IC883 and PGC043234: the stories of steady and intermittent accretion onto a SMBH

In collaboration with:

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enhance SF and AGN activity

transform the morphology of the interacting galaxies

Taken from Antonis Georgakakis' page:
http://www.mpe.mpg.de/~age/mergers.html
Classification of IR selected galaxies:

- IR luminosity
- Merger stage

(Yuan+10)

What is expected:

- SFR increases *in the central regions* of interacting galaxies (e.g., Sanders+88)
- AGN is also triggered, but obscured (Satyapal+14)
- SF decays due to SN feedback and gas exhaustion in about 200 Myr, when the accretion onto a BH is more efficient (Wild+09)
Accretion onto a SMBH ($10^6 - 10^{9.5}\, M_\odot$)

Artist impression of a SMBH at the centre of a galaxy (ALMA observatory)

Accretion rate

High

Low
Accretion onto a SMBH ($10^6 - 10^{9.5} M_\odot$)

Accretion rate

- High
- Low

Tidal Disruption Events (TDEs) – Tracing dormant or actively accreting SMBHs?

Preference for post-starburst hosts (Arcavi+14; French+16)

Artist impression of a SMBH at the centre of a galaxy (ALMA observatory)

Komossa+15
A target from the Luminous InfraRed Galaxy Inventory (LIRGI) – an e-MERLIN legacy programme (PIs: Conway & Pérez-Torres)

Advanced stage merger (starburst-AGN composite, Yuan+10)

- $D \sim 100$ Mpc $\Rightarrow$ 1 mas $\sim$ 0.5 pc
- $L_{\text{IR}} \sim 4.7 \times 10^{11} L_\odot$
- $\nu_{\text{CCSN}} \approx 1.3\ yr^{-1}$

The starburst dominate the energetics of the system, but there should be an AGN therein: [Ne V] line.
Two SNe within a year – Radio follow-up with e-MERLIN

SNe 10cu & 11hi not detected...

~ 1 kpc radio structure at 140° resembles that of the warped ring of molecular gas (Downes+Solomon98)

Each radio component has a CO (2-1) clump counterpart

B2a has the highest concentration of molecular mass ($4 \times 10^8 \, M_\odot$) but A is the dynamical centre of the ring.

Romero-Cañizales +12

(the first publication based on e-MERLIN data)
e-MERLIN + e-EVN observations

AGN & SB together?

Right Ascension (J2000)

Declination (J2000)

(e-MERLIN)

(e-EVN)

Peak Intensity = 4.89 mJy/beam
Cont. lev. = 44 x (-3,3,5,9,15,27,45) microJy/beam

Peak Intensity = 3.82 mJy/beam
Cont. lev. = 66 x (-3,3,5,9,15,27,45) microJy/beam

$\theta = 165 \times 88$ mas, $PA = -11.6$

$\theta = 9.2 \times 6.4$ mas, $PA = -76.1$

243 pc

24 pc
New ejected component at 8.4 GHz: not present in VLBA observations from 15.05.2011 at the same frequency (although at slightly lower resolution).

- The jet-like component was probably ejected sometime between May 2011 and November 2012 ⇒ it has moved at an apparent speed of $0.6 \, c < v < 1 \, c$.
- The jet dies out fast? No signs of it at $\theta > 2$ ...

Romero-Cañizales, Alberdi, Ricci +16 (submitted to MNRAS)
Increase in flux $\Rightarrow$ new jet at all frequencies
IC883: recurrent activity?

$S_v$ (mJy)

(θ=7x6 mas)

Time (days)

Flux density

Time

2011  2012  2013  2014

Flux density

2011  2012  2013  2014  ...  ...
The core ($L_{8.4\text{GHz}} > 1 \times 10^{28} \text{ erg s}^{-1} \text{ Hz}^{-1}$) has a flat spectrum between 5 and 8.4 GHz (and even up to 32.5 GHz), but it is highly absorbed at 1.7 GHz.

- A Gigahertz Peaked Spectrum source candidate? (the least luminous one!)
IC883 – what radio emission tells us

\[ R = 7.3 \text{ pc} \]

\[ L_R = 1.3 \times 10^{39} \text{ erg s}^{-1} \]

\[ B_{\text{eq}} = 2.5 \text{ mG} \]

\[ \tau_{\text{syn}} \approx 3 \times 10^3 \text{ yr} \]

1 – 10 mG for other GPS sources (Tyul'Bashev 2001), but an order of magnitude larger than for other LIRGs in an advanced merger (Drzazga+11)

Other young sources have been previously reported (Tingay+03) with luminosities below the average for GPS sources

GPS source in an active star-forming galaxy? (Norris+12)
Host of ASASSN-14li: one of the few TDEs displaying both thermal (X-rays, optical, UV) and non-thermal radio emission.
Post-starburst galaxy unveiled as a merger remnant with a low-luminosity Type II AGN prior to ASASSN-14li. Star-formation is negligible.

VLT MUSE (1' x 1') obtained as part of the AMUSING project (PI: J. Anderson, T. Kruehler, L. Galbany)

Prieto+16 (submitted to ApJL) arXiv:1609.00013
ASASSN-14li at low-resolution radio observations

- Radio emission: steady source ($S_\nu \approx S_0 (\nu/1.4\text{GHz})^{-1}$) and a non-relativistic outflow.

- Old radiative age? ($\sim 10^7$ yr; Murgia+11)
1) If c2 was ejected on August 11-25 2014 → $v_{\text{app}} \sim 7.3c - 7.7c$

* The first TDE jet directly imaged? *

2) If $v_{\text{app}} \sim 0.04c - 0.12c$ → c2 was ejected 50 to 150 years ago

3) Dual BH system ($M_{\text{BH}} \sim 10^6 - 10^7 M_\odot$ → $R \sim 10^{18} - 10^{19}$ cm)
Take away points:

The EVN has allowed us to:

✔ Find unequivocal evidence of the AGN activity in IC883, potentially representing the least luminous ($L_{5\text{GHz}} \sim 6 \times 10^{28} \text{ erg s}^{-1} \text{ Hz}^{-1}$) and one of the youngest ($\sim 3 \times 10^3 \text{ yr}$) gigahertz-peaked spectrum sources.

✔ Resolve the radio emission of ASASSN-14li and its host. The nature of the components is not clear, though. But stay tuned to see the results of our upcoming observations!

Thanks for your attention!