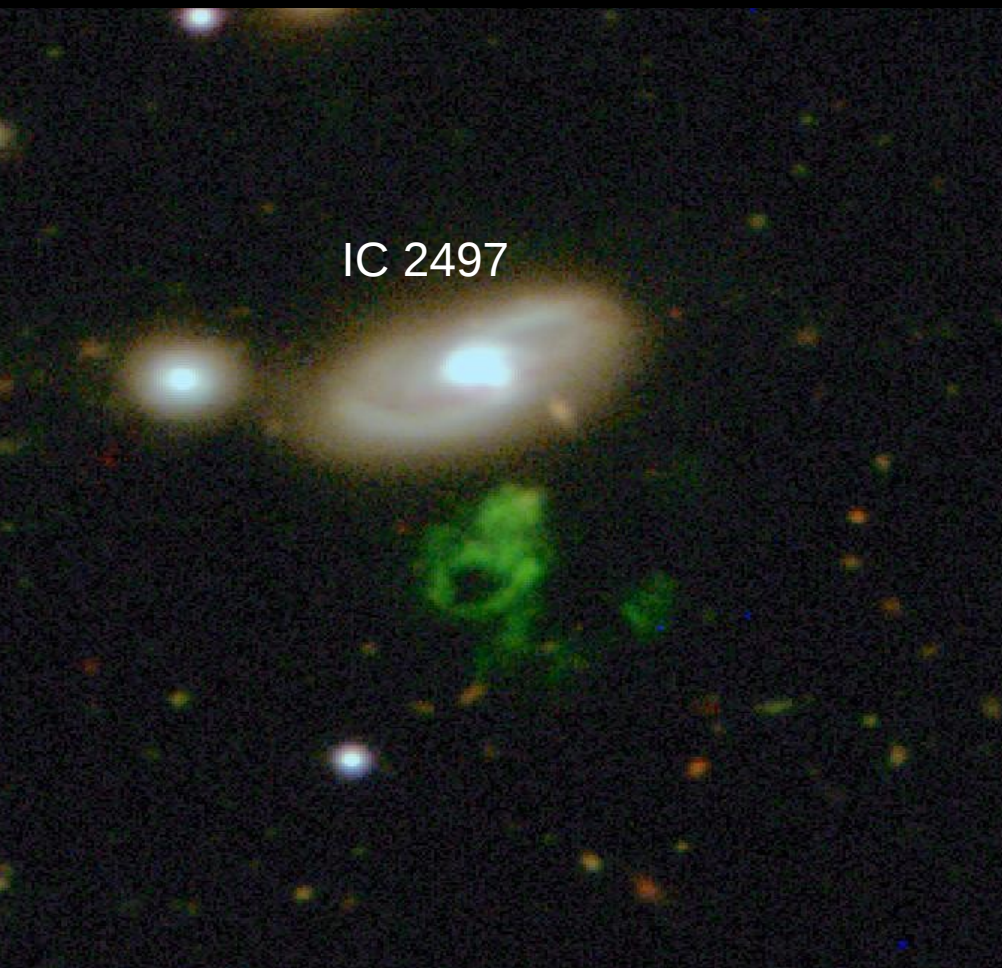
- Introduction
- × Observations
- Results
- Discussion
- Summary

Introduction



WHT gri composite

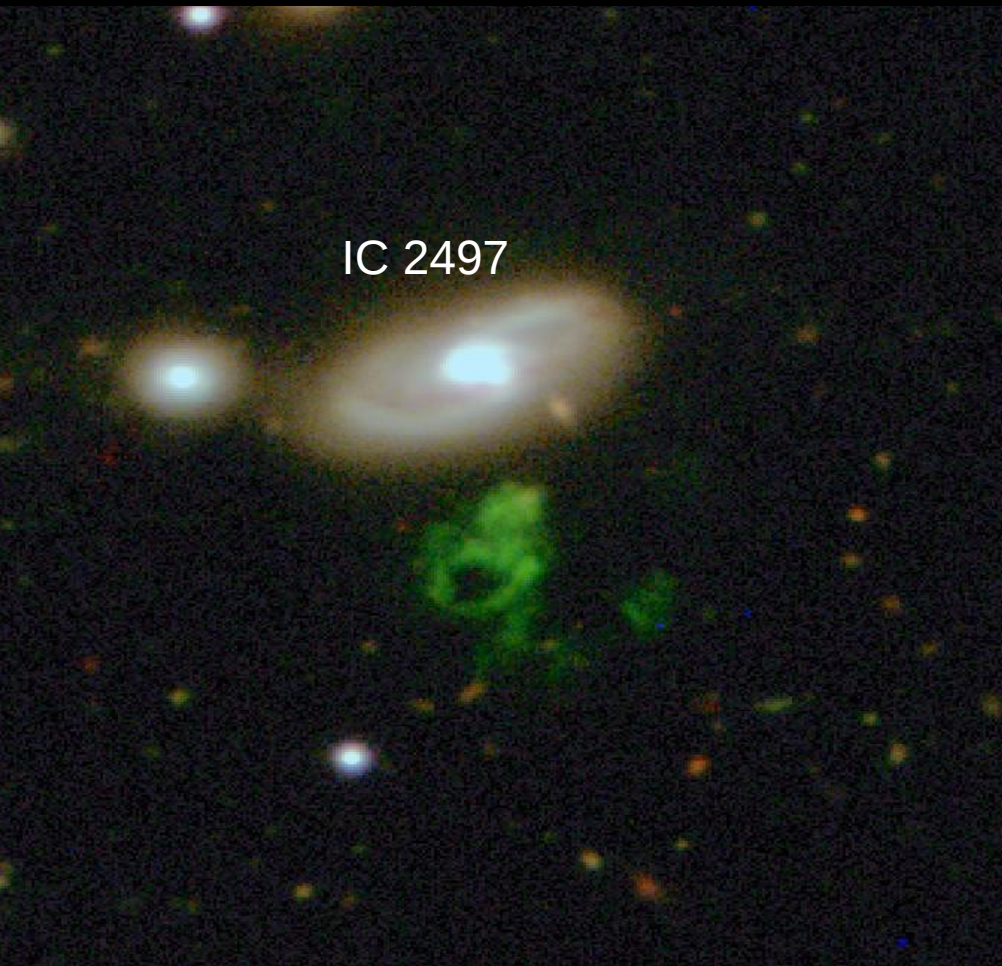
Introduction



- A strange blob of gas 25 kpc from the massive disk galaxy IC2497 ($z=0.050221$)

WHT gri composite

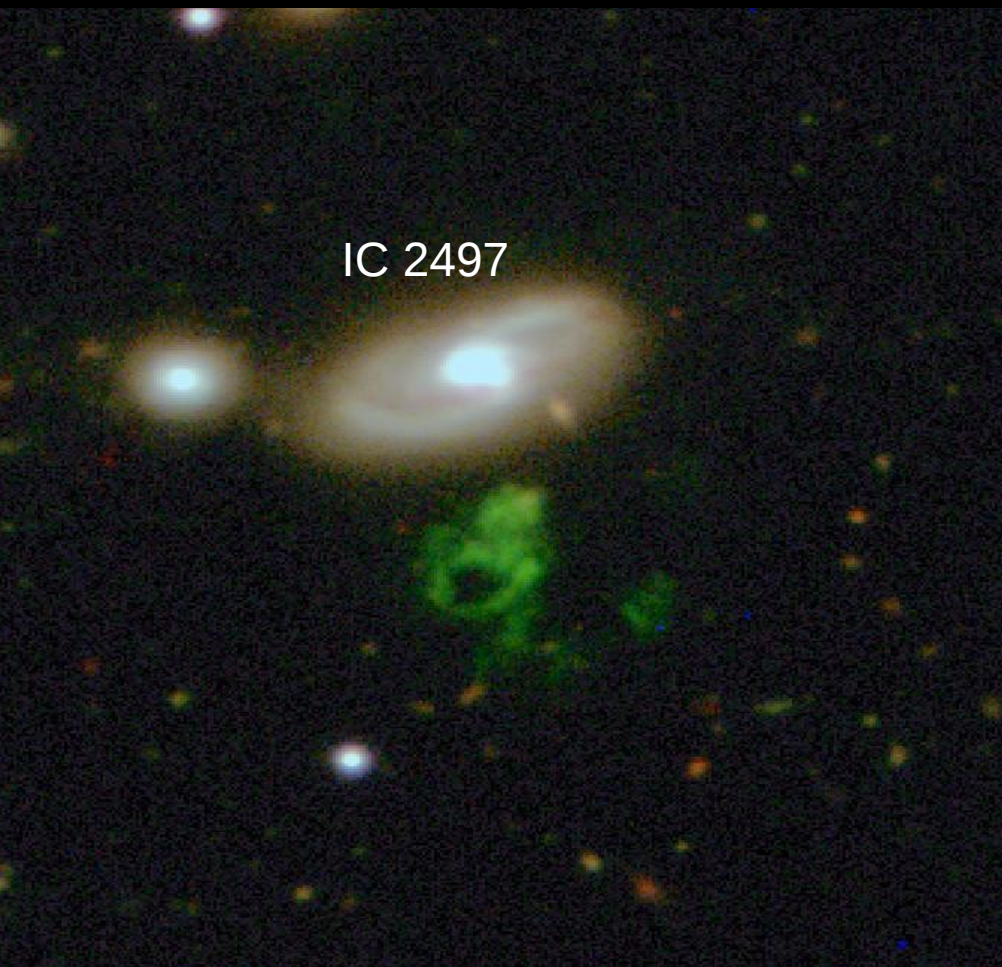
Introduction



WHT gri composite

- A strange blob of gas 25 kpc from the massive disk galaxy IC2497 ($z=0.050221$)
- Discovered by Dutch school teacher Hanny van Arkel in 2007
- Via the galaxyzoo.org morphological census.

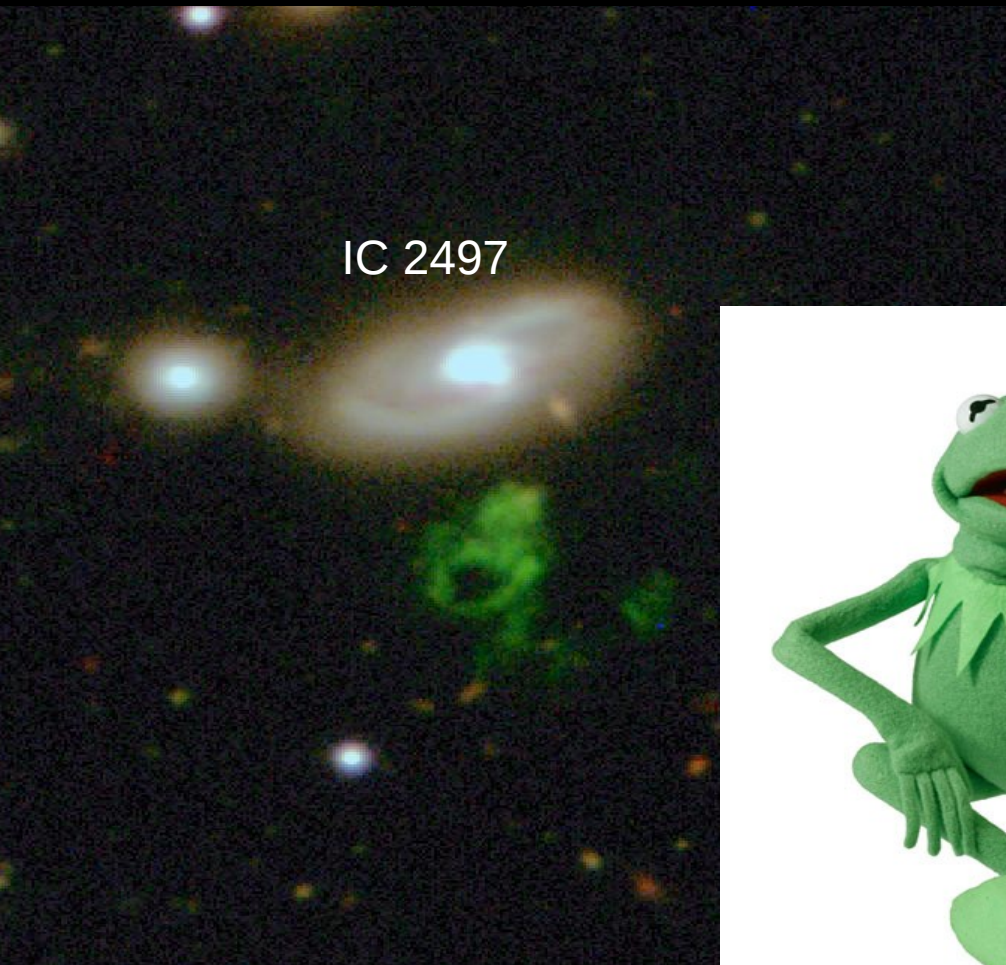
Introduction



WHT gri composite

- A strange blob of gas 25 kpc from the massive disk galaxy IC2497 ($z=0.050221$)
- Discovered by Dutch school teacher Hanny van Arkel in 2007
- Via the galaxyzoo.org morphological census.
- aka. “What the #\$\$%&?”, “The Green Space Frog” and “One Great Green Blob of Science”

Introduction



IC 2497

WHT gri composite

- A strange blob of gas 25 kpc from the massive disk galaxy IC2497 ($z=0.050221$)

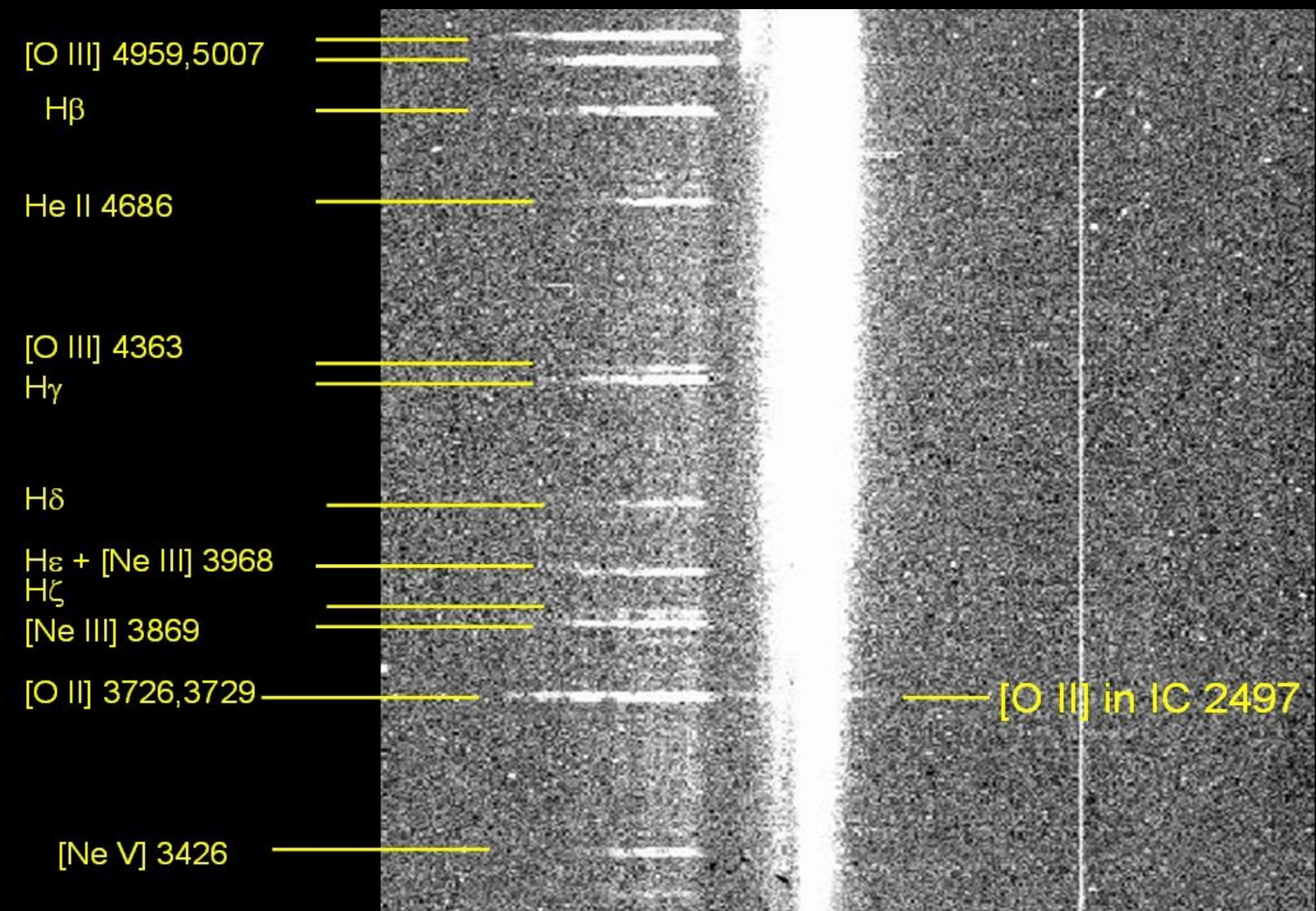


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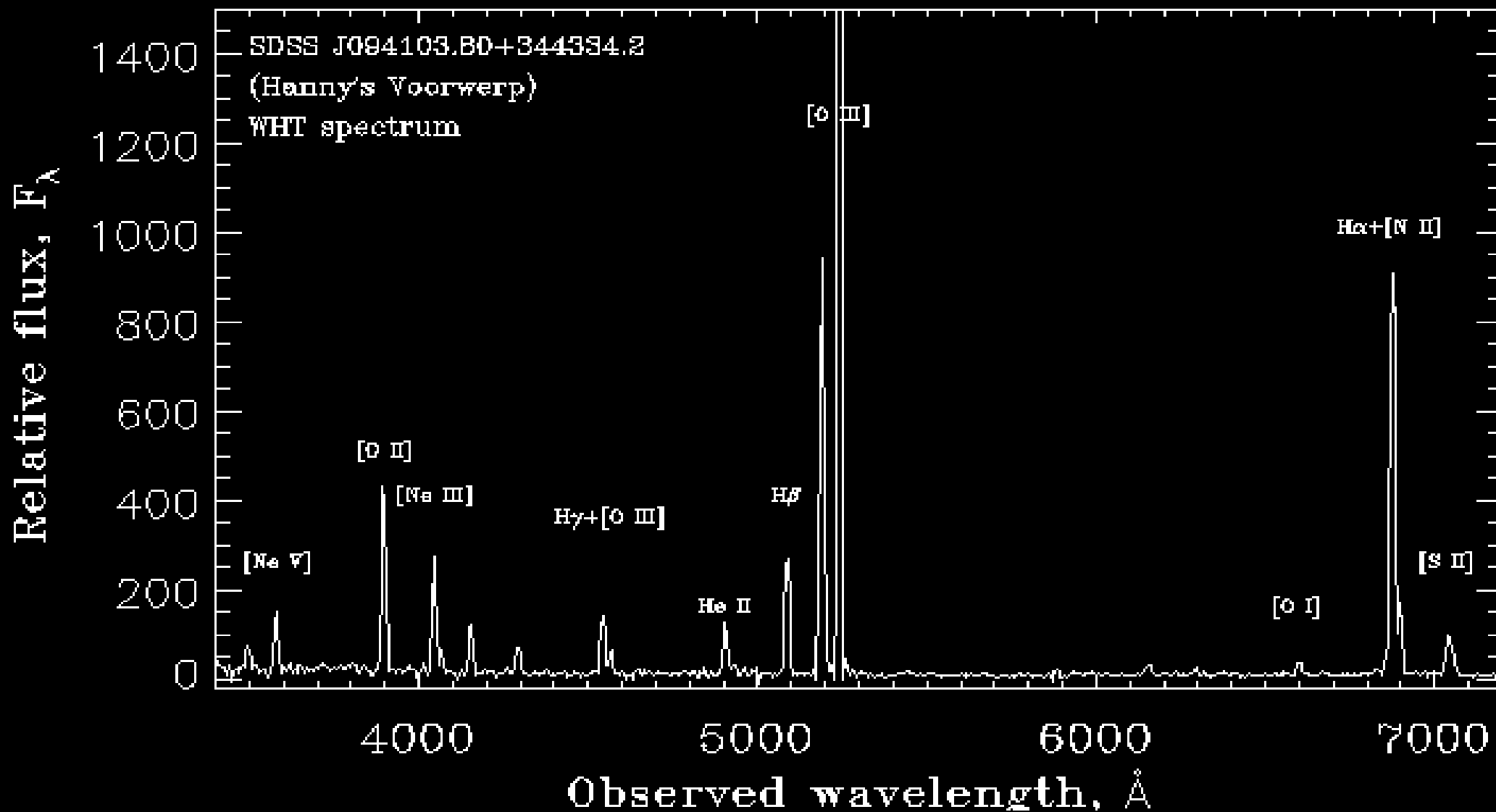
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Introduction



Introduction



Introduction

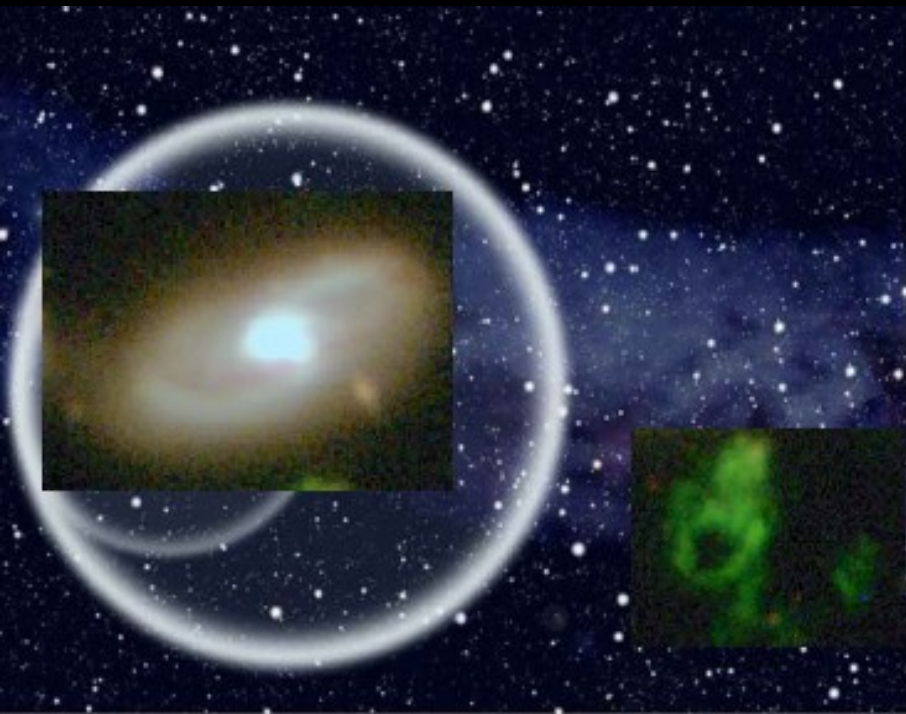
- Highly ionized gas
- kinematics from the optical spectra suggests ionization from photons, rather than ionisation from shocks
- No evidence for ionization source => very low continuum in spectra
- No X-ray emission from IC2497 detected
- In the optical the Voorwerp is blueshifted by 269 ± 20 km/s w.r.t. the galaxy.

So What's Going on?

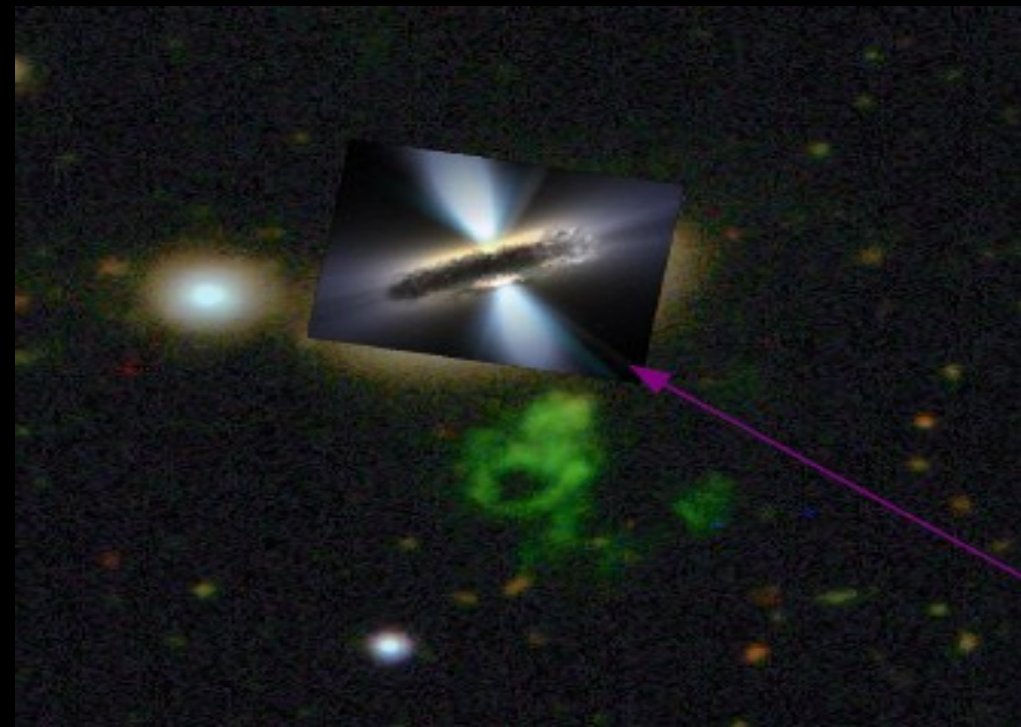
Lintott et al (2009) proposed two possible theories:

1. Voorwerp is a light echo.
Quasar event, that turned
off.

2. AGN at the centre of IC2497,
which illuminates the Voewerp,
but is obscured towards us



YERAC 2010, Spain



Hanny's Voorwerp

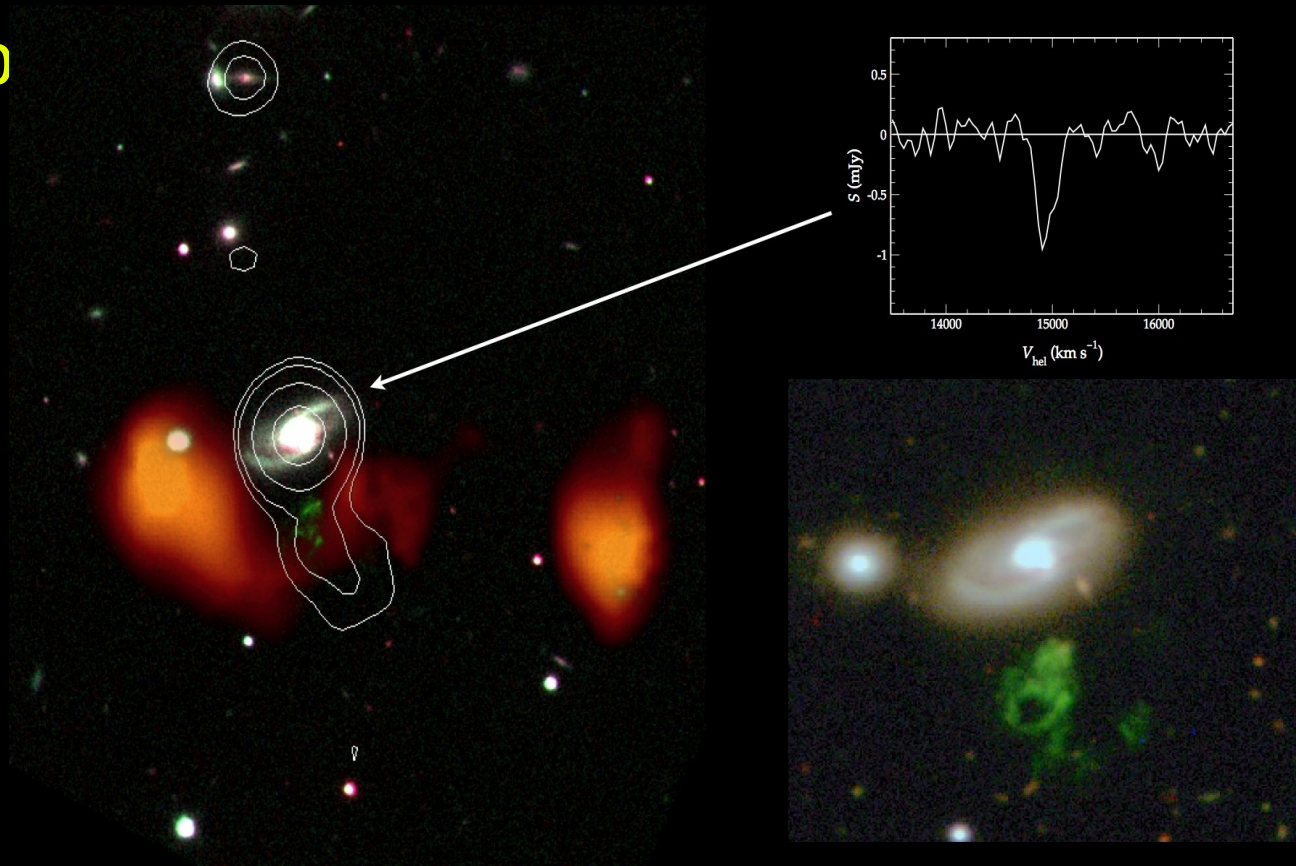
H.R.

First Radio Study

- Jozsa et al (2010) observed IC24 97 and Hanny's Voorwerp
- WSRT Continuum and HI
- Short evlbi (EVN) 18cm continuum

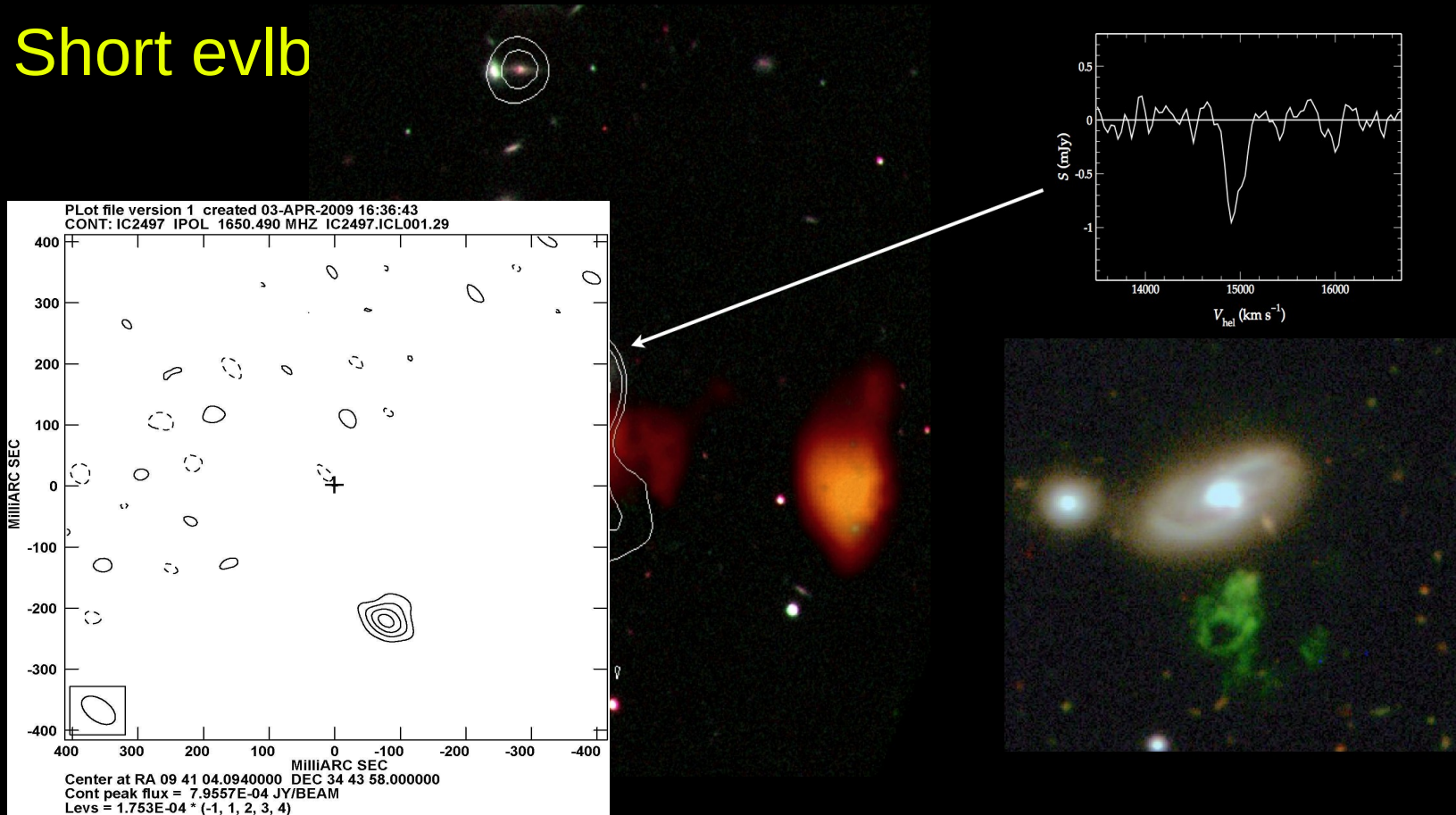
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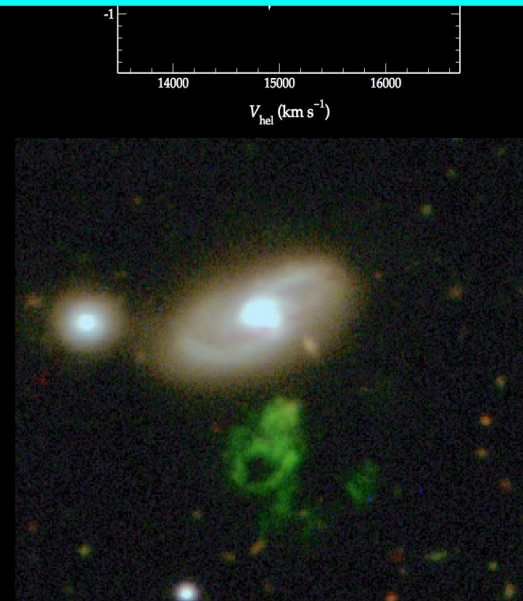
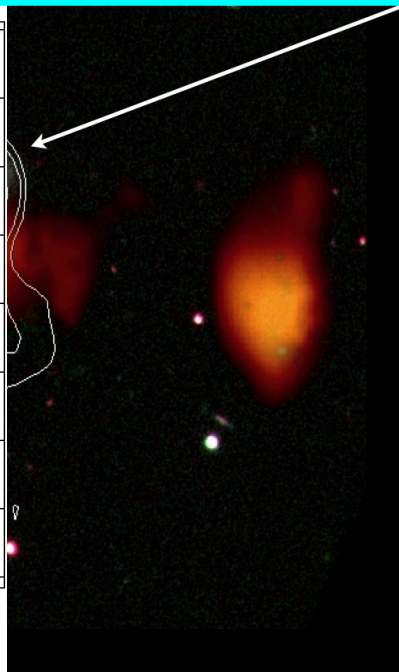
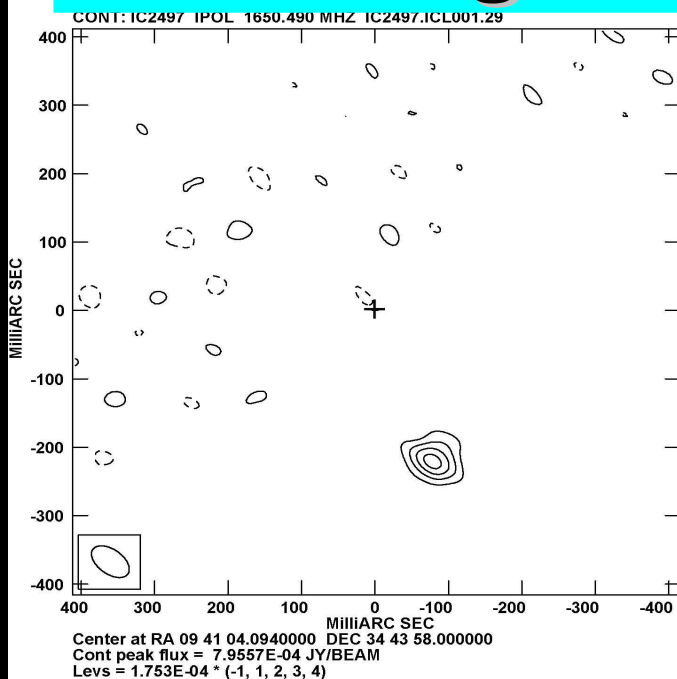
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First Radio Study

➤ Jozsa et al (2010) observed IC24 97 and Hanny's Voorwerp

➤ **V** Supports the AGN hypothesis, but the
➤ **S** energy produced by the Jet and the AGN
isn't enough



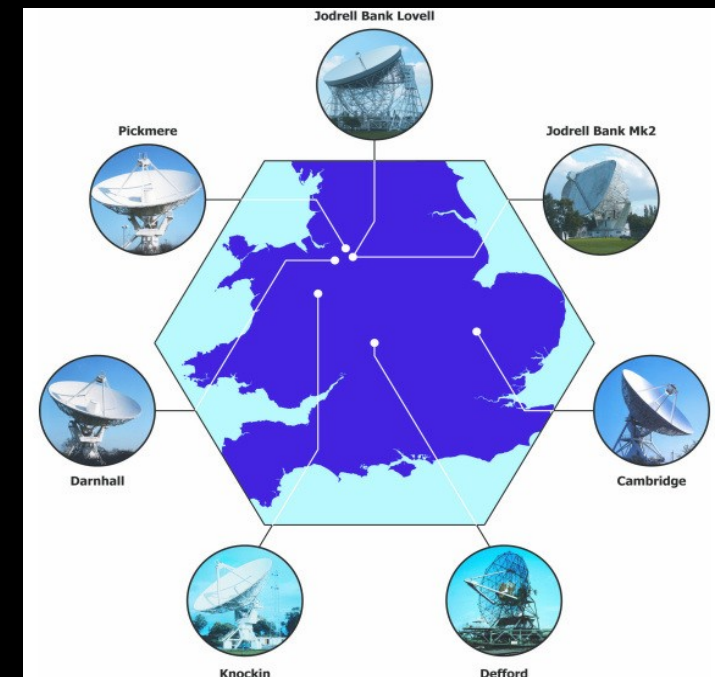
Observations

➤ Follow up observations:

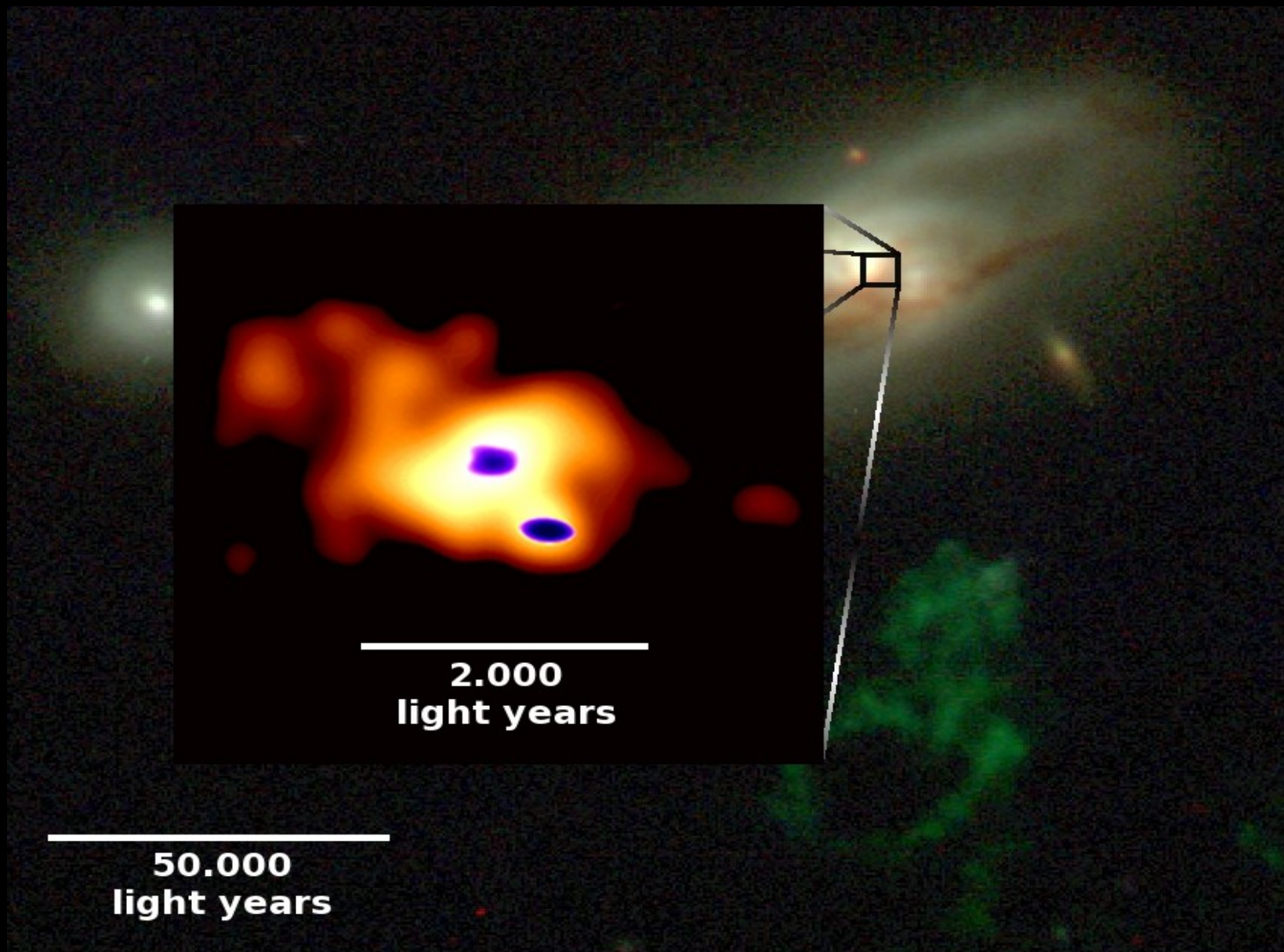
MERLIN 18 cm 1 x 17 hrs & 1 x 14 hrs (February 2009)

MERLIN 6 cm 2 x 18.s hrs (March 2009)

10.5 hr e-VLBI 18 cm (May 2009) - Ef, Mc, On, Tr, Wb, Cm, Jb, Da, De, Kn, & Ta



Results



Results

- Found 2 compact radio sources (C1, C2) separated by 300 mas
- Both sources were seen at 18 cm, but only C2 was seen at 6cm
- $T_b > 10^5$ – suggesting AGN activity
- $\alpha_{\text{(C2)}} = 0.12 \pm 0.01$ – Flat spectrum core
- $\alpha_{\text{(C1)}} = -1.38 \pm 0.10$ – hotspot in the large-scale jet
- FIR-Radio correlation, q-value = 2.2 ± 0.04
- Massive star formation rate ($M > 5M$) $\sim 12.4 M_{\text{solar}}/\text{yr}$
- or $\text{SFR}(M > 0.1 M) \sim 68 M_{\text{solar}}/\text{yr}$

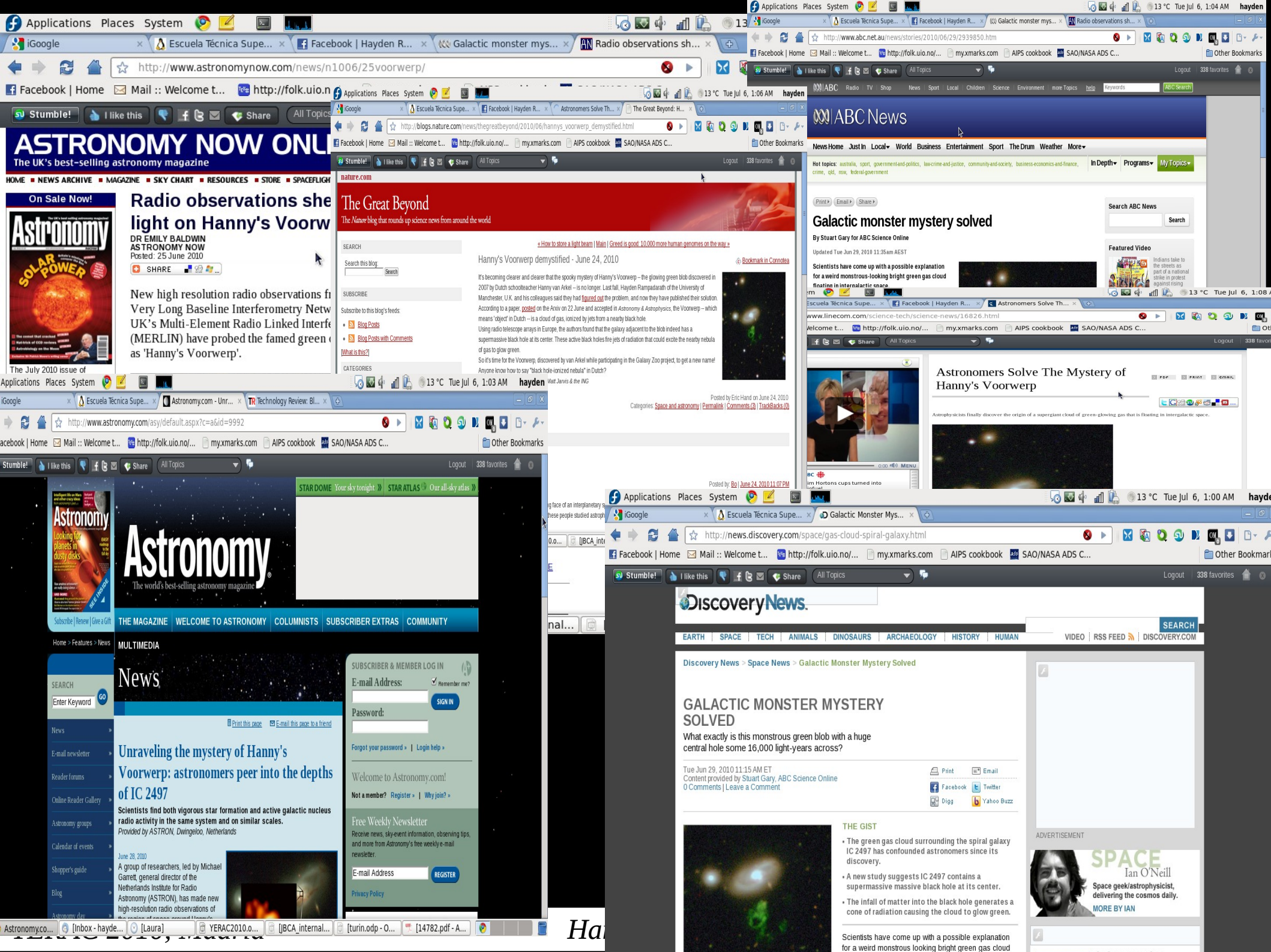
Discussion

- the total 18 cm radio emission from the galaxy is dominated neither by the compact sources nor large-scale emission, but extended emission confined within a sub-kpc central region
- IC 2497 is a typical luminous infrared galaxy
- Hanny's Voorwerp" results from ionization of gas of the surrounding HI that happens to be within the radiation cone of the AGN
- Provides conclusive evidence of the AGN Hypothesis

Discussion

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*Accepted as a letter for publication in A&A on 17th June
Posted on astro-ph on the 20th*



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Radio observations shed light on Hanny's Voorwerp

DR EMILY BALDWIN
ASTRONOMY NOW
Posted: 25 June 2010

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New high resolution radio observations from Very Long Baseline Interferometry Network UK's Multi-Element Radio Linked Interferometry (MERLIN) have probed the faint green glow as 'Hanny's Voorwerp'.

The July 2010 issue of

The Great Beyond
The Nature blog that rounds up science news from around the world

Hanny's Voorwerp demystified - June 24, 2010

It's becoming clearer and clearer that the spooky mystery of Hanny's Voorwerp – the glowing green blob discovered in 2007 by Dutch schoolteacher Hanny van Arkel – is no longer. Last fall, Hayden Rampadarath of the University of Manchester, UK, and his colleagues said they had figured out the problem, and now they have published their solution. According to a paper posted on the Arxiv on 22 June and accepted in *Astronomy & Astrophysics*, the Voorwerp – which means 'object' in Dutch – is a cloud of gas, ionized by jets from a nearby black hole.

Using radio telescope arrays in Europe, the authors found that the galaxy adjacent to the blob indeed has a supermassive black hole at its center. These active black holes fire jets of radiation that could excite the nearby nebula of gas to glow green.

So it's time for the Voorwerp, discovered by van Arkel while participating in the Galaxy Zoo project, to get a new name! Anyone know how to say "black hole-ionized nebula" in Dutch?

Posted by Eric Hand on June 24, 2010
Categories: Space and astronomy | Permalink | Comments (0) | TrackBacks (0)

ABC News

Galactic monster mystery solved

By Stuart Gary for ABC Science Online
Updated Tue Jun 29, 2010 11:35am AEST

Scientists have come up with a possible explanation for a weird monstrous-looking bright green gas cloud floating in intergalactic space.

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Astronomers Solve The Mystery of Hanny's Voorwerp

Astronomers finally discover the origin of a superplant cloud of green-glowing gas that is floating in intergalactic space.

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http://www.astronomy.com/asy/default.aspx?c=a&id=9992

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Discovery News

Galactic Monster Mystery Solved

What exactly is this monstrous green blob with a huge central hole some 16,000 light-years across?

Tue Jun 29, 2010 11:15 AM ET
Content provided by Stuart Gary, ABC Science Online
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THE GIST

- The green gas cloud surrounding the spiral galaxy IC 2497 has confounded astronomers since its discovery.
- A new study suggests IC 2497 contains a supermassive massive black hole at its center.
- The infall of matter into the black hole generates a cone of radiation causing the cloud to glow green.

Scientists have come up with a possible explanation for a weird monstrous looking bright green gas cloud

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News

Unraveling the mystery of Hanny's Voorwerp: astronomers peer into the depths of IC 2497

Scientists find both vigorous star formation and active galactic nucleus radio activity in the same system and on similar scales.
Provided by ASTRON, Dwingelo, Netherlands

June 28, 2010
A group of researchers, led by Michael Garrett, general director of the Netherlands Institute for Radio Astronomy (ASTRON), has made new high-resolution radio observations of the region of space around Hanny's Voorwerp.

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Discovery News

Galactic Monster Mystery Solved

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Future

- An X-ray paper has just been submitted
- Observations with HST (coming out soon)
- Lofar Observations
- eMERLIN proposal
- better WSRT obs
- STSci is preparing a webcomic
- M. Garret talk at the EVN

The screenshot shows a web browser window with the URL <http://hannysvoorwerp.zooniverse.org/>. The browser's address bar and tabs are visible at the top. The website header includes the title "Hanny & the Mystery of the Voorwerp" and navigation links: HOME, OUR PROJECT, THE STORY SO FAR..., THINGS TO KNOW, and GUIDELINES. Below the header, there is a section titled "A COMMUNITY WRITTEN GRAPHIC NOVEL" with a description: "We're seeking writers to help us tell the story of Hanny van Arkel's discovery of the Voorwerp. Interested? Join us at CONvergence, July 1-4, 2010, in Bloomington, MN for 3 days of writing and science." Two buttons are present: "I WANT TO WRITE!" and "I HAVE SOME QUESTIONS". To the right, a large image shows a green nebula-like structure, credited to "William Keel / Galaxy Zoo team". Below this, there are four smaller thumbnail images. A "Recent News" section is partially visible, and a green banner at the bottom right says "Seeking Illustrator - FOUND". The browser's taskbar at the bottom shows several open windows, including "Hanny & the ...", "Inbox - hayde...", "[Laura]", "YERAC2010.o...", "[JBCA_internal...", "[turin.odp - O...", and "[14782.pdf - A...".

Summary

- IC 2497 is an "active" galaxy in the broadest possible sense - it exhibits evidence of both a highly obscured AGN and nuclear star-forming activity
- Many AGN with weak radio sources exist but the presence of a large surrounding gas reservoir is most likely only present in interacting systems (such as LIRGs).
- Surrounding gas results from interactions with nearby galaxies (Jozsa et al 2009)
- Given that galaxy interactions are relatively uncommon in the nearby universe, phenomena such as Hanny's Voorwerp while appearing extremely dramatic are expected to be quite rare.