A JVN observation of double-peaked AGN 3C332

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Abstract

- We have been surveying to reveal major process of co-evolution of galaxies and SMBHs with JVN - merger process or not?

- 3C332 is one of our targets of this survey

- We detect at least single radio core of 3C332 at 8 GHz and estimate SMBH mass.
Introduction

Coevolution of Galaxies and SMBH

Maggorian relation and

Coevolution?

What is causing process of this coevolution?

Kormendy&Ho 2013
Process of Coevolution — merger

ΛCDM model suggests hierarchical processes

One of the major processes is merger and this process indicates coevolution between host galaxy and SMBH. (Kormendy&Ho 2013)

http://spaceinfo.jaxa.jp/ja/collision_of_galaxy.html
Introduction

Survey — for revealing frequency of merger

How do we assess the contribution of merger to coevolution of host galaxy and SMBH?

Counting the number of SMBHs from high-z to low-z

- High-resolution
- High-sensitivity
- Many targets

High-sensitivity VLBI observation.

Our group have been surveying observation to reveal signatures of merger by Japanese VLBI Network
Observation

**Japanese VLBI Network (JVN)**

Array performance
Baseline : 54 km ~ 2564 km
Sensitivity : 4 mJy ~ 94 mJy (@8 GHz)

http://www.astro.sci.yamaguchi-u.ac.jp/jvn/

Our observation

Array :
- Usuda(臼田) station
- Tsukuba(筑波) station
- Hitachi(日立) station
- Yamaguchi(山口) station

Sensitivity (8GHz) :
- $7\sigma$ ~ 3.6 mJy

Resolution(Baseline) :
- 10 mas(800 km)
Target

Radio Galaxy 3C332 ($z \sim 0.15$)

Properties:

- Pair of radio lobes (Miller 1985)
  - pair of radio lobes in 1.4 GHz with VLA.

- Double peaked AGN (Cao & Wang 2006)
  - bipolar outflow
  - accretion disk
  - symmetric BLR
  - a binary BLR in a binary SMBH system

Miller 1985

No detection with VLBI
No detection with VLBI

Properties:
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Miller 1985
Result

Image of 3C332

- Flux: \(\sim 30\) mJy@8 GHz
Origin of detected component in 3C332

- Brightness Temperature:
  \[ T_B \approx 2 \times 10^9 \text{ K} \]

- linear scale of beam size: \(-22 \text{ pc}\)
  \[ T_B > 10^5 \text{ K} \] (typical value of SN)

\(40 \text{ mas} = 88 \text{ pc}\)

The origin of component is
- AGN
- SNR or SNe
Discussion

**SMBH mass of 3C332 radio core**

Estimate SMBH mass (assumed single core)

← Fundamental Plane (Merloni et al. 2003, Falcke et al. 2004)

Paragi et al. 2014
Discussion

**SMBH mass of 3C332 radio core**

Estimate SMBH mass (assumed single core)

→ Fundamental Plane (Merloni et al. 2003, Falcke et al. 2004)

- $\log L_{5\text{GHz}} = 6.0 \times 10^{33}$ W
  (assumed $\alpha = 0.3$ (Slee et al. 1994))
- $L(2-10\text{keV}) = 1.6 \times 10^{36}$ W
  (Sambruna et al. 1999)

SMBH mass of 3C332: $4.0 \times 10^7 \text{ M} \odot$
Discussion

How many nuclei?

- Approaching within 22 pc
- Already merged
- One source is radio quiet

- Dual AGN only detected by Rodriguez et al. 2006: 
  ~ 7 pc (~7 mas)
Discussion

How many nu...

- Approaching

Typical value or not?

7 mas

Rodriguez et al.2006
How many nuclei?

But our observation is first detection for 3C332

Maybe many VLBI sources in hiding

- Dual AGN only detected by Rodriguez et al. 2006:
  ~ 7 pc (~7 mas)

We only say “detect radio core in 10 mas resolution”
Conclusion

• We detect radio core of double peaked AGN 3C332.

• Estimate SMBH mass of 3C332 from Fundamental Plane
  \[ M_{\text{BH}} \sim 4.0 \times 10^7 \, M_{\odot} \]

• Detected **single core**
  \[ \rightarrow \text{Three possibilities:} \]
  - Already quenched in radio
  - Already merged
  - One source is quenched
Future work

3C93 — nearby double peaked AGN
3C8 and PKS0139-273 — high-z radio galaxies and much more samples sources

- 3C93 are not detected with JVN three baseline (3, December, 2014), (Yamaguchi, Tsukuba, Hitachi)
- 3C8 are only detected with JVN in short baseline (800 mas) (4, December, 2014), (Yamaguchi, Hitachi, Tsukuba)
- PKS0139-273 are observed by JVN
  - PKS0139-273 is observed 4 stations (21, May, 2015)
- Survey observation
  - ongoing project (have observed 109 targets)