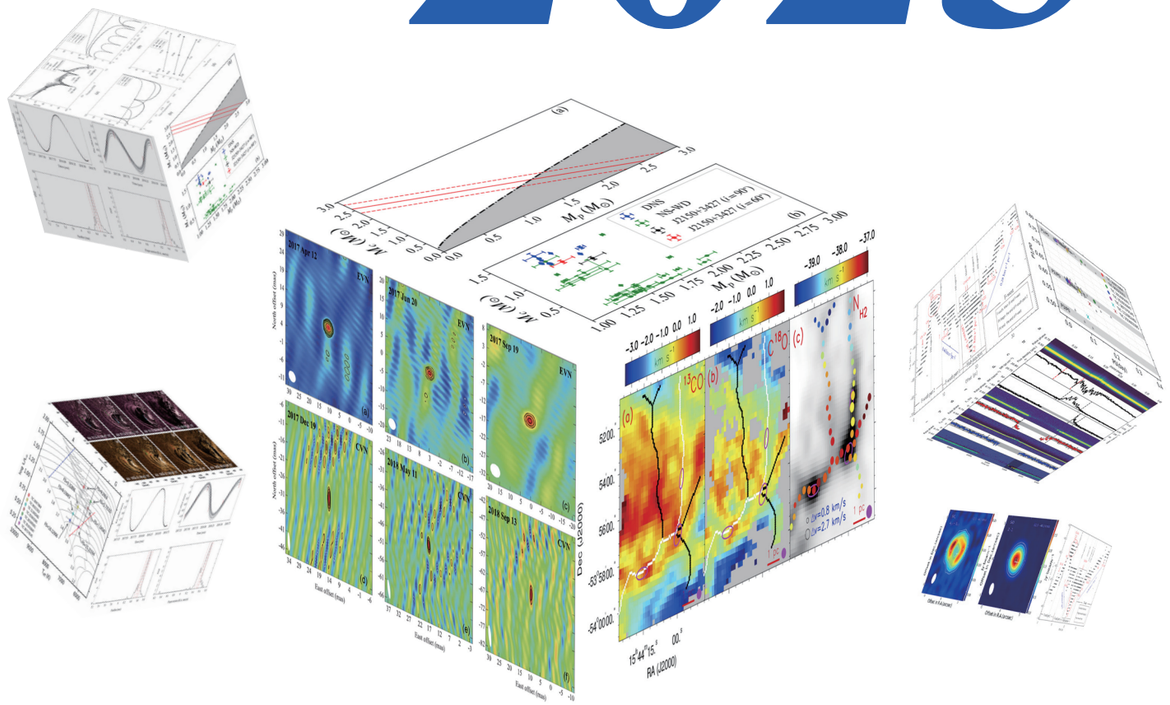
中国科学院新疆天文台
XINJIANG ASTRONOMICAL OBSERVATORY,CAS

Xinjiang Astronomical Observatory
Chinese Academy of Sciences
Annual Report
2023



Contents

Chief Editor: WANG Na
Content Authority: HAN Wei, JIANG Chenfeng
Proofreader: YUEN Rai
Assistant Editor: Marjan
Lay-out: Xinjiang Outstanding Advertising Co., Ltd

LETTER FROM THE DIRECTOR

2023 marked a year of achievements for XAO. This year, we fortified our commitment to fundamental research, championed technological innovation, and fostered international research cooperation, some of which have led to significant advancements and garnered widespread interest from research institutes and media outlets globally.

We have achieved notable progress in astronomical research. For example, a reversal in the Faraday rotation measure was observed in a spider pulsar for the first time, new candidates for double neutron stars have been identified with Five-hundred-meter Aperture Spherical radio Telescope (FAST), four rotational transition spectral lines of the SiC2 molecule around carbon-rich AGB stars exhibiting an annular spatial distribution have been detected.

The year 2023 saw smooth technological advancements, mainly including the completion of schematic designs and reviews for the QiTai radio Telescope (QTT) antenna system, the control system for the main reflector, and the Electro-Magnetic Compatibility (EMC) design. In addition, development tests have been conducted on the antenna control and observation software, the data acquisition backend for ultra-wideband high fidelity, and the shielding efficiency.

Our efforts to enhance the observation platform continue, ensuring a solid foundation for the installation of observation equipment. To aid in the location selection for domestic advanced large optical telescopes, we have persisted with site monitoring at the Muztagh station, where several optical astronomical instruments have been installed.

In the realm of S&T collaboration, we have solidified our partnerships with other astronomical research institutes. We were involved in the research that reveals the formation of indene (C9H7•) molecules within cold molecular clouds. This result has been recognized in Science Advances.The participation of the NanShan 26-m Radio Telescope (NSRT) in providing VLBI data has contributed to confirming the precession of the jet nozzle connecting to a spinning black hole in M87. This discovery has been published in Nature. Moreover, the discovery of key evidence for the existence of nanohertz gravitational waves around the globe using pulsars has been recognized by Science magazine as one of the top ten scientific breakthroughs of 2023.

The relentless efforts of our research teams and management have been central to our progress. We remain dedicated to pushing the boundaries of astronomical research and associated key technologies. We extend a warm welcome to universities and institutes worldwide to engage in scientific communication and exchange with XAO.

As we look ahead, we are filled with optimism for the future of XAO and the groundbreaking discoveries that lie ahead. Thank you for your continued support and interest in our work.

Xinjiang Astronomical Observatory
Chinese Academy of Sciences
Annual Report 2023

ABOUT US

XAO, under the Chinese Academy of Sciences (CAS), was founded in 1957. With its headquarters in Urumqi, XAO maintains and operates several astronomical observing stations situated at Nanshan, Qitai, Muztagh and Kashgar. The main observational facilities include the NanShan 26-m Radio Telescope, Nanshan One-meter Wide-field Telescope, Nanshan 1.2-m Optical Telescope, and more. These facilities are also critical to China deep space exploration.

Research at XAO is comprised of four research units: Radio Astronomy Research Division, Optical Astronomy Research Division, Computer Application Research Division and Solar Physics Research Group. Each of the three divisions is made up of several research groups from different research fields. The research fields include pulsar emission and gravitational wave detection, star formation and evolution, galaxies and cosmology, astrochemistry, time domain optical astronomy and wide field survey, solar physics, space objects and debris, and astronomical techniques and methods.

XAO is responsible for managing a number of laboratories and research centers. The former includes the Xinjiang Key Laboratories of Radio Astronomy and Astrophysics and the Xinjiang Key Laboratories of Microwave Technology. The research centers include the International Research Center for Radio Astronomy and Technology, the China-Central Asia Joint Research Center for Astroarcheology and the Xinjiang University-NAOC Joint Research Center for Astrophysics.

International collaboration serves as an important channel for XAO to promote the development of astronomy, astrophysics and other related fields in science. XAO has already established friendly relationship with many international research organizations.

XAO also holds a wide range of well-received science popularization activities, including the “public star parties”, student field trips to the NanShan station, campus visits by astronomers, open days at all our observing stations.

Our mission is to realize the main targets to establish Xinjiang Astronomical Observatory as an internationally recognized institute for astronomical research that advances the frontier of scientific pursuits, and by accelerating the construction of Qitai radio telescope as a world-leading comprehensive radio astronomical facility.

Management

WANG Na
Director of XAO, CAS
Deputy Director of NAOC,CAS
Research Field: Radio Astronomy, Pulsars,
Technology of Large Aperture Radio Telescope

FENG Tao
Deputy Director of XAO, CAS

CHEN Maozheng
Deputy Director of XAO, CAS
Research Field: Radio Astronomical Methods,
Microwave Cryogenic Receiver, Digital Backend

Jarken ESIMBEK
Deputy Director of XAO, CAS
Research Field: Radio Astronomy, Star Formation
and Evolution

MA Lu
Secretary of Commission for Discipline
Inspection of XAO, CAS
Research Field: Space Objects and Debris

Research

ZHOU Xia
Head of Radio Astronomy
Research Division
Research Field:
Neutron Stars and Pulsars

ZHANG Yu
Head of Optical Astronomy
Research Division
Research Field:
Binary Star, Stellar Population, Open
Clusters, Variable Stars, Galactic
Structure

ZHANG Hailong
Head of Computer Application
Research Division
Research Field:
Intensive Computing and
Data Research

CUI Lang
Head of NanShan Station
Research Field:
VLBI Astrophysics, Multi Wavelength
Variability of AGN

DING Zhen
Head of Qitai Station
Research Field:
Active galactic nucleus(AGN),
Blazars, Intra-day variability (IDV)

BAI Chunhai
Head of Muztagh Station
Researeh Field:
Optical Astronomy and Technology

HE Dalin
Head of Kashi Station
Research Field:
Pulsar Timing

Administration

WANG Shi
Chief of General Administration
Main responsibilities: Organization and coordination of the general administration

HAN Wei
Chief of Science and Technology Department
Main responsibilities: Management of scientific and research programs and grants

WANG Weiping
Chief of personnel and education department
Main responsibilities: Recruitment, Talent management, Salary management

ZHU Cui
Chief of Engineering Project Department
Main responsibilities: Project management and quality control

GAO Yasi
Deputy chief of Financial Department
Main responsibilities: Development and management of the financial systems

JIANG Chenfeng
Chief of Science Communication Center
Main responsibilities: Management and coordination of science communication resources and science popularization

SUN Guanglei
Deputy Chief of Infrastructure and Logistic Support Office
Main responsibilities: Assets management, Infrastructure construction, Logistics management

Xinjiang Astronomical Observatory
Chinese Academy of Sciences
Annual Report 2023

RESEARCH HIGHLIGHTS

Measurement of the magnetic field in eclipse medium of a spider pulsar PSR J2051-0827

Contact: WANG Shuangqiang
Email: wangshuangqiang@xao.ac.cn
The Astrophysical Journal, Volume 955, Number 1
Article link: https://doi.org/10.3847/1538-4357/acea81

Spider pulsars are a subclass of millisecond pulsar binary systems with low mass companions in short-period orbits. In spider pulsars, the pulsar wind and electromagnetic emission ablate and may destroy the companion.

Researchers from pulsar research group at XAO have measured the magnetic field of a spider pulsar PSR J2051-0827.

Using the Five-hundred-meter Aperture Spherical radio Telescope (FAST), the researchers investigated the polarization properties of a spider pulsar PSR J2051-0827 and found direct evidence of the existence of magnetic field in the eclipse medium of PSR J2051-0827.

During the egress of the eclipse of PSR J2051-0827, they found a regular decrease in rotation measure (RM), which changes from 60 to -28.7 rad m^{-2}. This regular decrease in RM indicates that there is a significant magnetic field in the eclipse medium.

The line-of-sight magnetic field strength was estimated to be 0.1 G based on the variation of RM. Considering the magnetic field levels in the eclipse medium, the researchers suggested that cyclotron damping may not be the primary eclipse mechanism at the L-band.

Furthermore, the phenomenon of RM reversal could be caused by a change in the magnetic field strength along the line of sight due to binary orbital motion.The RM reversal phenomenon provides evidence for a complicated and magnetized immediate environment of the source. The results suggest that the environments of spider pulsars share some similarities with some fast radio bursts (FRBs).

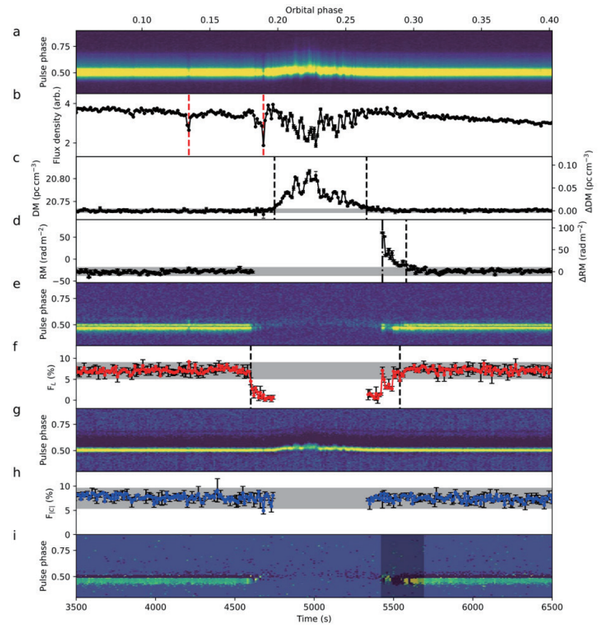


Figure: The polarization properties of PSR J2051-0827 vs. orbital (Image by XAO)

Identification of a new double neutron star candidate

Contact: WU Qingdong
Email: wuqingdong@xao.ac.cn
The Astrophysical Journal Letters, Volume 958, Number 1
Article link: https://iopscience.iop.org/article/10.3847/2041-8213/ad0887

The researchers from the pulsar research group conducted timing studies on the pulsar PSR J2150+3427 discovered during the Commensal Radio Astronomy Fast Survey Transients (CRAFTS) using the Five-hundred-meter Aperture Spherical radio Telescope (FAST). Their measurements showed that it is in a highly eccentric orbit with a period of 10.59 days, and its companion is very likely a neutron star. The detected periastron precession, due to relativistic effects, is 962 times the rate of Mercury's perihelion precession. The total mass of the binary system is 2.59 times the mass of the Sun, with the companion's mass being greater than or equal to 0.98 times the mass of the Sun.

Currently, about 4,000 pulsars have been discovered, and only 10% are in binary systems with companions, such as planets, white dwarfs, neutron stars, and stars. Binary systems with neutron star companions are very rare, accounting for less than 1% of the pulsar population. The progenitors of double neutron star (DNS) systems are two massive stars. The more massive primary star evolves late and undergoes a supernova explosion, giving birth to the first neutron star. The dying companion evolves into a red giant, from which the first neutron star accretes matters through the Roche lobe, producing X-ray radiation and accelerating the rotation of the first neutron star. The second supernova explosion in this system gives birth to the second neutron star.

Researchers conducted timing analysis on 2.7 years of data for the pulsar PSR J2150+3427. They measured the system's periastron precession and estimated its total mass, providing limits on the mass of the pulsar and its companion. It is likely a DNS, but the possibility that J2150+3427 is a neutron star-white dwarf (NS-WD) system cannot be completely ruled out at present. The pulsar's spin-down luminosity is $5.07(6)\times10^{29}$ erg s^{-1}, making it a very low-luminosity pulsar. Continued observation in the coming years will further improve the measurement accuracy of the periastron precession and may detect additional relativistic effects to reduce the measurement errors of the pulsar and companion masses.

Double neutron star systems can be used to study the formation process of pulsars, reveal the supernova explosion and the "kick" velocity at the time of the system's birth, and also serve as highly precise tests of general relativity. They hold significant research value.

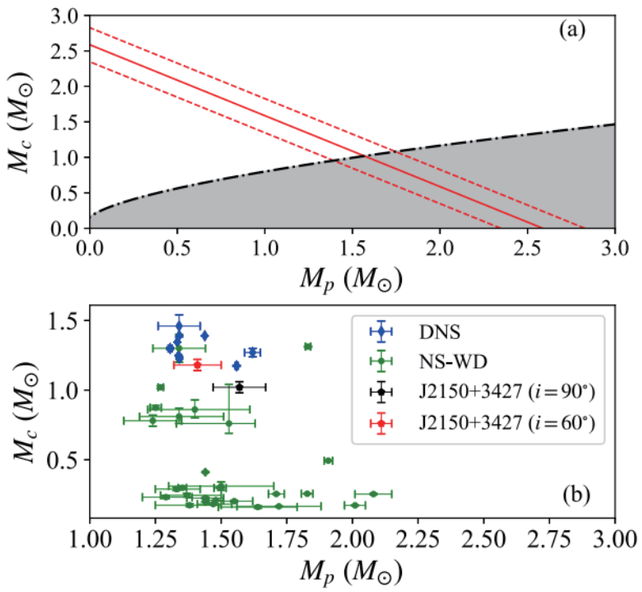


Figure: The masses of the pulsar and its companion star

Statistical properties of dispersion measure and waiting time on repeating fast radio burst

Contact: WANG Yubin
Email: wangyubin@xao.ac.cn
Monthly Notices of the Royal Astronomical Society, 524, 569–576 (2023)
Article link: https://doi.org/10.1093/mnras/stad1922

Repeating fast radio bursts (FRBs) are mysterious radio transient sources in the universe, which emit repeating radio pulses each lasting for a few milliseconds. Plasma lensing is related to the cold, non-magnetized, and inhomogeneous plasma cloud in cosmic space, which can refract the radio signal forming images with frequency-dependent properties, such as the frequency-dependent dispersion measure (DM).

The waiting time, the interval between two adjacent bursts within an observational campaign, is also an important parameter for a repeating FRB. Thus, the statistical properties on the multi-frequency DMs and waiting times of a repeating FRB can unveil the lensing effects in the propagation path.

Recently, WANG Yubin, a Ph.D. candidate at XAO, under the guidance of his supervisor Dr. ZHOU Xia, and his collaborators, segregated the multi-frequency observational data of repeating FRBs, and studied the statistical characteristics of DM and the waiting time of FRB180916.J0158+65 (FRB 180916 for short).

The researchers found that a frequency-dependent two-component Gaussian function could fit the DM, and the waiting time distribution exhibited a bimodal pattern with discontinuities. After the statistical analysis of the relevance of the three parameters with the waiting time and observed frequencies, they also identified that variations in the widths, fluences, and peak density fluxes of bursts might be contributed by some external mechanisms.

In addition, they compared the delay time due to lensing effects with the waiting time in the distribution and the delay time induced by frequency-dependent DM. The results indicate that emission from FRB 180916 might suffer from the plasma lensing effects in the propagation path. The high mass X-ray binary scenario was a more suitable explanation for the origin of the FRB after discussing many possible models for burst production.

The discovery of a young hub-filament G326.611+0.811 undergoing global collapse

Contact: HE Yuxin
Email: heyuxin@xao.ac.cn
The Astrophysical Journal, Volume 957, Issue 2
Article link: https://doi.org/10.3847/1538-4357/acf766

High-mass stars play a crucial role in the evolution of galaxies, serving as significant sources of baryonic matter and UV radiation within galaxies. However, the formation of high-mass stars remains poorly understood to this day. Dense components within molecular clouds commonly exist in the form of filamentary structures. The majority of high-mass dense clumps distributed within these structures, serving as the birthplaces for high-mass stars/clusters. Therefore, studying filamentary structures and the dense clumps within them has become the key to understanding the formation of high-mass stars/clusters.

Recently, researchers led by HE Yuxin from XAO, and Hongli Liu from Yunnan University, along with other collaborators, discovered a young hub-filament system, G326.611+0.811, that is undergoing global collapse. This finding provides an ideal testbed for studying the kinematics, dynamics, and formation of high-mass stars/clusters, particularly at the intersection of filamentary structures, known as the Hub position.

During the process of clump collapse to form stars, filamentary structures can effectively transport material to the clumps and sustain the mass required for the formation of high-mass stars/clusters within the clumps. Clumps located at the Hub position can acquire mass more efficiently through multiple filamentary structures, thereby favoring the formation of high-mass stars/clusters.

The hub-filament system G326.611+0.811 comprises a central hub and at least four hub-composing filaments, divided into a major branch (F1 and F2) and a side branch (F3-F5). The major branch of filaments hosts 14 Herschel 70 μm point sources, resembling a necklace, indicating its status as a young hub-filament.

The cloud exhibits ongoing high-mass star formation, characterized by three massive dense clumps with high clump-averaged mass infalling rates ($>10^{-3}$ $M_\odot$ yr^{-1}) within the major filament branch. Velocity gradients observed along the five filaments in both ^{13}CO and $C^{18}O$ (J = 2-1) emission suggest that filament-aligned gravitational collapse towards the central hub drives high-mass star formation in this region.

Furthermore, researchers observed periodic velocity oscillations along the major filament branch, with a characteristic wavelength of ~3.5 pc and an amplitude of ~0.31-0.38 km/s, possibly due to clump-forming gas motion induced by gravitational instabilities.

This source represents a continuum of material transport from low-density gas to denser filamentary structures and ultimately to dense clumps, making it an ideal showcase of early filamentary structure global collapse.

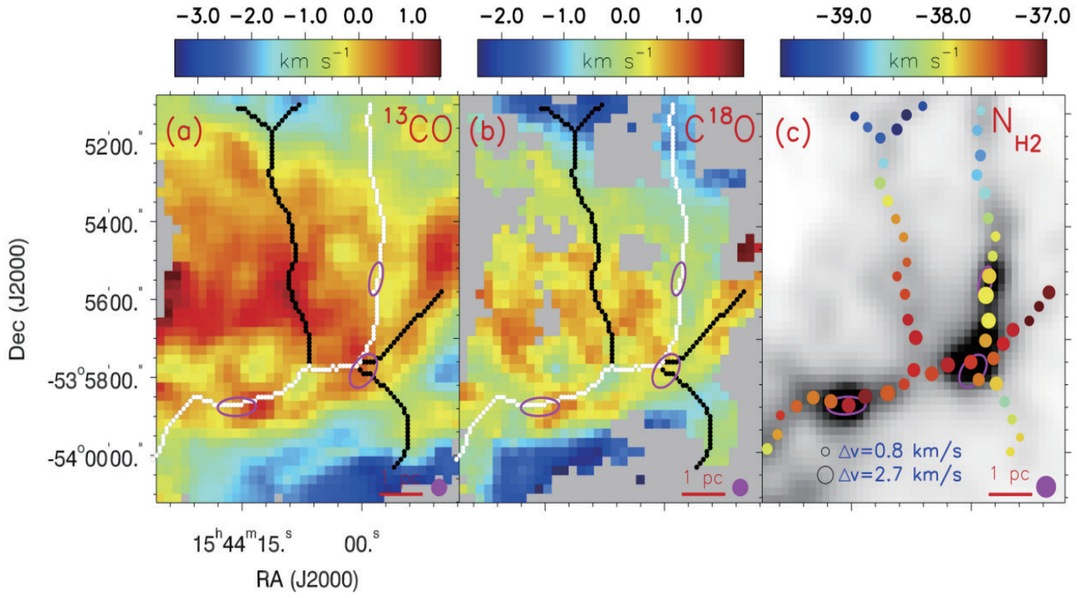


Figure: (a) The map illustrates the differences between the first velocity moment (velocity field) of ^{13}CO (J = 2–1) and the systemic velocity of the cloud. The main and branched skeletons are shown as white and black curves, respectively. Magenta ellipses mark the dust clumps. The filled magenta circle in the lower right corner indicates the beam size of the CO observation. (b) Same as the left panel, but for $C^{18}O$ (J = 2–1). (c) Color-coded line-of-sight velocity centroids of $C^{18}O$ (J = 2–1) extracted along filaments overlaid on top of an H_2 column density map. The sizes of the symbols indicate the line width of $C^{18}O$(J = 2–1). The filled magenta circle in the lower right corner indicates the beam size of the Herschel 500 μm wave band.

The discovery of gravitational collapse and aceretion flows in hub filament system G323.46-0.08

Contact: MA Yingxiu
Email: mayingxiu@xao.ac.cn
Astronomy and Astrophysics, 2023, 676, A15
Article link: https://www.aanda.org/articles/aa/pdf/2023/08/aa46248-23.pdf

Hub-filament systems are ubiquitous in molecular clouds. Most dense clumps and cores are formed in filaments and play a key role in star formation process. Therefore, investigating hub-filament system is one of the best ways to understand high-mass star formation.

Recently, MA Yingxiu, a PhD student from the XAO and her collaborators have found a hub filament system G323.46-0.08, which provides evidences for gravitational collapse and accretion flows.

The filaments in molecular clouds may overlap to form a hub-filament, which includes a dense hub and filaments associated with it. In a scenario of global hierarchical collapse of molecular clouds dominated by gravity, these filaments constitute channels for gas funneling from extended cloud to dense clumps in the hub. The clumps in the hub will accrete more materials from the surroundings, and they become more massive and are more likely to form high-mass star clusters.

The researchers found that the hub-filament system G323.46-0.08 consisted of three sub-filaments (F-north, F-west and F-south), with the high-mass clump AGAL323.459-0.079 located at the hub center. Large scale accretion flows were observed in F-west and F-south, indicating that they were transporting gas to the central clump.

The minimum accretion rate was estimated to be 1,216 solar masses ($M_\odot$) Myr^{-1}, and filamentary accretion flows appeared to be an important mechanism for supplying materials necessary to form the central high-mass clump AGAL 323.459-0.079 and to propel the star forming activity taking place therein.

In the hub, the gas velocity gradients increased significantly, and it showed a V-shaped structure in the Positon-Velocity diagram, which traces the accelerated gas motions undergoing gravitational collapse.

The researchers obtained the best-fitting parameters from a gravitational collapse model in the study, with a hub-junction mass between 1,000 and 1,500 $M_\odot$ that are consistent with the observed mass 1,100 $M_\odot$ for AGAL323.459-0.079.

The study strongly supports the theory of global hierarchical collapse.

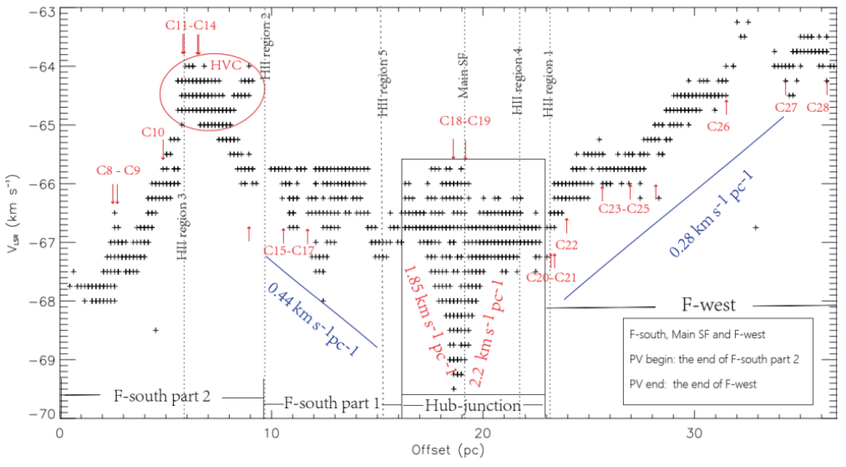


Figure: Gas velocity variation along the long axis of filament

The discovery of an annular distribution of SiC_2 in the circumstellar envelopes of carbon-rich asymptotie giant branch stars

Contact: FENG Yanan
Email: fengyanan@xao.ac.cn
Frontiers in Astronomy and Space Sciences, Volume 10
Article link: https://www.frontiersin.org/articles/10.3389/fspas.2023.1215642/full

The circumstellar envelopes (CSEs) of asymptotic giant branch (AGB) stars contain a large number of molecules, which account for about one-third of all molecules discovered in interstellar space.

Gas and dust are essential components of CSEs, and SiC_2 is one of the significant constituents of dust grains in carbon-rich AGB stars. Whether SiC_2 is “parent” molecules formed in the photosphere or during the high-temperature dust

formation process (exhibiting a "solid" spatial distribution), or a "daughter" molecule formed through photodissociation of "parent" molecules in the outer envelopes (exhibiting an annular distribution), has been a long-standing debate.

Researchers led by Ph.D. candidate FENG Yanan and Prof. LI Xiaohu from XAO have conducted observational work on the SiC_2 molecule in circumstellar envelopes of three carbon-rich AGB stars (AI Vol, II Lup, and RAFGL 4211) using the Atacama Large Millimeter/Submillimeter Array (ALMA).

They found that the spatial distribution of the four rotational transition spectral lines of SiC_2 molecules around these three sources exhibited an annular distribution, indicating the feature of a typical "daughter" species.

In addition, they compared the ALMA results of SiC_2 and SiO molecules in AI Vol. The SiO molecule exhibited a "solid" distribution feature, indicating that it is a "parent" molecule, which is consistent with previous studies.

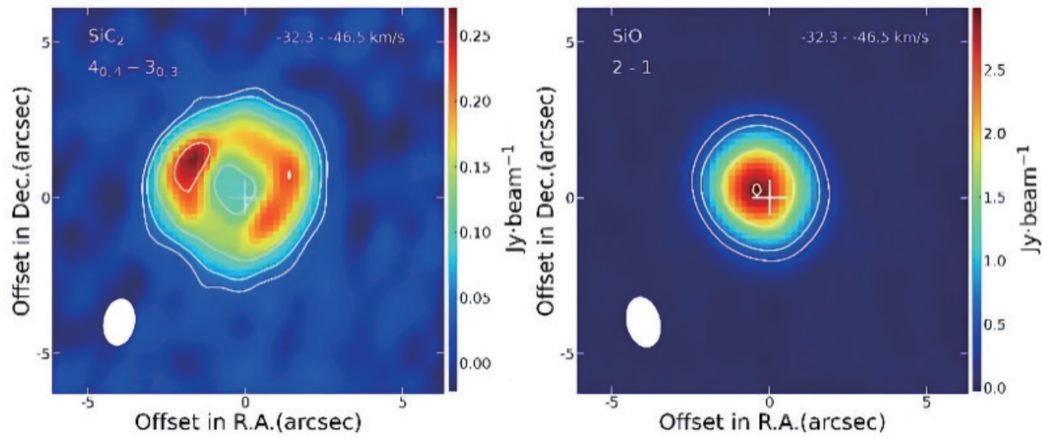


Figure: ALMA observation results of SiC_2 (left panel) and SiO (right panel) molecules toward the carbon-rich AGB star: AI Vol.

Realization of very long baseline interferometry astrometrie measurements on white dwarf pulsar AR Scorpii

Contact: JIANG Pengfei; CUI Lang
Email: jiangpengfei@xao.ac.cn; cuilang@xao.ac.cn
Monthly Notices of the Royal Astronomical Society, Volume 520, Issue 2
Article Link: https://ui.adsabs.harvard.edu/abs/2023MNRAS.520.2942J

An international research team led by Dr. CUI Lang from the XAO has imaged the compact weak radio emission region and measured the astrometric parameters with high precision for the radio star AR Scorpii (AR Sco) using multi-epoch Very Long Baseline Interferometry (VLBI) observations.

VLBI astrometric observations of radio stars can validate the quality of Gaia Celestial Reference Frame (GCRF) and help to improve the accuracy and robustness of the link between the International Celestial Reference Frame (ICRF) and GCRF.

AR Sco is the only-known radio-pulsing white dwarf binary to date, which consists of a rapidly rotating magnetic white dwarf and a M-type main-sequence star. It has a broadband spectrum and unusual pulsations detected at the radio, infrared, optical, and ultraviolet bands.

To determine the astrometric parameters of AR Sco at radio band independently, the researchers conducted multi-epoch VLBI phase-referencing observations with the European VLBI Network (EVN), the Chinese VLBI Network (CVN), and the New Zealand Warkworth 30-m telescope.

Besides the primary calibrator, an additional weak extragalactic source, very close to the target AR Sco, played a key role as a secondary calibrator for phase-referencing to improve the astrometric precision.

The researchers detected the compact radio emission and provided high-precision astrometric measurements for AR Sco.

This work provided new and independent astrometric results to validate the Gaia results for AR Sco. Based on the astrometric results, the researchers analyzed the kinematics of AR Sco and found that the Galactic space velocities of AR Sco were quite consistent with that of both intermediate polars (IPs) and polars.

Furthermore, they estimated the upper limit of the radio-emitting region size of AR Sco and suggested that the radio emission should be located within the light cylinder of its white dwarf.

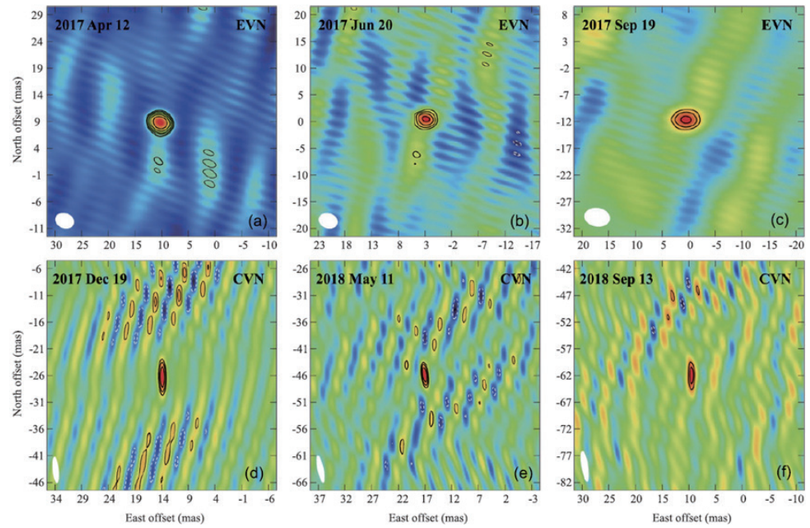


Figure 1: The VLBI images of the WD pulsar AR Sco.

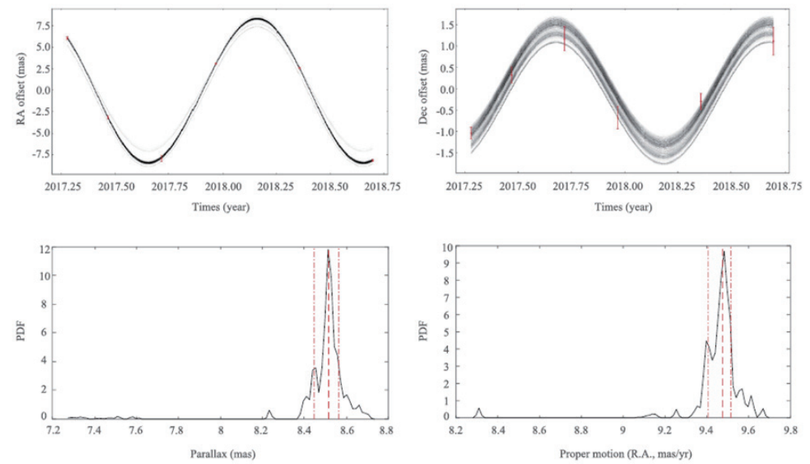


Figure 2:. Illustration of the bootstrap astrometric fit for AR Sco.

Certification of seven large-amplitude δ Scuti stars

Contact: LV Chenglong
Email: lvchenglong@xao.ac.cn
The Astrophysical Journal, Volume 959, Number 1
Article link: https://doi.org/10.3847/1538-4357/acf999

High-amplitude δ Scuti stars (HADS) are typical late A-type or early F-type pulsating stars. They are located at the intersection of the main sequence and the classical instability strip on the Hertzsprung-Russell diagram. These stars show pulsation periods ranging from 1 to 6 hours, with amplitude exceeding 0.3 magnitudes.

LV Chenglong, a PhD student from XAO, and his collaborators successfully identified seven HADS stars with significant pulsation characteristics from over 59,000 δ Scuti stars using precise time-series photometric data from the TESS space telescope.

The study utilized high-precision photometric data from the TESS space telescope, providing crucial information for certifying and understanding HADS pulsation characteristics. Through comprehensive analysis of light curves, period-luminosity relations, and period ratio diagrams, two radial pulsating HADS (TIC 30977864 and TIC 387379145) and a double-mode pulsating HADS (TIC 30977864) were confirmed, along with four other stars possibly exhibiting triple-mode pulsation.

In addition, the researchers conducted a statistical analysis of the relationship between metallicity and pulsation period for 176 HADS stars. Future research will involve studying a larger sample of HADS stars by combining spectroscopic data, addressing ratio issues of the pulsation period, and providing stronger constraints to build precise stellar models.

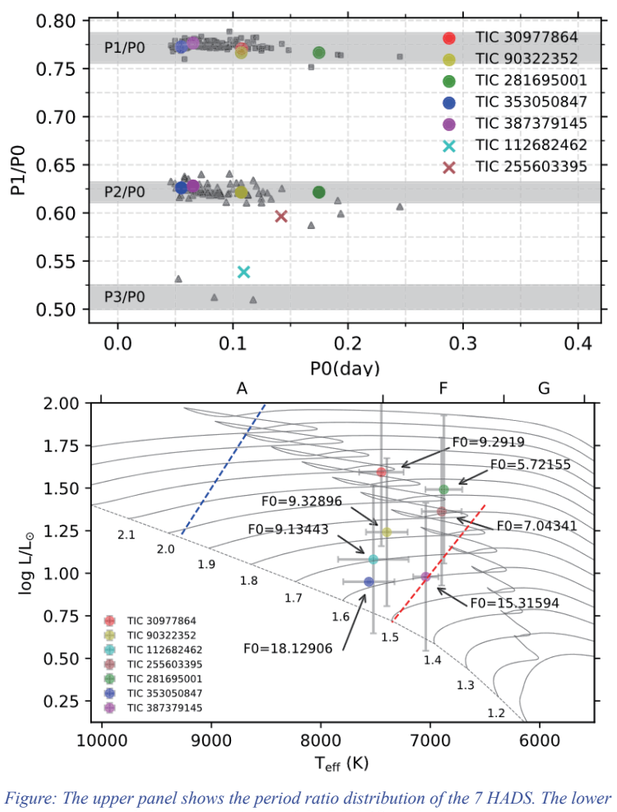


Figure: The upper panel shows the period ratio distribution of the 7 HADS. The lower panel shows the positions of the 7 HADS on the Hierogram.

Xinjiang Astronomical Observatory
Chinese Academy of Sciences
Annual Report 2023

How energy is released during the flare eruption?

Contact: SHEN Jinhua
Email: shenjh@xao.ac.cn
The Astrophysical Journal, 950:71 (10pp)
Article link: https://doi.org/10.3847/1538-4357/accc8c

A research team led by Dr. SHEN Jinhua from XAO investigated the process of energy release from a X1.7 class limb flare using the radio observations made by Nobeyama, as well as the X-ray observations made by RHESSI and EUV observations from SDO/AIA.

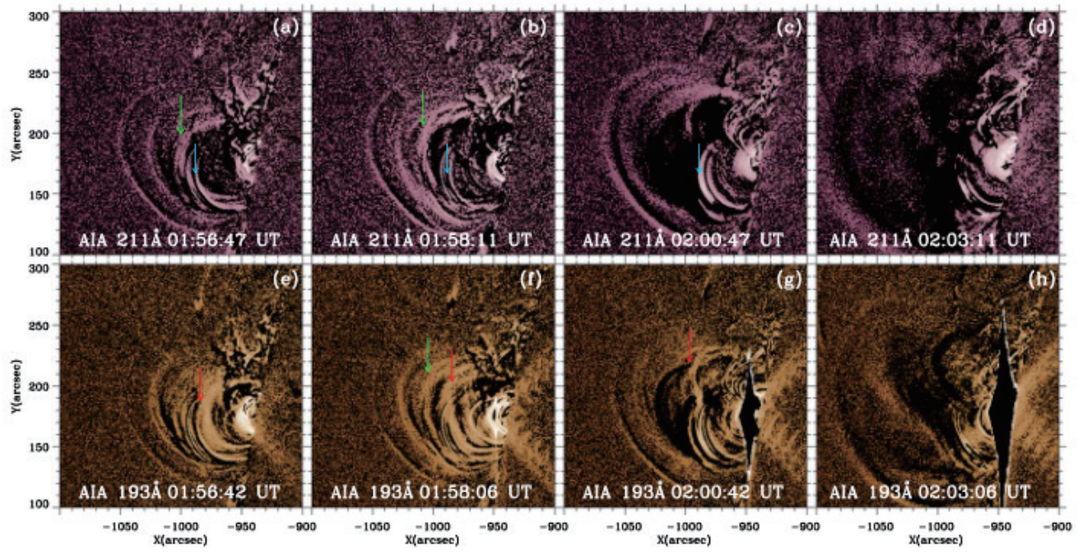
The researchers found that the microwave source shows a recurrent decrease and increase during its overall upward motion,and it shows a kind of recurrent contraction and expansion. The time period of the recurrent contraction and expansion corresponds to the period of post-contraction oscillation of EUV loops, and the oscillatory motions are closely correlated with four microwave/hard X-ray peaks that displayed unusually increase in the nonthermal emission levels by several times.

"In the study, we investigate the filament with bidirectional material transport, and two newly formed hot channel magnetic flux ropes. They activated and powered the onset of the flare", said Dr. SHEN.

For the process of the energy release of the flare, they found that the formation of magnetic flux ropes is due to the continuous magnetic reconnection. Furthermore, the radio and X-ray coronal sources in 25–50 keV energy bands are located at the top of the flare loop, which is regarded as the place of particle acceleration. In addition, the spectral evolution of the flare shows a soft–hard–harder behavior, which suggests a continuing acceleration of particles while they are trapped in flaring loops.

According to our results, the contraction of the peripheral magnetic loops is more likely due to the vortex and sink flows generated by an upward erupting magnetic flux rope rather than a coronal implosion. On the other hand, the EUV waves crossing and hitting the peripheral loops further lead to their contraction to arrive at a new equilibrium after the eruption.

The research will provide more insight into the physics of dynamic coronal magnetic field and particle acceleration during solar flares. It also has important implications for understanding the energy release of solar flares.



Research Bites:

The pulsar discoveries by FAST/CRAFTS: follow-up timing of 24 pulsars

Contact: WU Qingdong
Email: wuqingdong@xao.ac.cn
Monthly Notices of the Royal Astronomical Society, Volume 522, Issue 4
Article link: https://doi.org/10.1093/mnras/stad1323

Using the FAST telescope, the researchers from pulsar research group discover new pulsars, including 2 millisecond and 22 normal types. The results detailed the pulsars' properties through precise timing and measurements. These pulsars are fainter and more distant than typical, with some exhibiting behaviors like nulling and subpulse drifting. The study also suggested that the current Galactic electron density models may need revision for certain regions. The researchers emphasized that further pulsar discoveries will deepen our knowledge of neutron star physics and their population characteristics.

The use of correlation analysis method to find evidence of 0J 287 jet precession

Contact: YUAN Qi; ZHANG Ming
Email: yuanqi@xao.ac.cn, zhangm@xao.ac.cn
The Astrophysical Journal,Volume 949, Number 1
Article link: https://iopscience.iop.org/article/10.3847/1538-4357/acc5ec/pdf

OJ 287 is a typical blazar with relativistic jets, and because the jet points very close to the observer's line of sight, they show a strong beaming effect. At present, flares of about 12 years period have been observed in the optical band, and there is evidence of flares observed in the radio band too. YUAN Qi, a doctoral student from XAO, under the guidance of Prof. LIU Xiang and Prof. ZHANG Ming, analyzed the cross-correlation between jet observables by using the multi-band and multi-epoch VLBI monitoring data of the blazar OJ 287. It was successfully verified that the co-modulation properties among the observables could be attributed to the geometric effect of jet precession. This study showed that the precessing candidates of active galactic nucleus can be selected by using the correlation analysis method, without complex parameterized model fitting to jet kinematics. In addition, the researchers did not find any strong correlation between the polarization position angle of the core and the internal jet position angle at 15 GHz and 43 GHz, implying that the order of the polarization position angle in the core region at those frequency bands is low.

Process on Electron Cyclotron Maser Emission with Fully relativistic condition

Contact: ZHANG Lijie; SHEN Jinhua
Email: zhanglijie@xao.ac.cn shenjh@xao.ac.cn
The Astrophysical Journal, Volume 944, Number 1
Article link: https://doi.org/10.3847/1538-4357/acaef9

A research group at XAO, together with their collaborators from the Lishui University and the Purple Mountain Observatory, carried out a preliminary study on the Electron Cyclotron Maser Emission (ECME) with a fully relativistic correction. The results showed that the fully ECME case has a greater advantage in exciting the ECM instability for non-thermal electron energy above 50 keV. The researchers confirmed that the fully relativistic corrected effects were important only in the energy above 50 keV, and the semi-relativistic ECM was still a good approximation for lower-energy case. In addition, for strong magnetic field environment, the X mode cutoff frequency can be lower than its peak frequency. Moreover, the radio emission from pulsars, flare stars and Blazar jets usually has extremely high brightness temperatures, which suggests that cyclotron maser instability must be involved. Therefore, it is necessary to consider a fully relativistic correction for ECME to enhance its usefulness for understanding these high-energy radio emissions.

Xinjiang Astronomical Observatory
Chinese Academy of Sciences
Annual Report 2023

TECHNOLOGY DEVELOPMENT

Environmental load-based error assessment and compensation for large antenna structures

The structural deformation of large-aperture radio telescope antennas caused by environmental loads, such as temperature and steady wind, can lead to antenna pointing deviations, thus reducing the antenna's observation time at high frequencies and severely restricting the telescope's high-precision service characteristics. Therefore, establishing a real-time evaluation and compensation system for correcting large antenna structural errors under environmental loads can effectively improve the comprehensive performance of the antenna outdoors. Established from the high-precision measurement of environmental loads on antenna structures and real-time error compensation methods, a sensor layout method based on temperature-sensitive point search strategy was proposed. This method does not rely on thermodynamic simulation. Instead, it can achieve real-time high-precision measurement of the temperature field of the radio telescope antenna structure and accurately grasps the temperature distribution pattern of the radio astronomical telescope (as shown in Figure 1). A temperature field-structural displacement field influence matrix was established, and a rapid matrix algorithm for structural thermal deformation was proposed for real-time evaluation of the structural deformation errors caused by environmental loads on the radio telescope. Using the Nanshan 26-meter radio telescope of the Xinjiang Astronomical Observatory, an assessment test of the antenna pointing deviation caused by environmental loads was conducted. Using data obtained from inclinometers, fiber optic temperature sensors, and wind speed and direction sensors of the Nanshan Station, the pointing deviations of the mount and backbone were evaluated, which provided important support for the correction of pointing deviations (as shown in Figure 2). The research results will be used to enhance the performance of the Xinjiang 110-meter diameter fully steerable radio telescope. They provide significant technical and methodological support for breakthroughs in radio astronomy research and the high-quality completion of national major tasks.

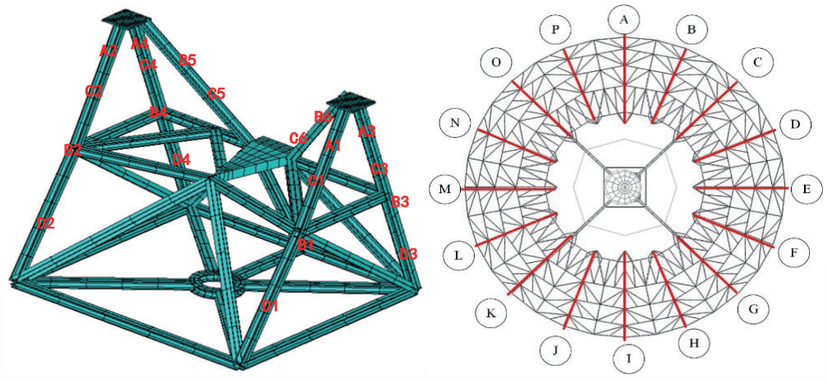
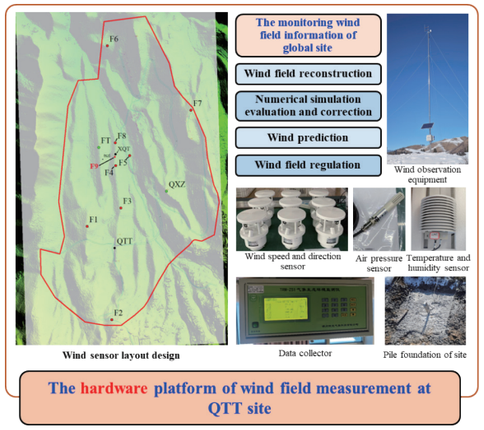


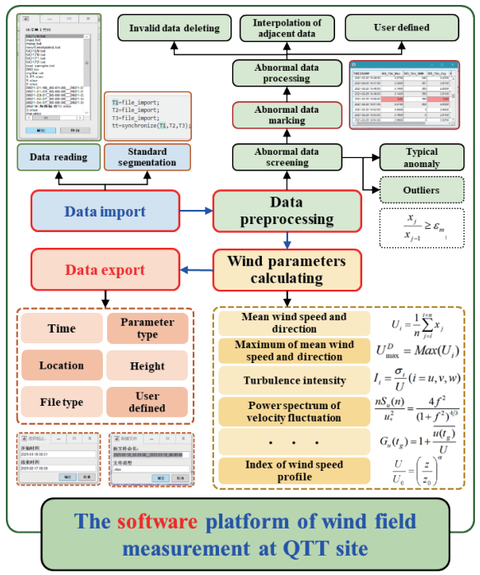
Figure 1: Diagram of Sensor Layout

Figure 2: Installation Location of the Sensor on the Antenna (Partial)

Construction of software and hardware platforms for wind field measurement at the QTT site

The measured wind data is the first data to study the wind characteristics, and it is necessary for the accurate acquisition of wind field information. However, the QTT site is located in a mountainous area, and the near-surface winds are influenced by the topography of mountains, river valleys and basins, giving rise to variable flow tracks and speeds. Based on the multi-point deployment of wind sensors, one can obtain comprehensive wind characteristic information for antenna wind-resistant design. The group designed and built a multi-purpose wind measurement system for the entire area of the QTT site. The system design contains two parts: wind sensor layout design and wind observation data processing system design. The wind sensor layout design adds 9 new wind monitoring points on the basis of the existing 60 m wind tower and 15 m weather station. In addition to the monitoring function of global wind field information at the site, the wind sensor layout also meets the research needs of wind resistance, such as wind field reconstruction based on measurement, numerical simulation evaluation and correction, wind prediction, and wind field regulation. Multiple functions imply a large amount of data collection, and the huge amount of raw data places significant stress on the sorting and analysis of wind characteristic information. Therefore, a wind observation data processing system is designed. The functions of the system include importing and sorting data from multiple types of sensors, screening and processing abnormal data, calculating a variety of wind parameters, and freely assessing wind parameters, thereby realizing efficient and fast processing of wind characteristic information. At present, the main body of the system has been built and some of the functions are being improved.





Researchers propose new technology to improve the observation sensitivity of QTT

QTT will be equipped with Ultra-Wide Band (UWB) signal receiving and processing system. In order to upgrade the performance of the telescope, the engineers from the QTT signal receiving and processing team of XAO designed a new UWB signal acquisition and processing experimental system.

The UWB system can improve the observation sensitivity of the telescope by increasing the bandwidth. However, it also poses great challenges to signal acquisition, transmission and processing. In addition, the wider bandwidth will also incorporate more electromagnetic interference signals, impacting the quality of astronomical observations and causing a saturation effect on the system.

Xinjiang Astronomical Observatory
Chinese Academy of Sciences
Annual Report 2023

In order to avoid the UWB signal phase and amplitude fluctuations caused by environment and temperature changes in the analog transmission link, the new system uses a high-performance, low-power RFSoC circuit to directly sample the RF signal at the receiver end. In addition, the new signal acquisition circuit uses higher quantization accuracy to increase the dynamic range of the received signal, thus avoiding saturation caused by strong interference.

The researchers aimed to realize real-time processing of the UWB signals. To do that, they divided the UWB signals into multiple digital sub-bands, which are transmitted to the remote High-Performance Computer (HPC) cluster through 100 Gb high-speed digital fiber links for processing.

The final system is more flexible and expandable. Its controlling program can be configured based on the available computing resources according to the observation bandwidth and computational complexity. Furthermore, each HPC node is configured with NVMe SSD cards for high-speed baseband data recording to realize raw astronomical information capture and adaptive RFI elimination.

To verify the actual observation effect of the system, the researchers deployed it on the Nanshan 26-meter radio telescope and conducted pulsar observation experiments. They found that the signal-to-noise ratio of the merged pulsar data is obviously stronger than that of the unmerged single subband data, which indicates that the system is working as expected.

This work provides a high-performance and flexible solution for the design of QTT's versatile UWB backends.

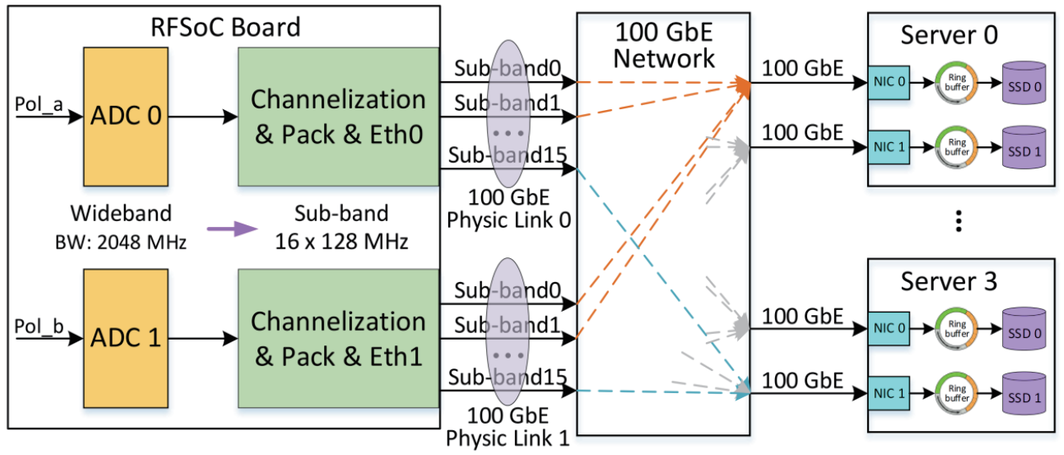


Figure: Architecture of the UWB signal acquisition and processing system. The system directly digitizes the dual-polarized wideband signal at the RF end and divides it into 16 groups of digital narrow basebands, which are transmitted to 4 servers through 100 GbE links for real-time processing.

A wideband pulsar terminal based on RFSoC

In order to evaluate the radiated emission from the Radio Frequency System-on-Chip (RFSoC), which will be used in the QTT project, the radiation emission from internal components of the HTG-ZRF8 RFSOC development board was measured with the near-field probes in the chamber. A component-level electromagnetic radiation evaluation method was proposed (Fig.1). This method was used to analyze the radiation distribution of the internal components of the chip, providing technical support for the electromagnetic protection of the internal module. In addition, the radiated emission characteristics of HTG-ZRF8 RFSOC were measured and analyzed according to the GJB151B standard in conjunction with the QTT electromagnetic compatibility control requirements. As a result, the requirements for electromagnetic protection design were proposed to provide support for further shielding protection design.

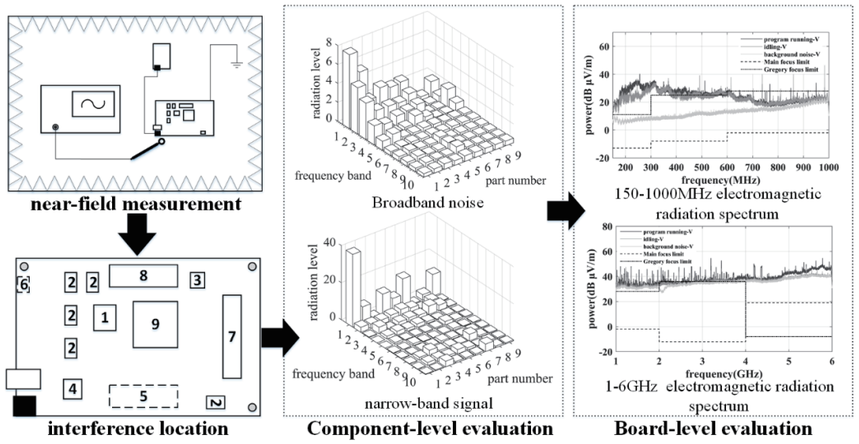


Figure 1: Evaluation of RFSoC electromagnetic radiation

Based on Robinson's equivalent circuit model and electromagnetic topology theory, we proposed a calculation method for SE (Shielding Effectiveness) of multi-layer rectangular shielding cavity with apertures using the BLT equation. The method was used to analyze the influence of multi-layer cavity structure, layer spacing, hole shape, radiation source installation position, shielding layer number, and other factors on shielding effectiveness. The theoretical calculation and numerical simulation results (Figure 2) show that the SE increases with the increase of layer spacing when the frequency is low, and the SE shows periodicity when the frequency is high. We also calculated the performance of three-layer shielding. It is found that increasing the number of layers can effectively increase the SE, and the increase is approximately linear with the increase of the number of layers rather than a simple additive relationship. This provides important theoretical support for the design of ultra-high-performance shielding schemes for large radio telescopes.

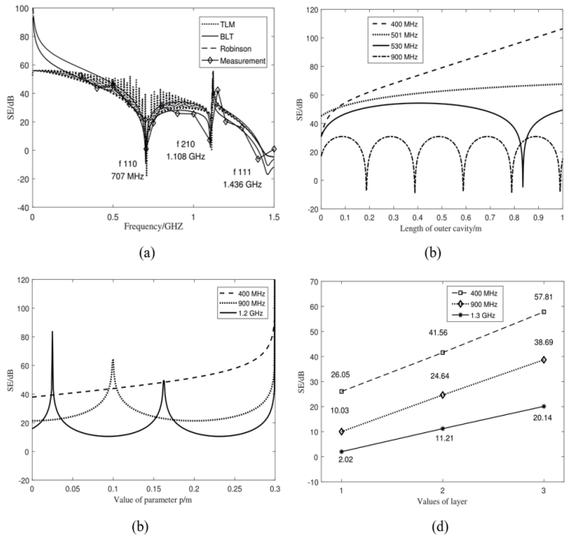


Figure 2: Different influencing factors of shielding effectiveness of multi-layer cavity

Research on Phased Array Feed (PAF) array decoupling, parameter measurement, and front-end cooling system design

Combining the 1.25GHz microstrip antenna PAF array, impedance conversion matrices were established using the open circuit voltage method and the receiving mutual impedance method, respectively. Decoupling weights were calculated for both methods, and two decoupled beam synthesis networks were established. The patterns of the entire array of the 16 element microstrip antenna PAF array before and after decoupling were tested under the condition that only the weighted amplitude and phase were weighted. Finally, the first zero depth of the pattern corrected by decoupling network was lowered, which is similar to the simulation results , without coupling, and achieved decoupling function well. Using a 0.7-1.8 GHz Vivaldi antenna PAF array, a study was conducted on the measurements of the S-parameters, beam synthesis and scanning, uniform weighting and conjugate field matching weighting, as well as the cross polarization parameters. At the same time, combining with the Vivaldi antenna PAF array, a full array integrated cooling cryogenic dewar design based on spherical, dome shaped, and horn shaped multi-layer vacuum windows was carried out.

Xinjiang Astronomical Observatory
Chinese Academy of Sciences
Annual Report 2023

SCIENTIFIC COOPERATION

Research:

Gas-phase formation of the resonantly stabilized 1-indenyl (C9H7•) radical in the interstellar medium

Contact: LI Xiaohu
Email: xiaohu.li@xao.ac.cn
Science Advances, Vol 9, Issue 36
Article link: 10.1126/sciadv.adi5060https://doi.org/10.1039/D2CP03084E

The 1-indenyl (C9H7•) radical, a prototype aromatic and resonantly stabilized free radical carrying a six- and a five-membered ring, has emerged as a fundamental molecular building block of nonplanar polycyclic aromatic hydrocarbons (PAHs) and carbonaceous nanostructures in deep space and combustion systems. However, the underlying formation mechanisms have remained elusive. Here, we reveal an unconventional low-temperature gas-phase formation of 1-indenyl via barrierless ring annulation involving reactions of atomic carbon [C(3P)] with styrene (C6H5C2H3) and propargyl (C3H3•) with phenyl (C6H5•). Macroscopic environments like molecular clouds act as natural low-temperature laboratories, where rapid molecular mass growth to 1-indenyl and subsequently complex PAHs involving vinyl side-chained aromatics and aryl radicals can occur. These reactions may account for the formation of PAHs and their derivatives in the interstellar medium and carbonaceous chondrites and could close the gap of timescales of their production and destruction in our carbonaceous universe.

This work is based on the collaboration of scientists from the Xinjiang Astronomical Observatory (XAO), the University of Hawaii, Florida International University, and CA-Berkeley. LI Xiaohu is one of the corresponding authors from XAO. We conducted the astrochemical models using the nova results measured in the lab by Prof. Kaiser Ralf's group. These modeling studies reveal captivating findings. A match between the modeled and observed fractional abundances has also been achieved for indene (C9H8) with dominating formation routes involving the reactions of methylidyne (CH) with styrene (C8H8) and o-benzyne (C6H4) with allyl (C3H5). These fractional abundances suggest that the 1-indenyl radical (C9H7•) might be detectable by radio telescopes such as the Green Bank Observatory and Yebes Radio Telescope.

Monitoring of radio galaxy M87 confirms black hole spin

Contact: CUI Lang
Email: cuilang@xao.ac.cn
Nature, Vol 621, 28 September 2023
Article link: https://www.nature.com/articles/s41586-023-06479-6

The nearby radio galaxy M87, located 55 million light-years from the Earth and harboring a black hole 6.5 billion times more massive than the Sun, exhibits an oscillating jet that swings up and down with an amplitude of about 10 degrees, confirming the black hole's spin.

The study, which was headed by Chinese researcher Dr. CUI Yuzhu and published in Nature on Sept. 27, was conducted by an international team using a global network of radio telescopes. This work made use of a total of 170 epochs of observations obtained by the East Asian VLBI Network (EAVN), the Very Long Baseline Array (VLBA), the joint array of KVN and VERA (KaVA), and the East Asia to Italy Nearly Global (EATING) network. In total, more than 20 telescopes across the globe contributed to this study.

Radio telescopes in China also made contribution to this project, including NanShan 26-m Radio Telescope (NSRT) of XAO, one of the four founding members of EAVN, which is located in the hinterland of Eurasia with a unique geographical location and excellent observation environment. It has participated in the joint observations of EAVN since 2017, providing the longest interferometric baseline for observing the EAVN 22 GHz frequency band. This is a key factor in improving the spatial resolution of EAVN and plays an important role in analysing the precession of the M87 supermassive black hole jet. NSRT enhances the angular resolution of EAVN observations, offering good quality data with both high sensitivity and high angular resolution that are essential to obtain this achievement.

The research team, after a comprehensive analysis of telescope data spanning from 2000 to 2022, has uncovered an 11-year cycle in the precessional motion of the jet base emanating from the supermassive black hole in the M87 galaxy. This cycle aligns with the predictions made by Einstein's General Theory of Relativity and establishes a connection between the jet's dynamics and the black hole's properties, confirming that the black hole in M87 does indeed spin. The study leveraged the proximity of M87 to Earth, allowing for detailed resolution of the jet formation regions near the black hole using Very Long Baseline Interferometry (VLBI). This method was exemplified by the black hole shadow imaging achieved with the Event Horizon Telescope (EHT). By examining 23 years of VLBI data from M87, the team was able to detect the periodic precession of the jet at its base, which provided valuable insights into the nature of the central black hole.

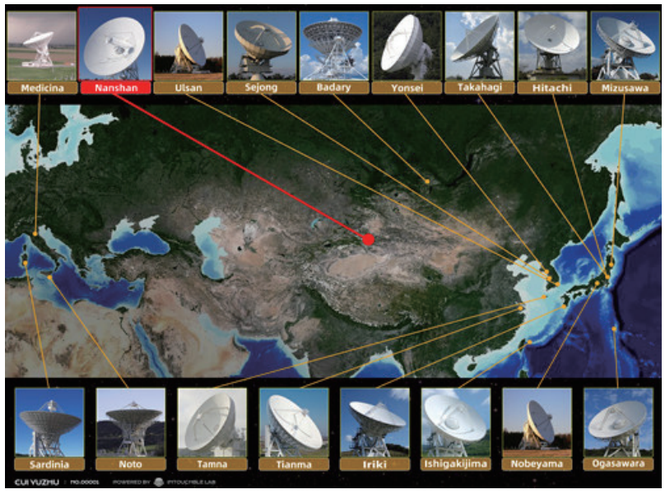


Figure 1: Locations of the EAVN VLBI network telescopes, with the NSRT highlighted in red In VLBI observations, the NSRT can fill the gap of radio telescopes in Central Asia.

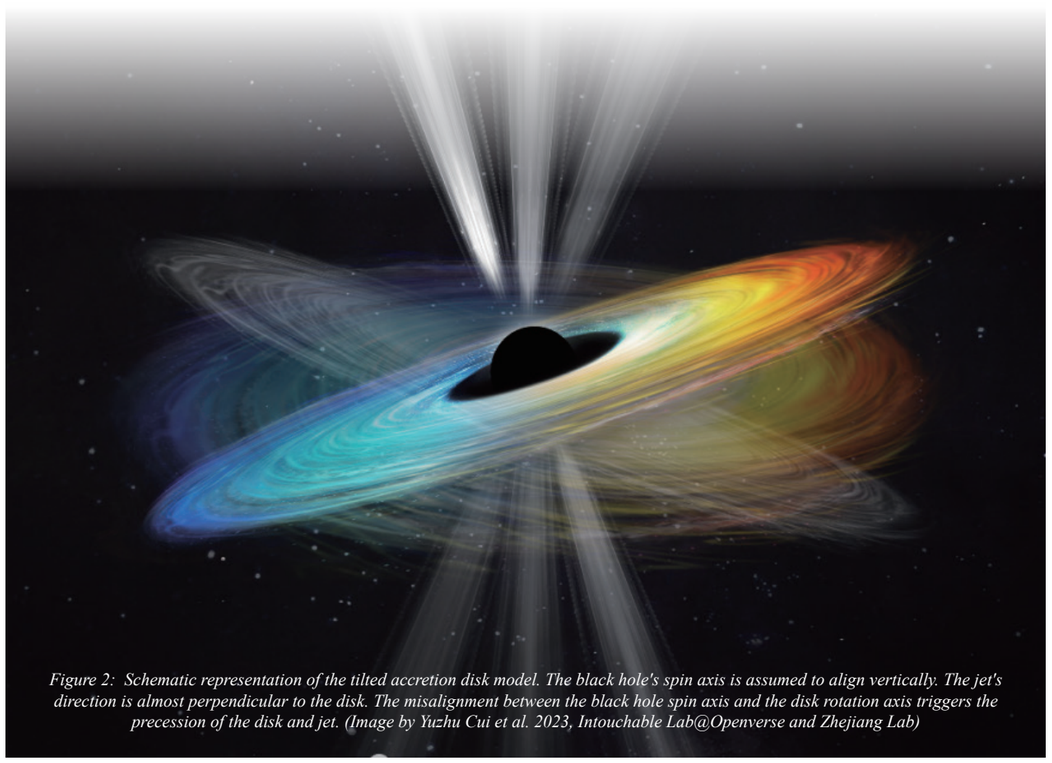


Figure 2: Schematic representation of the tilted accretion disk model. The black hole's spin axis is assumed to align vertically. The jet's direction is almost perpendicular to the disk. The misalignment between the black hole spin axis and the disk rotation axis triggers the precession of the disk and jet. (Image by Yuzhu Cui et al. 2023, Intouchable Lab@Openverse and Zhejiang Lab)

Xinjiang Astronomical Observatory
Chinese Academy of Sciences
Annual Report 2023

A shock flash breaking out of a dusty red super-giant

Contact: Abdusamatjan Iskandar
Email: abudu@xao.ac.cn
Nature, volume 627, pages754–758 (2024)
Article link: https://doi.org/10.1038/s41586-023-06843-6

Core collapse supernovae typically occur in massive stars at the end of their evolution when nuclear fusion ceases. The resulting shock wave from gravitational collapse can quickly penetrate the star's outer layer, causing an instantaneous burst of radiation known as the shock-breakout emission. These extremely early radiation signals are crucial for understanding the propagation of shock waves, the asymmetry of supernova explosions, and the circumstellar environment of the exploding star. However, there are very few international observations of supernova shock-wave radiation, particularly multi-wavelength data, which has hindered our understanding of these processes.

A team of researchers and amateur astronomers from various domestic and international scientific institutions, led by Professor Wang Xiaofeng of Tsinghua University, successfully captured and studied the extremely early shock wave radiation signal of SN 2023ixf, a supernova in the M101 galaxy. By analyzing multi-color photometric data taken approximately one hour after the explosion, they observed, for the first time, the peculiar phenomenon of the shock wave radiation shifting from red to blue. They combined insights from shock wave propagation, circumstellar dust ablation, and material interaction to successfully explain the multi-band light curve of SN 2023ixf during its rise.

The research included observations from the SNOVA and NEXT telescopes at the Nanshan Station of the Xinjiang Astronomical Observatory (XAO) of the Chinese Academy of Sciences. Researchers from XAO were also involved in data processing and analysis, contributing as co-authors of the study.

Newly discovered near-earth object

A new Near-Earth Object has been discovered by the Nanshan One-meter Wide field Telescope (NOWT) of Xinjiang Astronomical Observatory (XAO).

This Near-Earth Object was first observed by the NOWT on Feb. 26. The Minor Planet Center under the International Astronomical Union confirmed the discovery of the Near-Earth Object which was designated as 2023 DB2.

The discovery was a result of cooperation between the XAO and Xingming amateur astronomy team.

The researchers confirmed that the Near-Earth Object 2023 DB2 is not a threat to the Earth. It is more than 30 million km away from Earth's orbit at its closest approach, approximately 80 times the distance between the Earth and the Moon.

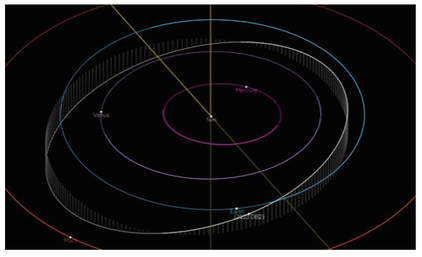


Figure: The orbit of Near-Earth Object 2023 DB2

XAO will offer its full support to further the cooperation with amateur astronomers, especially with Xingming Observatory.

Colloquia:

1. Major Science and Technology projects of the Xinjiang Uygur Autonomous Region-Research on key technologies for the detection of nanohertz gravitational waves using pulsar time arrays- March 23, 2023.
2. The Qitai radio telescope contract signing ceremony-April 20, 2023.
3. Project kick-off meeting on "Research on nanohertz gravitational wave detection by pulsar time array in China" and "Research on key technologies of high-sensitivity ultra-wideband receiver and wideband phased array receiver"- April 12,2023.
4. Seminar on the CPTA environmental load measurement and electromechanical clutch control project - July 31 - August 2, 2023.
5. Seminar on the National Key Research and Development Program of China-SKA Program for the Study of the cosmic magnetic field with the SKA pilot telescope-August 11-13, 2023.
6. The 3rd SKA training course on scientific data processing-August 13-21, 2023.
7. Central Asia Radio Astronomy Training Course, August 15-26, 2023.
8. 2023 Academic Symposium on Stellar Light Change- August 21-24, 2023.
9. Seminar on Strategic Cooperation between Xinjiang Astronomical Observatory and Hangzhou Dianzi University-October 12, 2023.

LECTURES

1 . Introduction to the features and capabilities of the Giiisp platform (NAOC, CAS)

2 . Searching for compact objects with time-domain optical observations (Xiamen University, GU Weiming)

3 . Spitzer Space Telescope study of evolved stars in infrared-- Ryszard Szczerba (Nicolaus Copernicus Astronomical Center Polish Academy of Sciences, Ryszard Szczerba)

4 . China Sky Eye - FAST Project: A long march of science and technology in the new era (NAOC, CAS, ZHANG Chengmin)

5 . Analysis and improvement of the Ethereal experiment (NAOC, CAS, CHEN Xuelei)

6 . Searching for supermassive black holes (Peking University, Luis C. Ho)

7 . Bootstrapping Forefront Science with Small Telescopes (Taiwan Central University, CHEN Wenping)

8 . A new galaxy (Purple Mountain Observatory, XU Ye)

9 . Probing the stellar initial mass function with CNO isotopes (Nanjing University, ZHANG Zhiyu)

10 . Searching for falling gas in galaxies (Purple Mountain Observatory, AO Yiping)

11 . Formation of millisecond pulsars with low mass companions, ultra-compact X-ray binaries, and gravitational wave sources (Yunnan Observatory, CHEN Hailiang)

12 . Lambda-CDM or MOND? (Max Planck Institute for Radio Astronomy, Christian Henkel)

13 . SUNRISE: The rich molecular inventory of high-redshift dusty galaxies revealed by broadband spectral line surveys (Chalmers University of Technology, YANG Chentao)

14 . Introduction of Korean VLBI Network (w/ ExtendedKVN) and KJCC (Korea Astronomy and Space ScienceInstitute, Oh Se-Jin)

15 . Black Hole to White Hole Transition in Quantum Gravity and Its Image (Peking University, MA Yongge)

16 . Search for exotic quark objects (Nanjing University, HUANG Yongfeng)

17 . Star Formation - the Tai Chi between Gravity, Turbulence, and Magnetic Fields (The Chinese University of Hong Kong, LI Huabai)

18 . An introduction to the large terrestrial optical telescopes of the world in the future (Purple Mountain Observatory, LI Jiangtao)

19 . Deciphering Galaxy Quenching: Insights from the Multiphase Circumgalactic Medium (University of Chicago, QU Zhijie)

20 . High-angular-resolution studies of the accretion phenomena in massive-star formation and synergy with single-dish maser monitoring and submm/IR/optical observations (Ural Federal University, Andrey Sobolev)

Xinjiang Astronomical Observatory
Chinese Academy of Sciences
Annual Report 2023

Experience of an international staff at XAO

Amazing experience in China

Ryszard Szczerba

Working in Dr. LI Xiaohu's astrochemistry group provided me with a unique opportunity to acquaint myself with the group members and delve into their scientific endeavors, specifically focusing on astrochemistry processes in circumstellar envelopes of evolved stars. I actively participated in various projects, collaborating with students on preparing papers for submission to publications.

In addition to my scientific endeavors, the support I received from the group members was invaluable in navigating the daily aspects of life, especially considering my limited knowledge of Chinese. The group members were not only friendly but also exceptionally helpful. Initially, they guided me through the process of ordering food in various restaurants, demonstrated how to make payments using WeChat, and provided insights into using a translator for effective communication with service staff or restaurant owners.

Their assistance extended beyond dining experiences - they patiently explained how to utilize taxi services and navigate the metro system in Urumqi. From purchasing metro tickets to understanding this mode of transportation. Moreover, they taught me how to leverage the translator to convert information from Chinese to English, proving to be an invaluable tool in various situations. This newfound skill significantly improved my daily life, even when navigating the city alone. Their willingness to share their knowledge and make my experience in Urumqi more comfortable left a lasting positive impact.

Xinjiang Astronomical Observatory (XAO) offers excellent working conditions, contributing to a conducive and productive environment. The office spaces are both clean and spacious, featuring comfortable working chairs and sizable desks. The seminar room, equipped with modern amenities, facilitates efficient group meetings. The working conditions at XAO coupled with the availability of supporting amenities, are indeed excellent, fostering a comfortable and well-equipped environment for researchers and students.

FACILITIES

Platform

The colloquium on 1.93-m optical telescope for enhancing cooperation on telescope construction

The colloquium on 1.93-m optical telescope was held in Atushi city from May 25 to 29, 2023. More than 150 scholars and students from over 30 institutes, universities and governmental units attended the colloquium.

The 1.93-m optical telescope is jointly built by Xinjiang Astronomical Observatory (XAO), Beijing Normal University, Nanjing Institute of Astronomy and Optical Telescope, Xinjiang University and the local government of Kizilsu Kirghis Autonomous Prefecture.

At the colloquium, the five partners stated that the 1.93-m optical telescope represented not only a significant step to the optical facility construction in the western China, but also a vigorous promotion for the scientific development and talent cultivation in Kizilsu Kirghis Autonomous Prefecture. They also stated that they will spare no efforts to speed-up the construction of the telescope with cutting-edge technologies.

In addition, the construction of the 1.93-m optical telescope kicked off at the Muztagh station of XAO on May 27. It is expected that the telescope will make significant contributions to deep space exploration, and the study of gravitational waves, supernove, AGN, exoplanet searching and near-Earth object monitoring.

"The cold and dry climate at high-altitudes, combined with a sparse population far away from the city, make the Muztagh site one of the most preferred location for optical observations. We look forward to attracting more astronomical institutes to establish their telescopes at Muztagh site in the future, and we believe that the site will be a shinning pearl at the Silk Road Economic Belt." said Dr. WANG Na, the Director of XAO.

Telescopes

The NanShan 26-m Radio Telescope

The 26-m NanShan Radio Telescope (NSRT) is located at 87°10.67' E and 43°28.27' NB and at elevation of 2080.5m. The overall project to upgrade the previously 25-m NSRT started in early 2014 and completed in late 2015. The aperture of the telescope is now 26 meters, and currently equipped with L-, S/X-, C-, and K-band receivers and a Q-band receiver is on the way. The NSRT backend system is composed of VLBI backend, DFB and continuum backend, which are employed to complete the VLBI observations, pulsar and spectral line observations and AGN flux monitoring, respectively.

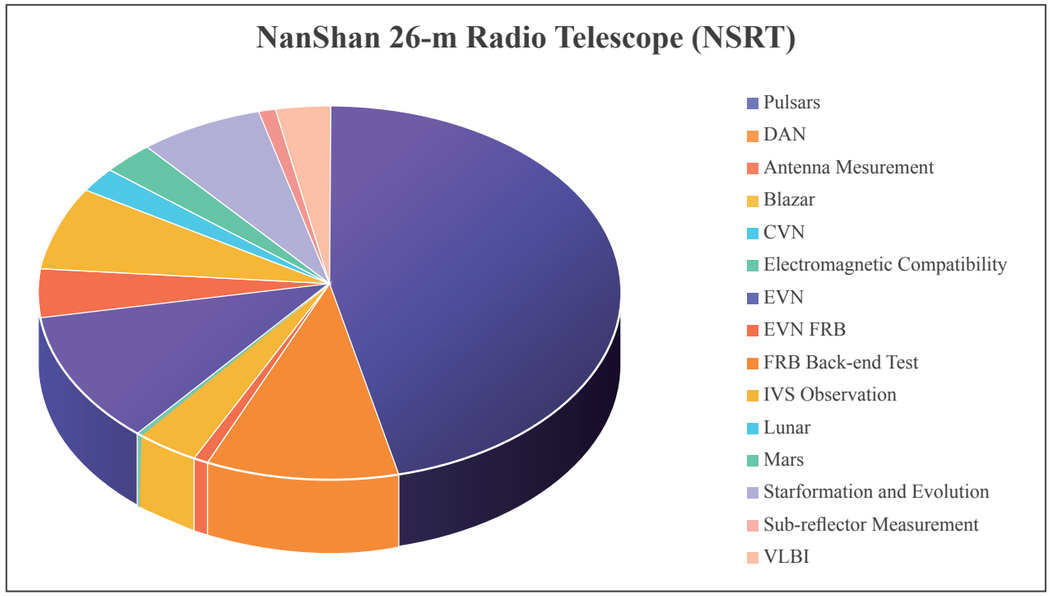
The Nanshan One-meter Wide-field Telescope

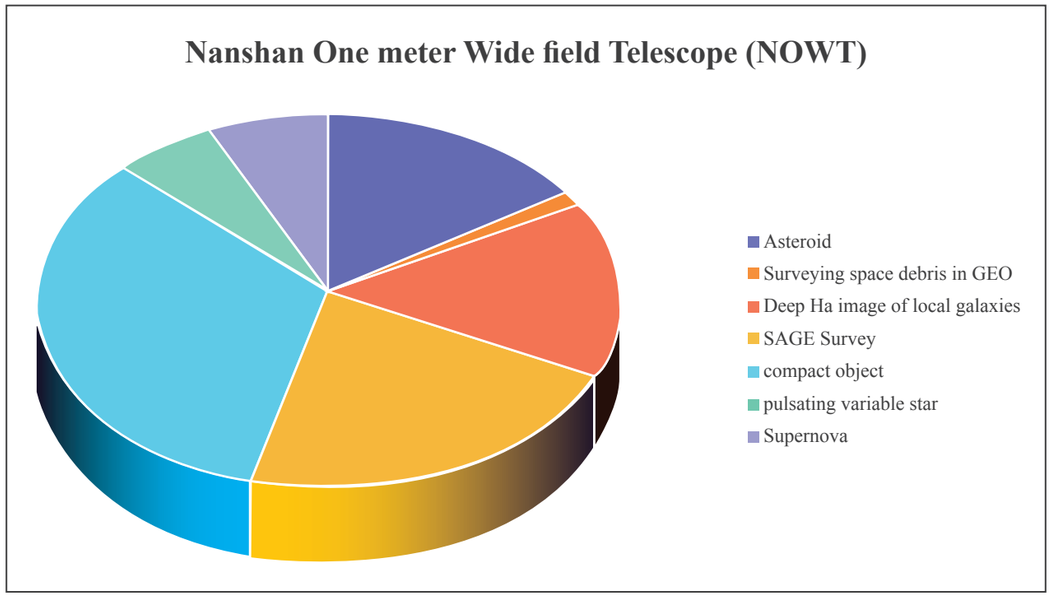
The Nanshan One-meter Wide-field Telescope (NOWT) was installed in March 2012. A distinctive feature of NOWT is its Alt-Azimuth mount configuration operating at prime focus with a field corrector. The effective field-of-view (FOV) is 1.37 degrees×1.37 degrees. The imaging system comprises a CCD camera mounted above a field derotator and a filter wheel. The filter wheel, featuring five positions, accommodates either the standard Johnson-Cousins (UBVRI) filters, the Sloan Digital Sky Survey (u'g'r'i'z') filters, or the Strömgren (uvby) filter set.

The Nanshan 1.2-m Optical Telescope

The Nanshan 1.2-meter optical telescope is a reflector telescope featuring an Alt-Azimuth mounting system and incorporating two Nasmyth focuses. One of the Nasmyth focus is dedicated to quantum communication experiments, with equipment having a focal length exceeding 13,000 mm and capable of providing a field of view of no less than l' x l'. The other focus, designed for astronomical observations, has a focal length greater than 9,400 mm and a field of view of at least 20' × 20', and is supplied with a spectrometer. The spectrometer is equipped with two low-resolution gratings (R~1300, 7500) and one medium-resolution grating (R~18000), allowing switching between low and medium resolution modes. Currently, both focuses are actively engaged in quantum communication experiments and optical astronomical observations.

Observation statistics:





STUDENT EDUCATION:

XAO has a group of qualified supervisors to advise and monitor the academic progress of their students. By utilizing XAO's professional facilities and academic strengths, the supervisors foster the students' skills in astronomical observation, data analysis, and technology application, as well as their scholarly development. We recruit outstanding students from around the world to join XAO to pursue their dreams in astronomical research.

We encourage students to participate in astronomical education. A team at XAO known as the "Starry Dew", composed mainly of graduate students, is a non-profit organization dedicated to astronomical education. Since its establishment, the team has vigorously carried out many astronomical popular science activities. In 2023, over 20 activities were conducted, which attracted almost 20,000 participants. The activities included popular science lectures, 'roadside astronomy', astronomical observations, and special lectures and activities in primary and secondary schools, colleges, and communities on the day of significant celestial events. Through these activities, the public's interest in astronomy has increased, and the students' innovative and practical abilities have also been enhanced.

SCIENCE FOR THE PUBLIC:

In 2022, XAO began the construction of a space museum in Yuli County to support the development of Daxi Village in Yuli County of Bayin'gholin Mongol Autonomous Prefecture. On 31 May 2023, which was also the seventh "National Science and Technology Workers' Day," the project was completed and a ceremony was held for the launch of the venue and the handover of keys. This is an important initiative by XAO to leverage its astronomical and scientific technology to support the rural revitalization strategy.

The space museum covers an area of 560 square meters. It is divided into sections such as the astronomy exhibition area, the space exhibition area, the achievement exhibition area, and the realistic simulation areas for the moon and Mars. It primarily uses model displays and interactive experiences to showcase the basic knowledge of astronomy and space, as well as the significant achievements made by the Chinese Academy of Sciences in astronomy and space exploration in recent years.

Over the past two years, XAO has organized a team of professional science popularization lecturers and graduate student volunteers, extending astronomical science knowledge to rural areas, primary and secondary schools,and communities. They conducted a series of activities, including telescope operation training, astronomy lectures, science and technology instructor training, and solar observation. With a total of 35 events and attracted nearly 25,000 participants, this has greatly enhanced the public's interest in astronomical science.

The local residents and students have expressed their gratitude, saying "Thank you to our friends from XAO for bringing us treasures," and found it puzzling that "The moon in the telescope has 'little bubbles' on it." The square of Daxi Village is pleasantly cool at night, but the enthusiasm of the people from all ethnic groups in Daxi Village continues to rise in front of the "eyes looking into the universe." We are delighted to know that Daxi Village has continuously released the dividends of improved public scientific literacy through popular science. We look forward to paint a new and charming "scientific" village card in Daxi village.