

High sensitivity VLBI observation for black hole candidates near Sgr A*

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○ ABSTRACT

Supermassive black holes (hereafter SMBHs) exist in the center of many galaxies, and they are observed as active galactic nuclei. The formation process of the SMBHs, however, remains unclear at present. A possible formation model of the SMBHs in the galactic center is BHs merging by collision and merging of small galaxies. Many small galaxies have been merged and absorbed into our galaxy in the past. Such galaxies had BHs in their center. If BHs evolve by merger, there is a possibility that relatively large BHs wander in the vicinity of the Sgr A*. The purpose of this study is to find BH candidates that have character like Sgr A*. We have performed VLBI observation for five compact radio sources with three baselines Yamaguchi, Tsukuba and Hitachi.

○ INTRODUCTION

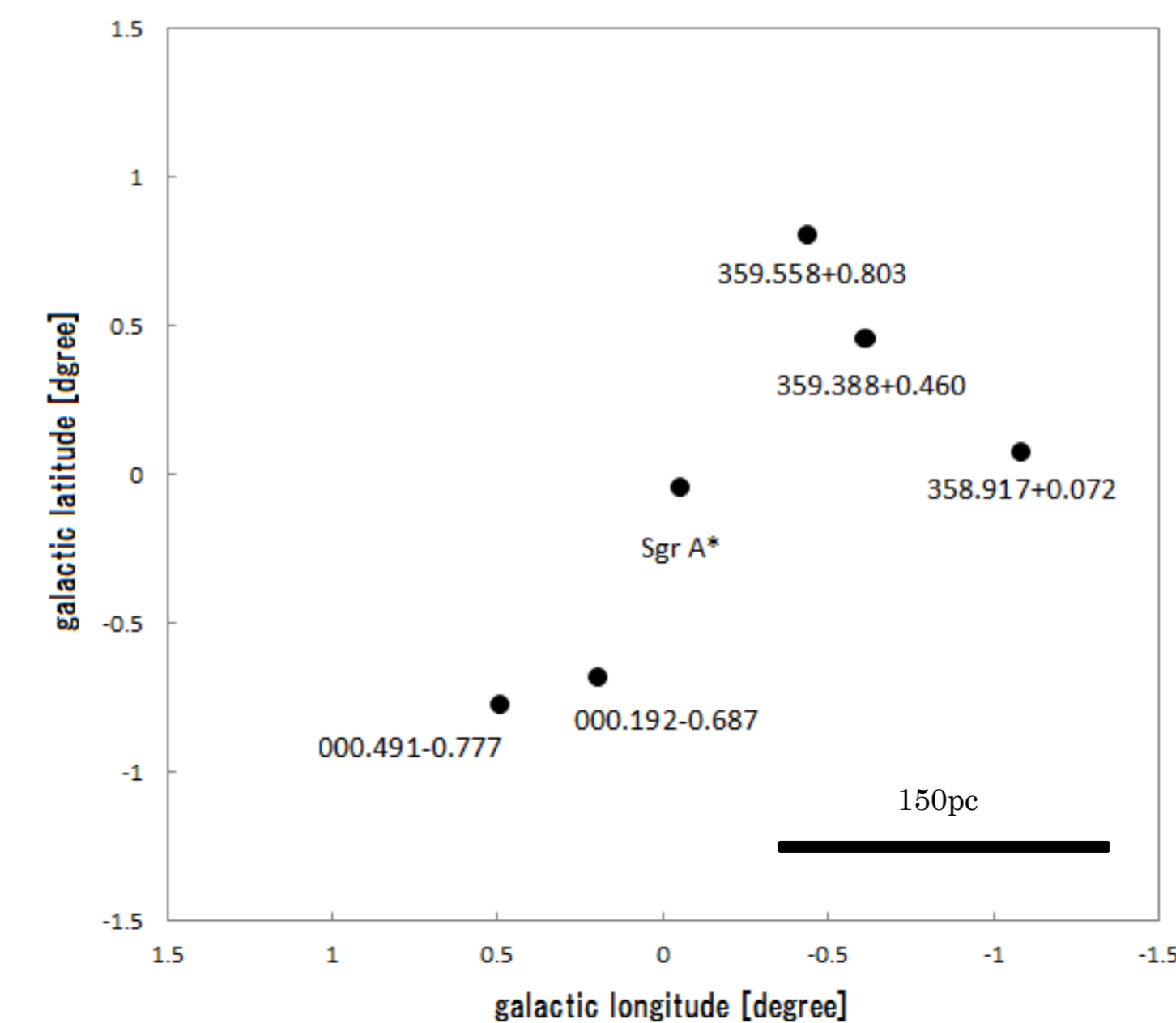
SMBHs with mass of 10^6 - $10^9 M_{\odot}$ are well known to be located at the central regions of galaxies. These formation processes remains unclear. It is considered that such SMBHs get the most of their mass through gas accretion in the process of growing. However, If seed BHs are small, the seed BHs cannot grow to SMBHs by only gas accretion with the Eddington accretion rate. Therefore, we consider the possibility of BHs mergers for the growth of SMBHs. It is considered that BHs merging occurs as a consequence of the collision and merging of small galaxies. In the cold dark matter (CDM) cosmology, a massive galaxy forms through the multiple merger of small galaxies. If the small galaxy has a MBHs, massive galaxies should contain multiple MBHs after merging. N-body simulations show that a multiple MBHs system can produce a heavier MBH at the galactic center^[1]. In the middle of this growth process, relatively large BHs wander in the galaxy. Such BHs existed in small galaxies that merged and absorbed.

SMBH (called Sgr A*) exist in the central region of our galaxy. If BHs evolve by merger, there is a possibility that relatively large BHs wander in the vicinity of the Sgr A*. It is estimated that if such BH candidates are actually BHs that existe in the central region of small galaxies, that exhibit properties similar to Sgr A*. In this case, BH candidate has the following characteristics.

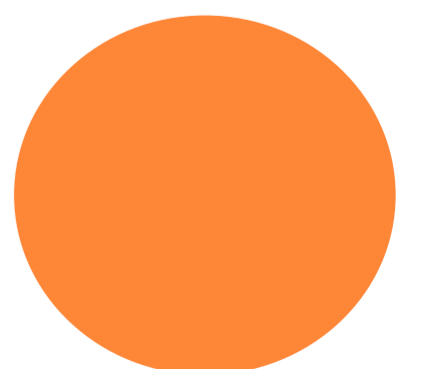
- Compact
- Flat spectrum
- Fast variability
- No or faint infrared counterpart
- Different proper motion from background AGNs

○ PURPOSE AND METHOD OF THIS STUDY

The aim of this study is to find BH candidates that have properties listed above. Since the candidate would have compact and flat spectrum, they would be detected by VLBI observation. For this purpose, we searched for compact radio sources in the galactic center region by JVN.



Spatial distribution of target sources



○ SOURCES SELECTION

Observed sources were selected on the basis of following criteria. Lazio & Codes (2008) made a VLA-A observation toward the galactic center, and the results are suitable for our purpose. We selected the target sources from the list of Lazio & Codes (2008).

- Observed in both the 5 and 1.4 GHz
- Flux density at 5GHz is larger than 10 mJy
- Size at 5GHz is less than 0.25"
- Spectral index is larger than -1

The selected five sources are shown in the table 1. Lowest flux density in the target sources is 11.5 mJy at 8 GHz for 000.491-0.777. This sources could be detected if it is compact enough for JVN resolution since detection sensitivity of JVN is ~3 mJy.

○ OBSERVATION

The observation was conducted on June 9, 2014. The duration of the observing session was 5.5 hours from 12:30 to 18:00 UT. The VLBI scans were carried out 4 times for each source. The recording time was 10 minutes for one scan. The following table (Table 2) shows observation parameters.

Table 2. Observation parameters

| | |
|-----------------------|------------------------------------|
| Telescope | Yamaguchi, Tsukuba, Hitachi |
| Date/Time | June 9, 2014 12:30 - 18:00 (UT) |
| Observation Frequency | 8.192-8.704 [GHz] |
| Polarization | RHCP |
| Bandwidth | 512 [MHz] |



Japanese VLBI Network (JVN)^[3]

Table 1. Target sources^[2]

| No | Name | RA (J2000.0) | | | Dec (J2000.0) | | | 5GHz | | | 1.4 - 5GHz |
|----|---------------|--------------|----|--------|---------------|----|-------|--------------|---------|------------|----------------|
| | | hh | mm | ss | ddd | mm | ss | I [mJy/beam] | S [mJy] | size [sec] | Spectral Index |
| 1 | 358.917+0.072 | 17 | 42 | 44.013 | -29 | 49 | 15.98 | 93.2 | 99.4 | 0.08 | -0.7 |
| 2 | 359.388+0.460 | 17 | 42 | 21.46 | -29 | 12 | 59.96 | 30.2 | 37.2 | 0.25 | -0.7 |
| 3 | 359.558+0.803 | 17 | 41 | 26.158 | -28 | 53 | 28.97 | 13.1 | 15.2 | 0.23 | -0.8 |
| 4 | 000.192-0.687 | 17 | 48 | 45.68 | -29 | 7 | 39.2 | 84.5 | 83.8 | 0 | 1 |
| 5 | 000.491-0.777 | 17 | 49 | 49.018 | -28 | 55 | 5.36 | 11.4 | 12.1 | 0.16 | -0.1 |

○ PROSPECT

The correlation has been done now. If fringe is detected, it is necessary to examine whether these BHs were in the central region of the small galaxies. As mentioned in the introduction, it is estimated that if detection sources are BHs that existed in the central region of small galaxies, that exhibit properties similar to Sgr A*. In this case, we believed that detection sources indicate the intensity fluctuations in the short-term. In addition, if detection sources exist in the Galactic center really, these proper motions are different from the AGN background. Therefore, it is planned to carry out a precise determination of the proper motion and position and exploration of the intensity fluctuation of detection sources.

○ REFERENCE

- [1]Tanikawa & Umemura ,(2011), ApJL , 728 , L31
- [2]Lazio & Codes ,(2008), ApJS, 174 , 481
- [3] <http://www.astro.sci.yamaguchi-u.ac.jp/jvn/img/jvnarray.jpg>
- Toshihiro Kawaguchi &Yuriko Saito & Yohei Miki & Masao Mori (2014) , ApJL , 798 , L13

