EHT-J Activities and New Imaging Technique with Sparse Modeling

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Fumie Tazaki (NAOJ)



- PhD @Kyoto University in March 2014
- "Study of Radio-Loud Active Galactic Nuclei with X-Ray Observations"

Newcomer to radio astronomy!

Present work: Development of a system to reconstruct super-resolved images with "sparse modeling."

Toward Snapshot of Black Hole

Event Horizon Telescope (EHT)

EHT-Japan activities

- Adding ALMA to EHT as a VLBI station (ALMA Phase-up Project)
 - * Developed and tested the optical fiber link system in Japan.
 - Installed the optical fiber link system on ALMA in 2014.
 - Performed the setup test in 2014.
- Test data analysis of M87 (Akiyama et al., submitted)
- Development of a new imaging technique





Test Observation of M87, Key Target of EHT Detection of closure phase of M87 with EHT!!

- * Detected closure phases are consistent with zero.
- * Data is consistent with all of the models.
- * In near future we will distinguish the models, with closure phases including ALMA.



Approaching Jet

Broderick & Loeb, (2009) Lu et al. (2014)



Counter Jet





Dexter et al, (2012)



An optimal model will be obtained with ALMA.

60 -40 -20 -

Relative RA (uas

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Accretion Disk

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Conventional Interferometry Imaging

*2D Fourier transformation of observed visibility

*Observed visibility is sampled in UV (spatial frequency: baseline vectors seen from the target source) plane.

$$I_{\nu}(x,y) = \iint S_{\nu}(u,v)e^{-2\pi i(ux+vy)}dudv$$

*Imperfectly sampled visibility \rightarrow fill unsampled place with zero \rightarrow dirty image

UV sampling



dirty image



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Image resolution is limited by beam size.

Development of Super-Resolution Technique



Honma et al. (2014)

Reconstructed image of M87 by sparse modeling with VLBA data @43GHz

Visibility sampling: 4472 \rightarrow Image grids: $128^2 = 16384$

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Jet limb-brightening and counter-jet are reconstructed!

Reliability of the New Technique

* Reproductivity of Observational Data



Model visibility calculated from sparse modeling image reproduces well observational data.

* Consistency between Least Squares Method and Sparse Modeling



Visibility sampling: 4472 ↓ Well-posed problem Image grids: 64² = 4096

Two images of sparse modeling and least squares method are the same.





Position of the black hole (preliminary)



Position of the black hole (preliminary)





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Strongly support the coreshift result (Hada et al. 2011).



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We obtain the jet structure as a function of the distance from the central engine (black hole).

Key of "jet formation" and "physics of high energy emission"

- ✤ Japanese group is contributing to
 - ALMA phase-up project (APP).
 - science of M87.
 - development of imaging technique with "sparse modeling."

Future Plan

 Development another new imaging technique, which reconstruct a image directly from closure phase.

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Black Hole Shadow will be Coming Soon!!



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Large $\lambda \rightarrow$ high sparsity (most pixel values are zero) Small $\lambda \rightarrow$ high data reproducibility







































- ALMA OSF (correlator, recorder)
- AOS (antenna operating site, 5000m)