Earth Faster, Closer to Black Hole in New Map of Galaxy

Earth just got 7 km/s faster and about 2000 light-years closer to the supermassive black hole in the center of the Milky Way Galaxy (Figures 1-2). But don't worry, this doesn't mean that our planet is plunging towards the black hole. Instead the changes are results of a better model of the Milky Way Galaxy based on new observation data, including a catalog of objects observed over the course of more than 15 years by the Japanese radio astronomy project VERA, having a central role in the East Asian VLBI Network (EAVN; Figure 3).

"The First VERA Astrometry Catalog" by VERA collaboration et al. and additional nine papers appeared in Publications of the Astronomical Society of Japan in August 2020 (Figure 4).

KASI's researchers have made contributions to the publications as PI and co-I authors (Supplementary information-1). In total, 23 institutes and universities, and 87 people are involved with the publications.

Detail

VERA (VLBI Exploration of Radio Astrometry, by the way "VLBI" stands for Very Long Baseline Interferometry) started in 2000 to map three-dimensional velocity and spatial structures in the Milky Way. VERA uses a technique known as interferometry to combine data from radio telescopes scattered across the Japanese archipelago in order to achieve the same resolution as a 2300 km diameter telescope would have. Measurement accuracy achieved with this resolution, 10 micro-arcseconds, is sharp enough in theory to resolve a United States penny placed on the surface of the Moon.

Because Earth is located inside the Milky Way Galaxy, we can't step back and see what the Galaxy looks like from the outside. Astrometry, accurate measurement of the positions and motions of objects, is a vital tool to understand the overall structure of the Galaxy and our place in it. This year, the First VERA Astrometry Catalog was published containing data for 99 objects.

Based on the VERA Astrometry Catalog and recent observations by other groups, astronomers constructed a position and velocity map. From this map they calculated the

center of the Galaxy, the point that everything revolves around. The map suggests that the center of the Galaxy, and the supermassive black hole which resides there, is located 25,800 light-years from Earth. This is closer than the official value of 27,700 light-years adopted by the International Astronomical Union in 1985. The velocity component of the map indicates that Earth is travelling at 227 km/s as it orbits around the Galactic Center. This is faster than the official value of 220 km/s.

Future

Now VERA hopes to observe more objects, particularly ones close to the central supermassive black hole, to better characterizes the structure and motion of the Galaxy. As part of these efforts VERA will participate in EAVN (East Asian VLBI Network) comprised of radio telescope located in Japan, South Korea, and China. By increasing the number of telescopes and the maximum separation between telescopes, EAVN can achieve even higher accuracy and sensitivity allowing us to observe more distant and fainter objects in the future.

Contact:

Prof. James O. Chibueze, Centre for Space Research, North-West University, Potchefstroom, South Africa.

Tel: 018-299-2426

Email: james.chibueze@nwu.ac.za

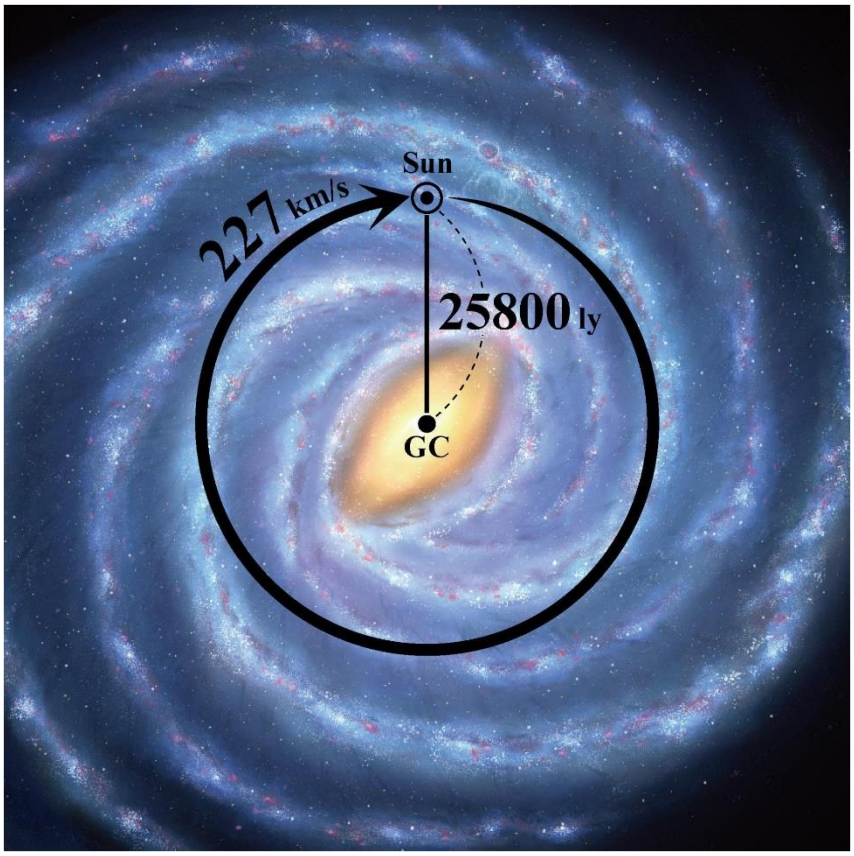
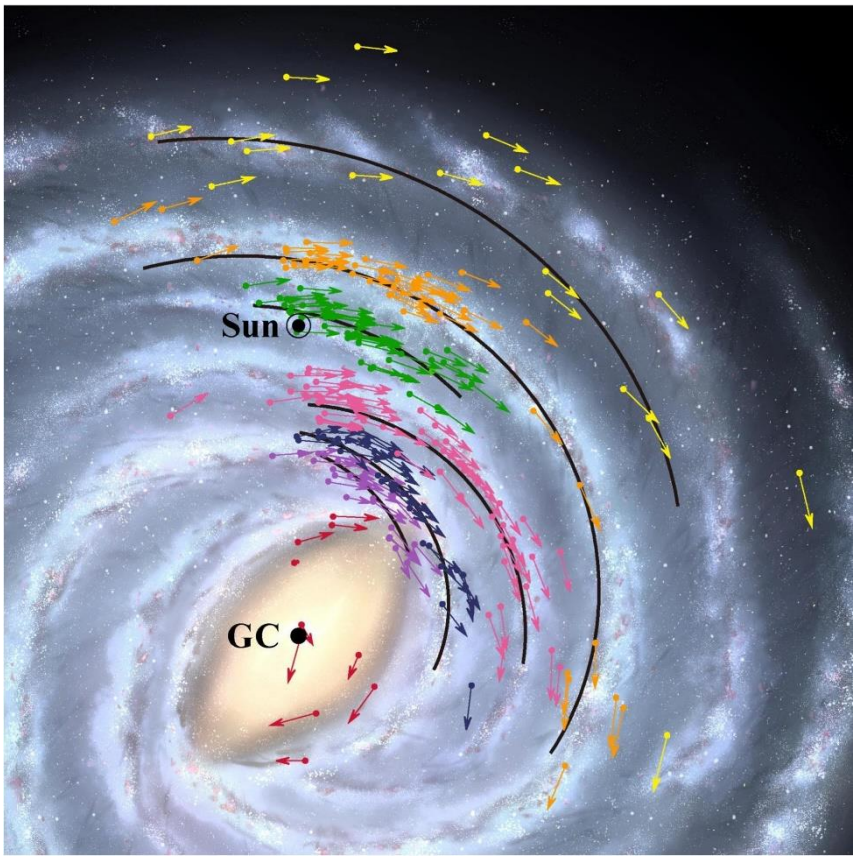


Figure 1: Solar position and rotation velocity are updated to be 258,000 light years from the center of the Milky Way Galaxy and 227 km/s, respectively. It requirs ~210 million years for the revolution of the Sun around the Milky Way Galaxy.



~~Caption~~ Figure 2: Position and velocity map of the Milky Way Galaxy. Arrows show position and velocity data for the 224 objects used to model the Milky Way Galaxy. The solid black lines show the positions of the Galaxy's spiral arms. The colors indicate groups of objects belonging the same arm. The background is ~~a simulation image.~~ an artist's conception of the Milky Way Galaxy, made based on observational data. © 2020- National Astronomical Observatory of Japan (NAOJ)

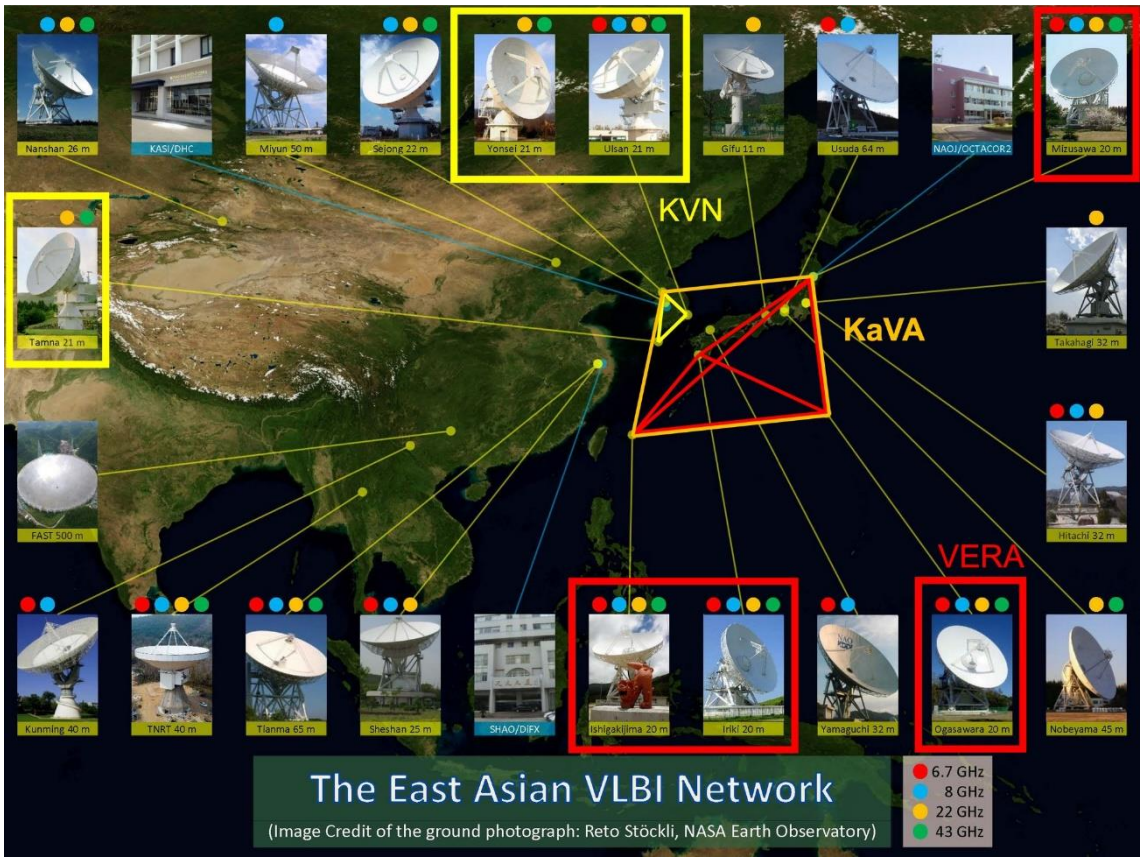


Figure 3: Array configuration of the VLBI networks in East-Asia. KaVA is a combined array of KVN in Korea and VERA in Japan. In Korea, there are three KVN 21 m radio telescopes in Seoul, Ulsan, and Seogwipo (in Jeju island). VERA consists of four 20 m radio telescopes in Mizusawa, Iriki, Ogasawara island and Ishigaki-jima. KaVA is now growing to the more powerful network, East-Asian VLBI Network (EAVN), under collaboration with China, Japan, Thailand, Korea, etc. © 2020- The EAVN Collaboration

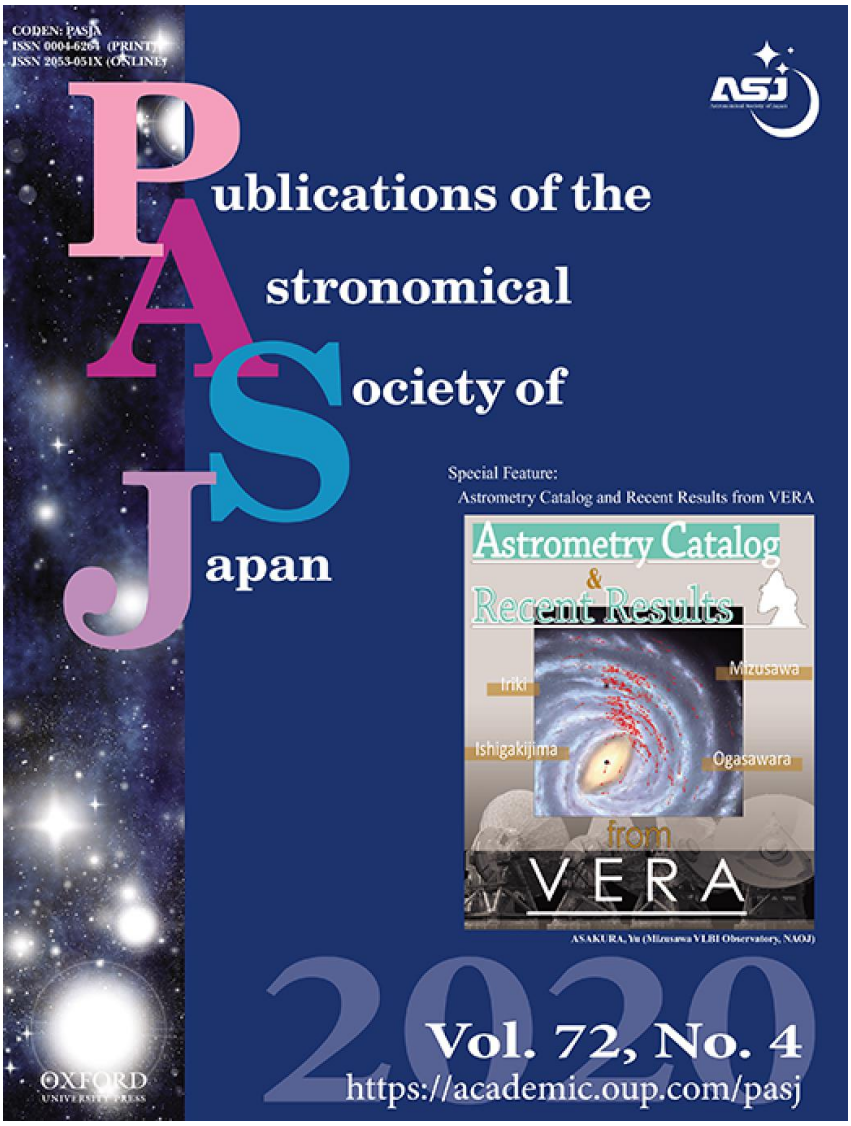


Figure 4: **'SPECIAL FEATURE: ASTROMETRY CATALOG AND RECENT RESULTS FROM VERA"** published from the Publication of the Astronomical Society of Japan, volume 72, Issue 4 (2020 August: https://academic.oup.com/pasj/issue/72/4)

Supplementary Information-1: Publication list of this research

1. **The First VERA Astrometry Catalog**, VERA Collaboration, Tomoya Hirota, Takumi Nagayama, Mareki Honma, Yuuki Adachi, Ross A Burns, James O Chibueze, Yoon Kyung Choi, Kazuya Hachisuka, Kazuhiro Hada, Yoshiaki Hagiwara, Shota Hamada, Toshihiro Handa, Mao Hashimoto, Ken Hirano, Yushi Hirata, Takanori Ichikawa, Hiroshi Imai, Daichi Inenaga, Toshio Ishikawa, Takaaki Jike, Osamu Kameya, Daichi Kaseda, Jeong Sook Kim, Jungha Kim, Mi Kyoung Kim, Hideyuki Kobayashi, Yusuke Kono, Tomoharu Kurayama, Masako Matsuno, Atsushi Morita, Kazuhito Motogi, Takeru Murase, Akiharu Nakagawa, Hiroyuki Nakanishi, Kotaro Niinuma, Junya Nishi, Chung Sik Oh, Toshihiro Omodaka, Miyako Oyadomari, Tomoaki Oyama, Daisuke Sakai, Nobuyuki Sakai, Satoko Sawada-Satoh, Katsunori M Shibata, Makoto Shizugami, Jumpei Sudo, Koichiro Sugiyama, Kazuyoshi Sunada, Syunsaku Suzuki, Ken Takahashi, Yoshiaki Tamura, Fumie Tazaki, Yuji Ueno, Yuri Uno, Riku Urago, Koji Wada, Yuan Wei Wu, Kazuyoshi Yamashita, Yuto Yamashita, Aya Yamauchi, Akito Yuda, PASJ, Vol. 72, Issue 4, No 50, 2020
2. **VEDA: VERA data analysis software for VLBI phase-referencing astrometry**, Takumi Nagayama, Tomoya Hirota, Mareki Honma, Tomoharu Kurayama, Yuuki Adachi, Yoshiaki Tamura, Yukitoshi Kanya, PASJ, Vol. 72, Issue 4, No 51, 2020
3. **Performance of VERA in 10 micro-arcsecond astrometry**, Takumi Nagayama, Hideyuki Kobayashi, Tomoya Hirota, Mareki Honma, Takaaki Jike, Mi Kyoung Kim, Akiharu Nakagawa, Toshihiro Omodaka, Tomoaki Oyama, Daisuke Sakai, Katsunori M Shibata, Yoshiaki Tamura, PASJ, Vol. 72, Issue 4, No 52, 2020
4. **Vertical structure and kinematics of the Galactic outer disk**, Nobuyuki Sakai, Takumi Nagayama, Hiroyuki Nakanishi, Nagito Koide, Tomoharu Kurayama, Natsuko Izumi, Tomoya Hirota, Toshihiro Yoshida, Katsunori M Shibata, Mareki Honma, PASJ, Vol. 72, Issue 4, No 53, 2020
5. **Astrometry of H_2O masers in the W48 A (G35.20-01.74) H II region with VERA: A compact disk outflow inside core H-2a**, James O Chibueze, Takumi Nagayama, Toshihiro Omodaka, Masayuki Nagano, Koji Wada, Ken Hirano, PASJ, Vol. 72, Issue 4, No 54, 2020
6. **Star formation rates in the L1482 filament of the California molecular cloud**, Toshihiro Omodaka, Takumi Nagayama, Kazuhito Dobashi, James O Chibueze, Akifumi Yamabi, Yoshito Shimajiri, Shinnosuke Inoue, Shota Hamada, Kazuyoshi Sunada, Yuji Ueno, PASJ, Vol. 72, Issue 4, No 55, 2020

7. **Annual parallax measurement of the Mira variable star BX Camelopardalis with VERA**, Masako Matsuno, Akiharu Nakagawa, Atsushi Morita, Tomoharu Kurayama, Toshihiro Omodaka, Takumi Nagayama, Mareki Honma, Katsunori M Shibata, Yuji Ueno, Takaaki Jike, Yoshiaki Tamura, PASJ, Vol. 72, Issue 4, No 56, 2020
8. **Trigonometric parallax of O-rich Mira variable star OZ Gem (IRAS 07308+3037): A confirmation of the difference between the P-L relations of the Large Magellanic Cloud and the Milky Way**, Riku Urago, Ryohei Yamaguchi, Toshihiro Omodaka, Takumi Nagayama, James O Chibueze, Masayuki Y Fujimoto, Takahiro Nagayama, Akiharu Nakagawa, Yuji Ueno, Miho Kawabata, Tatsuya Nakaoka, Kengo Takagi, Masayuki Yamanaka, Koji Kawabata, PASJ, Vol. 72, Issue 4, No 57, 2020
9. **FLASHING; New high-velocity H_2O masers in IRAS 18286-0959**, Hiroshi Imai, Yuri Uno, Daichi Maeyama, Ryosuke Yamaguchi, Kei Amada, Yuhki Hamae, Gabor Orosz, Jose F Gomez, Daniel Tafoya, Lucero Uscanga, Ross A Burns, PASJ, Vol. 72, Issue 4, No 58, 2020
10. **Astrometry and infrared observations of the Mira variable stars AP Lyncis, V837 Herculis, and BX Camelopardalis: Implications for the period-luminosity relation of the Milky Way**, James O Chibueze, Riku Urago, Toshihiro Omodaka, Yuto Morikawa, Masayuki Y Fujimoto, Akiharu Nakagawa, Takahiro Nagayama, Takumi Nagayama, Ken Hirano, PASJ, Vol. 72, Issue 4, No 59, 2020

Supplementary Information-2: Related websites

EAVN East Asian VLBI Network https://radio.kasi.re.kr/eavn/main_eavn.php
KaVA KVN and VERA Array https://radio.kasi.re.kr/kava/main_kava.php
KVN Korean VLBI Network https://radio.kasi.re.kr/kvn/main_kvn.php
VERA VLBI Exploration of Radio Astrometry
https://www.miz.nao.ac.jp/veraserver/index.html