SgrA* 22GHz KaVA(+TAK) observation and its Amplitude Calibration

I.J.Cho[1,2], T.Jung[1,2], G.Zhao[1], M.Kino[1], B.W.Sohn[1,2] + KaVA AGN sub-WG
1. Korea Astronomy and Space science Institute(KASI)
2. University of Science and Technology(UST)

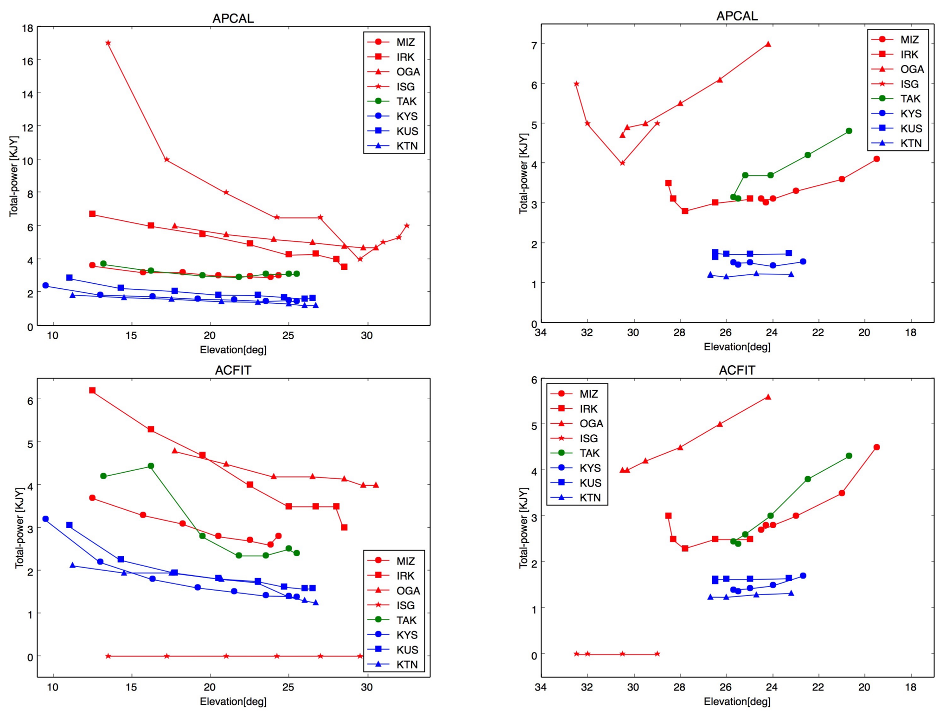
1. Introduction

Sgr A* located in the center of the Milky Way is of great interest to understand the physics of supermassive black hole(SMBH) and the interaction of the G2 cloud around Sgr A* with the accretion flow which was expected since 2013. In order to seize this rare opportunity, KVN and VERA Array (so called, KaVA) has started an intensive monitoring program of Sgr A* at 22/43 GHz where scatter broadening is reduced compared to lower frequency VLBI observations. We present the results of KaVA Sgr A* observation together with Takahagi (32m) and Yamaguchi (32m) telescopes at 22 GHz on March 24, 2013. We have tested both a standard amplitude calibration method using the Tsys and antenna gain information and a template amplitude calibration method which uses a peak of H2O maser line of nearby maser source (SgrB2), and found that the latter method is useful when an accuracy of Tsys measurement or antenna gain of a telescope is poor. In our comparison, the difference between the two methods is around 20% (~5% for the KVN and ~15% for the VERA when the elevation is above 20°). We also imaged Sgr A* with a peak flux of ~0.2 Jy/beam at 22GHz by applying a template method.

2. Observation and Data reduction

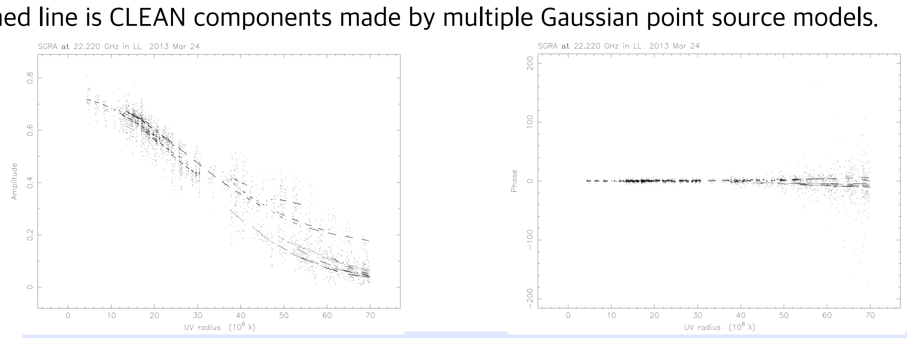
Two calibrators of NRAO530 and SgrB2 were used for a fringe finder and an amplitude calibration of SgrA*. Although total 9 telescopes including KaVA, Takahagi(TAK), and Yamaguchi(YAM) were participated, two telescopes(Ishigaki and Yamaguchi) were failed to detect the source due to bad weather.

We tried two methods for amplitude calibration in AIPS: one is 'APCAL' which uses a Tsys and antenna gain information, and the other one is 'ACFIT' using the peak flux of H2O maser line neaby the target to trace an antenna gain variation along the elevation. And then, we checked the elevation dependency of total power for each case. Both of them show similar trend but the total power stability was better in the case of ACFIT than APCAL, as we see in [Fig.1]. Also there was no available gain information for TAK, we applied the result of ACFIT.



[Fig.1] The elevation dependency of total power amplitude, for APCAL(upper) and for ACFIT(lower). First half of scan time from the lowest to highest elevation(left), and for the next scan time from the highest to lowest elevation(right) are shown.

With the result of amplitude and phase calibration, we kept going further editing to get an image of SgrA* by CLEAN process in DIFMAP. As a result, SgrA* was resolved in the UV radius up to 70 mega-lambda which corresponds to baseline length ~950km. In [Fig. 2], the faint scattered points are remained visibility data after calibration and editing, and the thick dashed line is CLEAN components made by multiple Gaussian point source models.

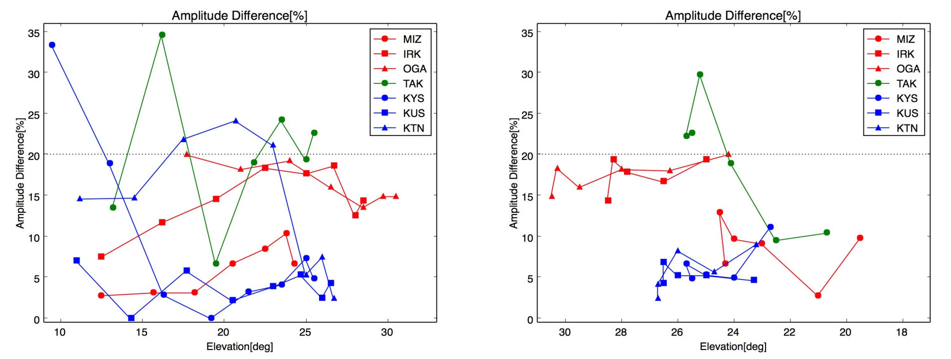


[Fig. 2] Visibility data and CLEAN components for UV radius to amplitude(left) and phase(right).

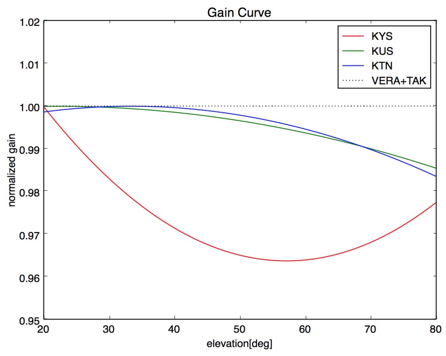
3. Results

(1) Amplitude Difference between APCAL and ACFIT

First, we compared the results of amplitude calibration with APCAL and ACFIT. Usually the difference is expected under 20%. In our comparison, it was well retained under 20%, except for Takahagi and Tamna telescopes. The remarkable result in this comparison, the amplitude difference was ~5% for the KVN, while it was ~15% for the VERA [Fig.3]. It's because the different gain curve for each array [Fig.4].



[Fig.3] Total power amplitude difference between APCAL and ACFIT, estimated by abs[(APCAL-ACFIT)/APCAL]x100[%].



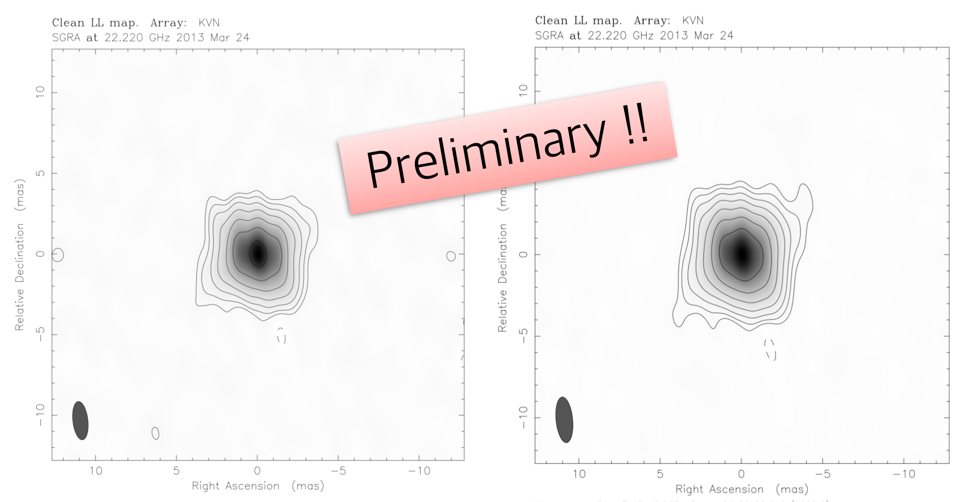
[Fig.4] Gain curve for each telescopes in KVN and VERA+TAK.

In the case of KVN, it uses the polynomial weighting along with the elevation while VERA uses a constant gain value. The difference of total power amplitude between two arrays is considered to come from the gain curve difference.

Therefore, with expectation, KaVA can be more improved if the gain information of VERA is changed. Because we cannot apply the ACFIT method for amplitude calibration when any maser line source not exists nearby a target, it's needed to improve the stability of APCAL which can be used at any time.

(2) SgrA* image

After the calibration of amplitude(with ACFIT) and phase, we got an image of SgrA* like [Fig.5] with the values in [Table 1] :



[Fig.5] (Left) Uniform weighted result, and (Right) Natural weighted result.

[Table 1]	Dynamic range	RMS	Peak flux	Beam size
Uniform	161	1.3 mJy/beam	0.211 Jy/beam	2.4 x 0.937 mas
Natural	413	0.56 mJy/beam	0.231 Jy/beam	2.81 x 1.03 mas

In the case of natural weighted result, the peak flux density is 0.231 Jy/beam. Because the accurate flux information is especially important for SgrA* research to study a mechanism that makes possible to emit such level of flux, this preliminary research may give a chance to begin the future works, such as fitting a model to see whether a structure exists for SgrA* and ultimately, whether the radio emission is from jet or accretion disk of SMBH.

4. Conclusion

We confirmed the amplitude difference between APCAL and ACFIT. As a result, ACFIT showed a better amplitude stability. However, we also need to improve the stability of APCAL by applying a weighting along with the elevation which means the gain curve because ACFIT is not always applicable.

In this research, we got a better amplitude calibrated result for SgrA* by ACFIT and got an image with 7 telescopes, while only 4 telescopes detect the source in the case of APCAL. The peak flux density was ~0.2Jy/beam and, with the value, we are planning to study more about what can be a radio emission mechanism of SgrA* having such flux density level.

References

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Gillessen, S., Eisenhauer, F., Fritz, T. K., et al. 2009, ApJL, 707, L114