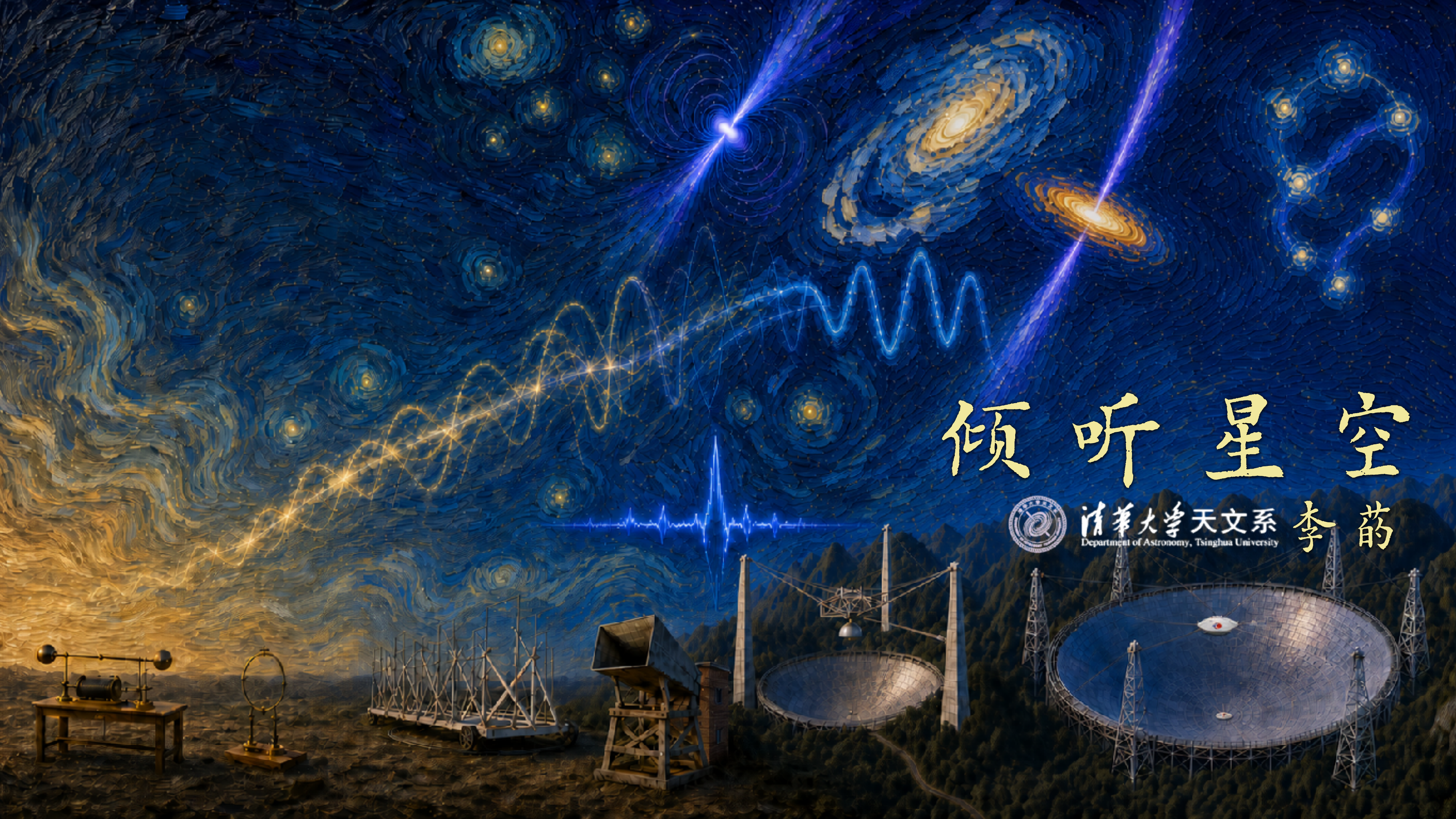


倾听星空



清华大学天文系 李菡
Department of Astronomy, Tsinghua University



平方公里阵 SQUARE KILOMETER ARRAY



批准书

中华人民共和国主席根据中华人民共和国第十三届全国人民代表大会常务委员会第二十八次会议的决定，批准二〇一九年三月十二日在罗马签署的《建立平方公里阵列天文台公约》。

中华人民共和国对条约中所载一切完全遵守。

为此，中华人民共和国主席在批准书上签字并加国印，以资证明。

中华人民共和国主席

A black ink signature, likely of Xi Jinping, in a cursive style.

中华人民共和国外交部长

A black ink signature, likely of Wang Yi, in a cursive style.

二〇二一年四月二十九日于北京

2026.2 SKA 国际科学委员会





Rendong Nan
FAST Chief Scientist
(2007-2017)



Phil Dimond
SKA director
(2011-2026)



Richard Schilizzi
SKA director
(2003-2011)

EARLY SKA CONCEPTS (1995–2005)

Three technological paths toward a square kilometre of collecting area

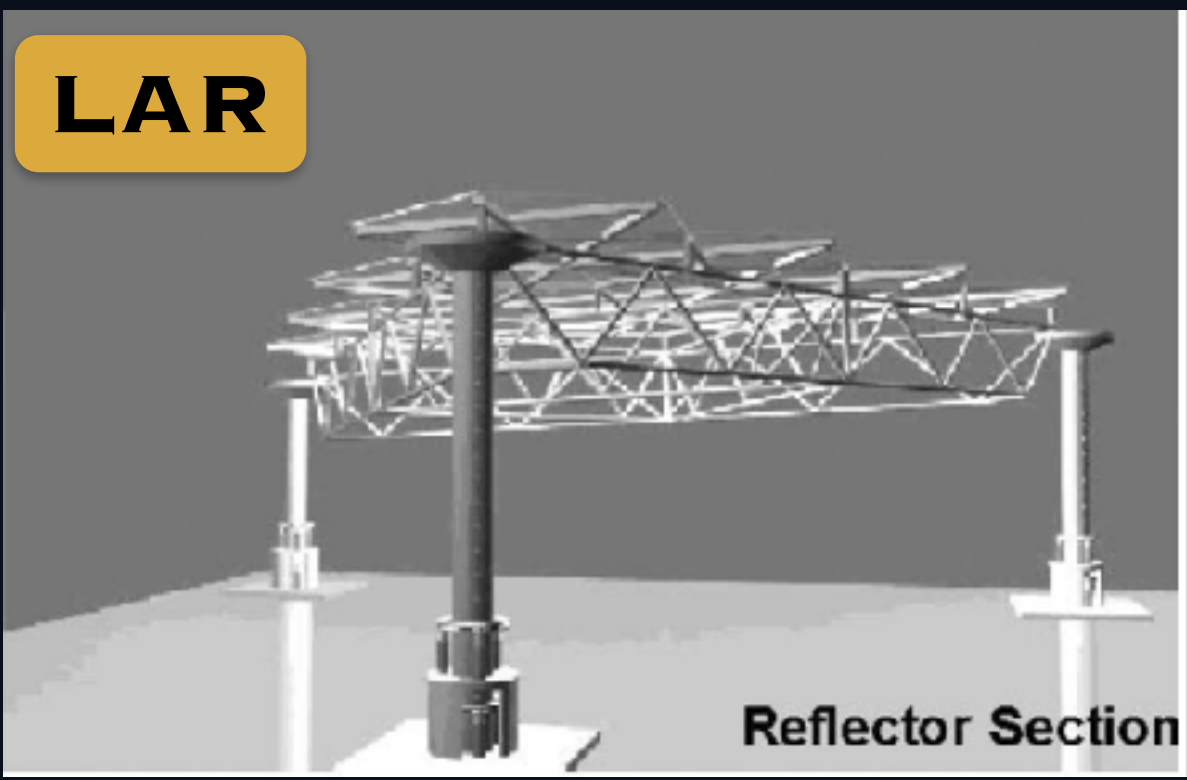
奥德赛-长征



FAST (NAN 2011)

LARGE NUMBER OF SMALL DISHES

- Mass production
- Excellent imaging
- Scalable architecture



LAR

LARGE ADAPTIVE REFLECTOR

- Aerostat-supported feed
- Extreme sensitivity
- High engineering risk



AA

APERTURE ARRAYS

- Electronic beamforming
- Huge FoV
- Multi-beaming

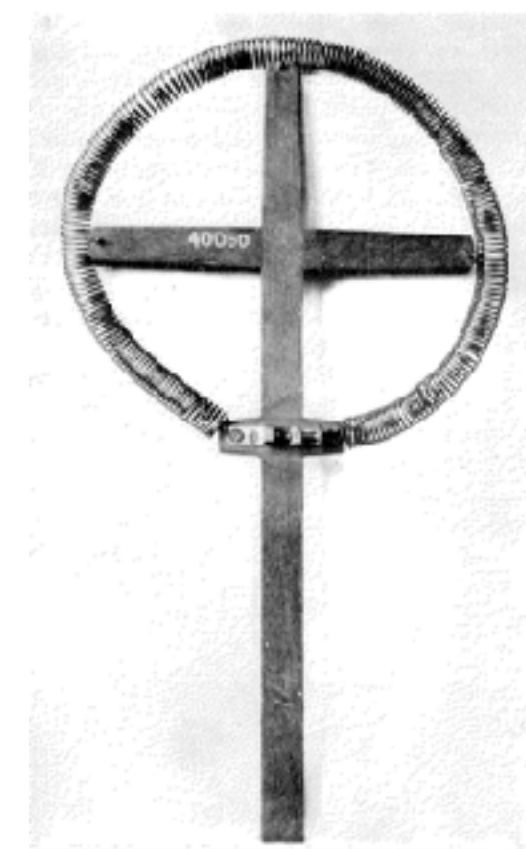
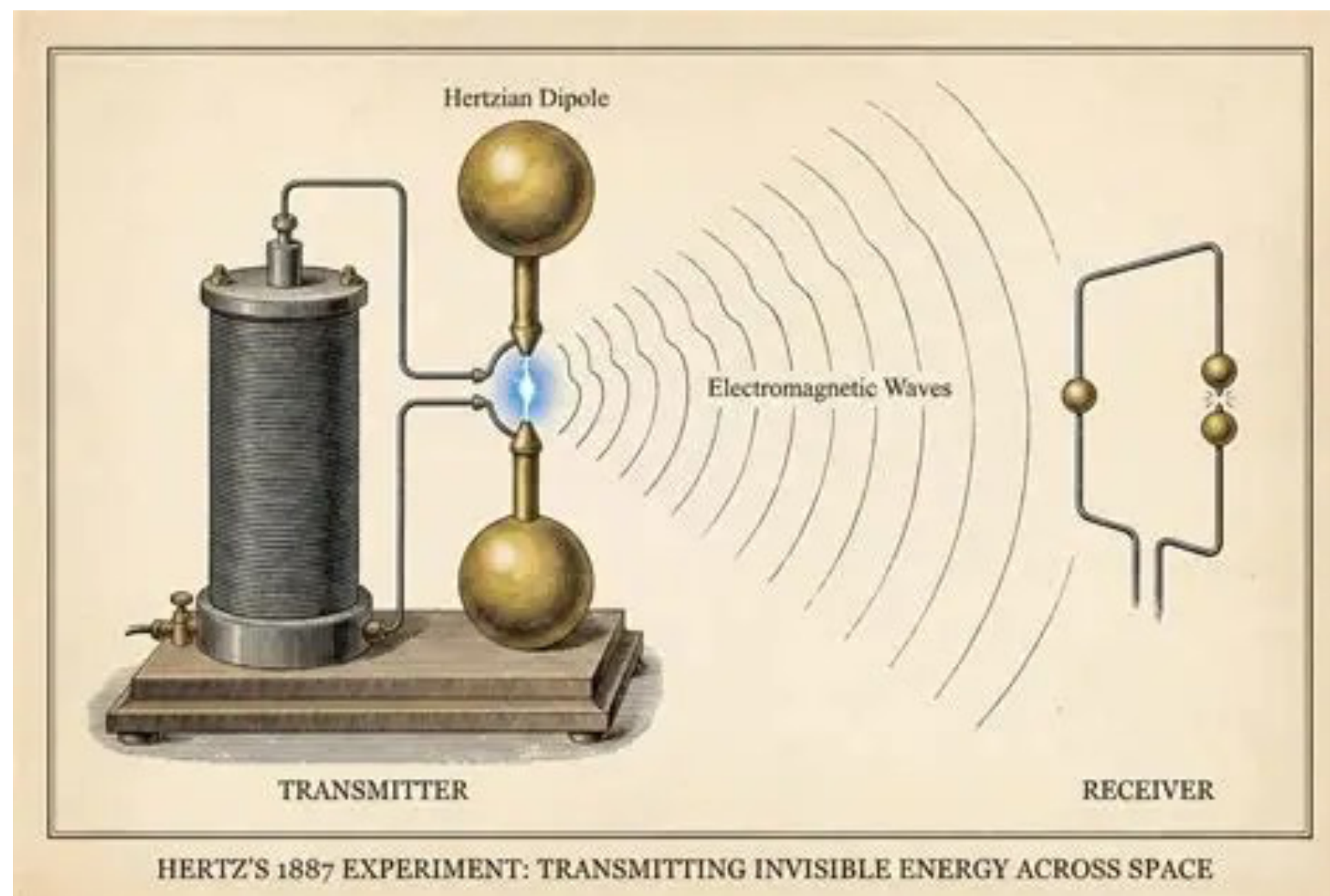
OUTCOME: LNSD → SKA-MID | LAR → FAST | APERTURE ARRAYS → SKA-LOW

Hall (2000); Dewdney et al. (2003); Schilizzi et al. (2007); ATA Concept Studies; Canadian Large Adaptive Reflector Project.



Heinrich Hertz 赫兹

(22 February 1857 – 1 January 1894) a German physicist



验证了电磁波的存在

1 hertz = 1 cycle per second;
2G, 3G, 4G, 5G ... billions of cycles per second



人类
第一个天线

先驱 · 射电天文学



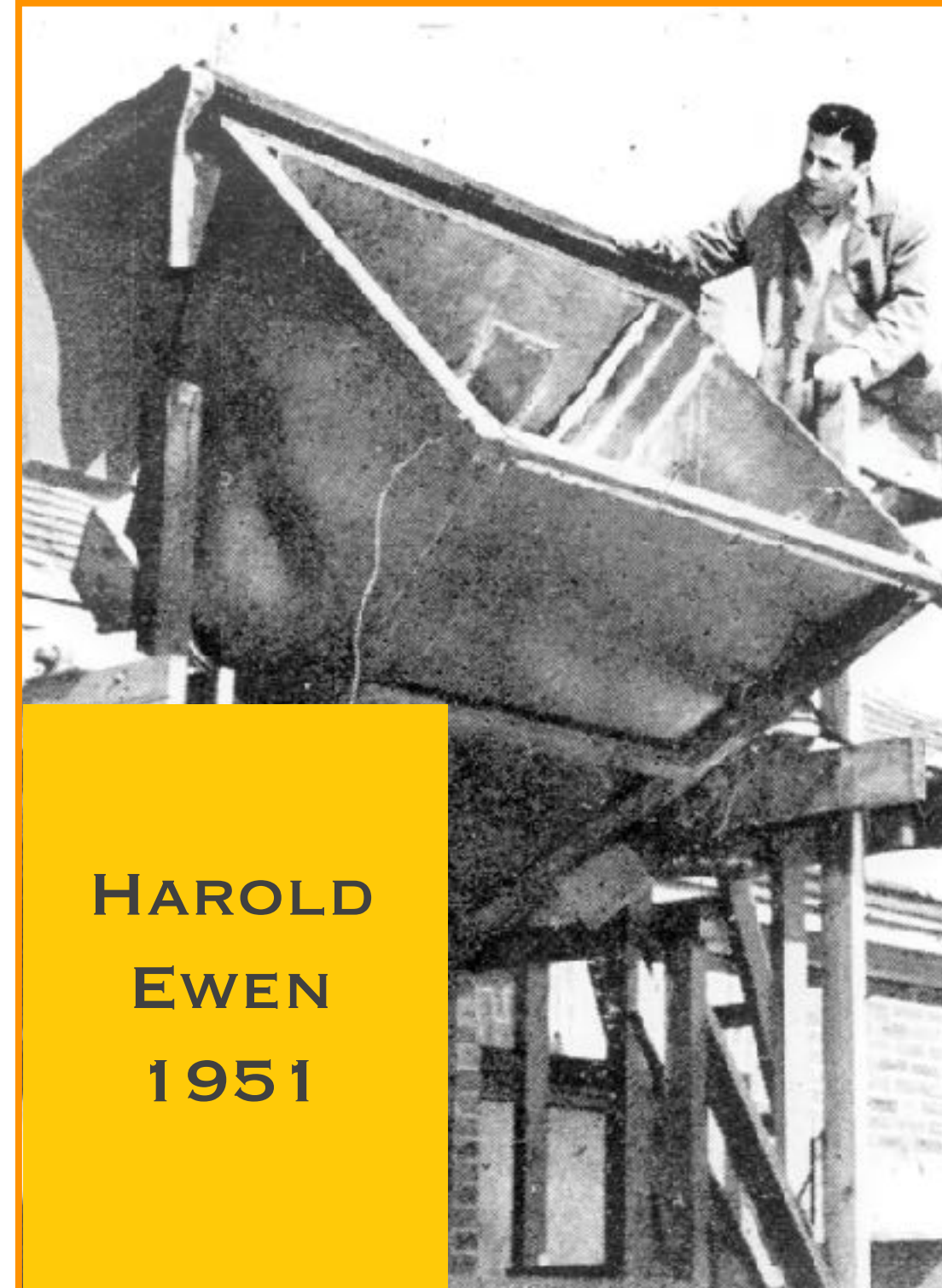
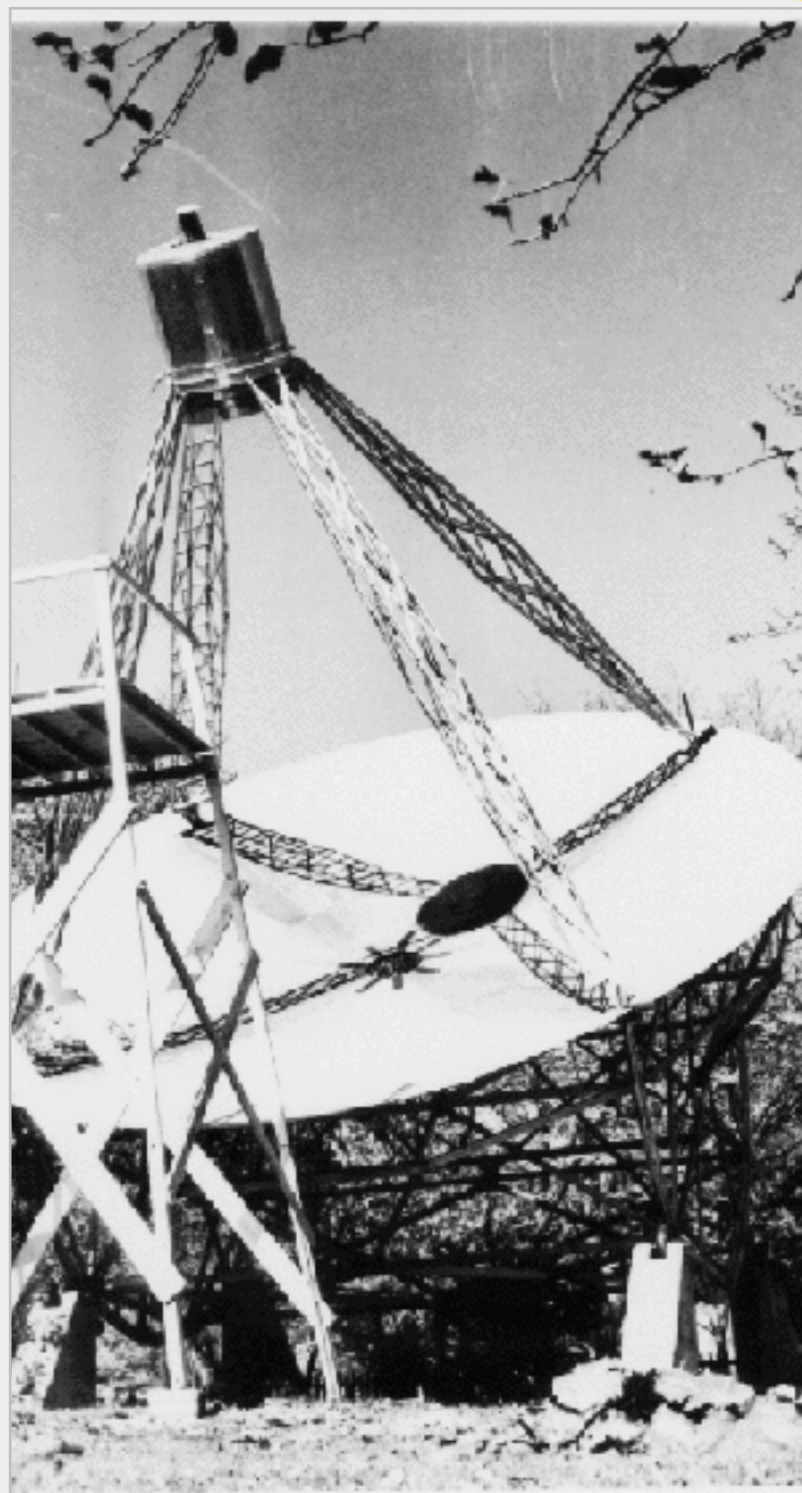
清华大学天文系
Department of Astronomy, Tsinghua University



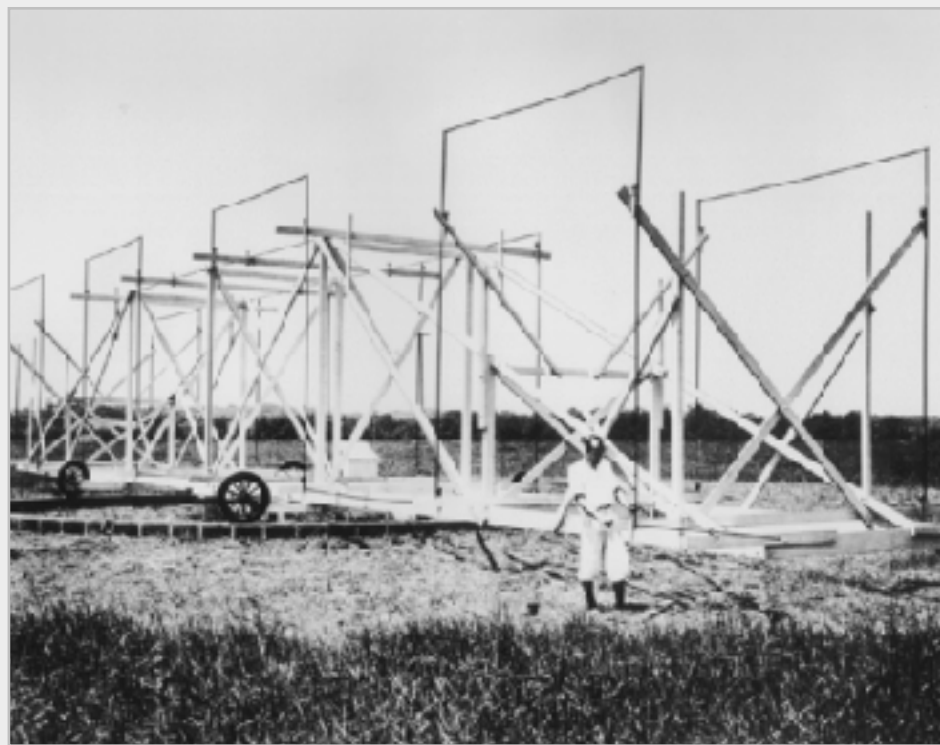
KARL
JANSKY
1932



GROTE
REBER
1938



HAROLD
EWEN
1951



发现 · 宇宙的原于气体辐射

HAROLD EWEN & EDWARD PURCELL
1951

Transit telescope designed to have the
Galactic Center pass through its beam

开创星际介质、银河
系动力学结构、恒星形
成及星际化学等许多天
文领域



**FREQUENCY
SWITCH**

发现 • 类星体

quasi-stellar objects
Quasar

3C 273

20世纪天文学
四大发现



3rd Cambridge catalog: 3C
(*Edge* 1959; @159 MHz, $>9Jy$)

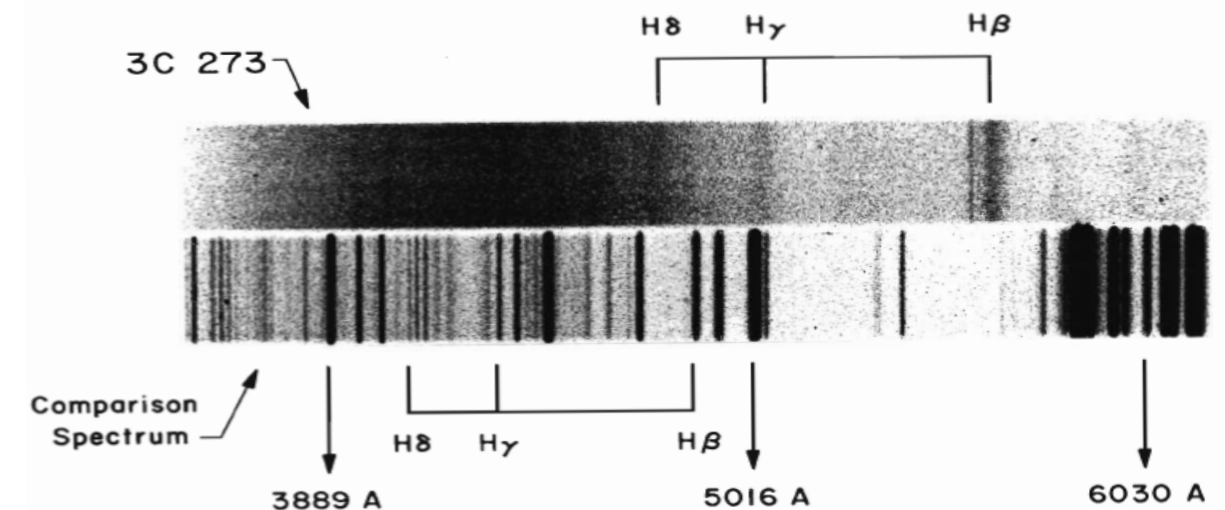
CYRIL HAZARD'S PRESENTATION

No. 4872 March 16, 1963 NATURE 1037

INVESTIGATION OF THE RADIO SOURCE 3C 273 BY THE METHOD OF LUNAR OCCULTATIONS

By C. HAZARD, M. B. MACKEY and A. J. SHIMMINS
C.S.I.R.O. Division of Radiophysics, University Grounds, Sydney

THE observation of lunar occultations provides the most accurate method of determining the positions of the components of the radio source 3C 273 reported by Hazard, Mackey and Shimmins in the preceding article are a star of about thirteenth magnitude. The spectral indices for components A and B of 3C 273 are -0.9 and 0.0 respectively. The spectral index of A is a



3C 273: A STAR-LIKE OBJECT WITH LARGE RED-SHIFT

By DR. M. SCHMIDT

Mount Wilson and Palomar Observatories, Carnegie Institution of Washington, California Institute of Technology, Pasadena

THE only objects seen on a 200-in. plate near the positions of the components of the radio source 3C 273 reported by Hazard, Mackey and Shimmins in the preceding article are a star of about thirteenth

Table 1. WAVE-LENGTHS AND IDENTIFICATIONS

λ	$\lambda/1.158$	λ_0	
3230	2797	2798	Mg II
4595	3968	3970	H ϵ
4753	4104	4102	H δ

The Nobel Prize in Physics 1974

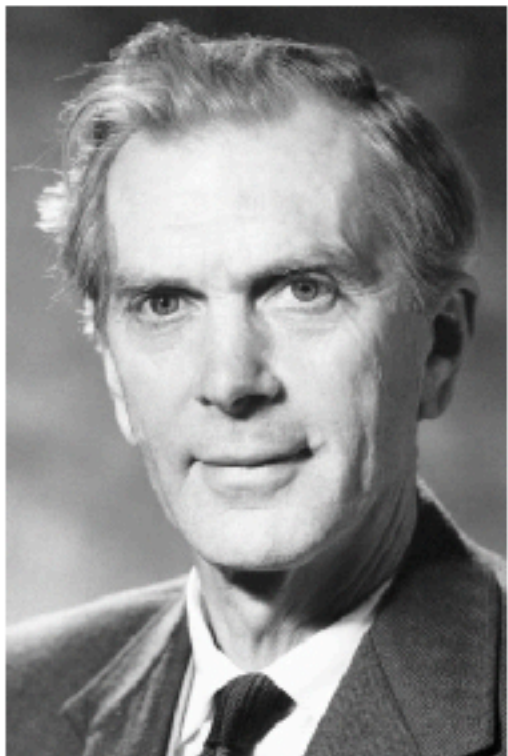


Photo from the Nobel Foundation archive.

Sir Martin Ryle

Prize share: 1/2



Photo from the Nobel Foundation archive.

Antony Hewish

Prize share: 1/2

The Nobel Prize in Physics 1974 was awarded jointly to Sir Martin Ryle and Antony Hewish "for their pioneering research in radio astrophysics: Ryle for his observations and inventions, in particular of the **aperture synthesis technique**, and Hewish for his decisive role in the discovery of pulsars"

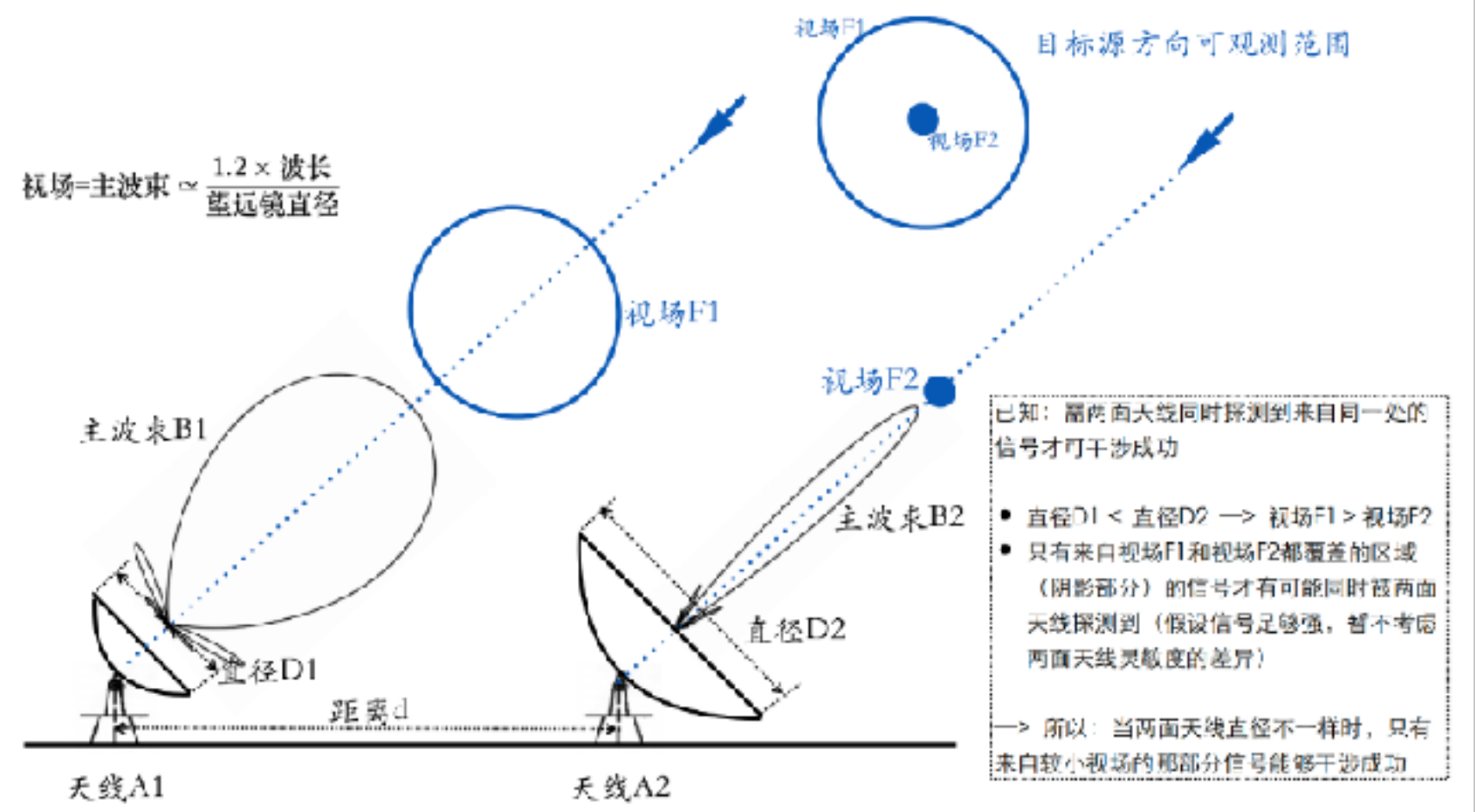
综合孔径

天线单元口径: d

单一基线等效口径: $d' = \sqrt{\eta_{coh}} \sqrt{d_1 \times d_2}$

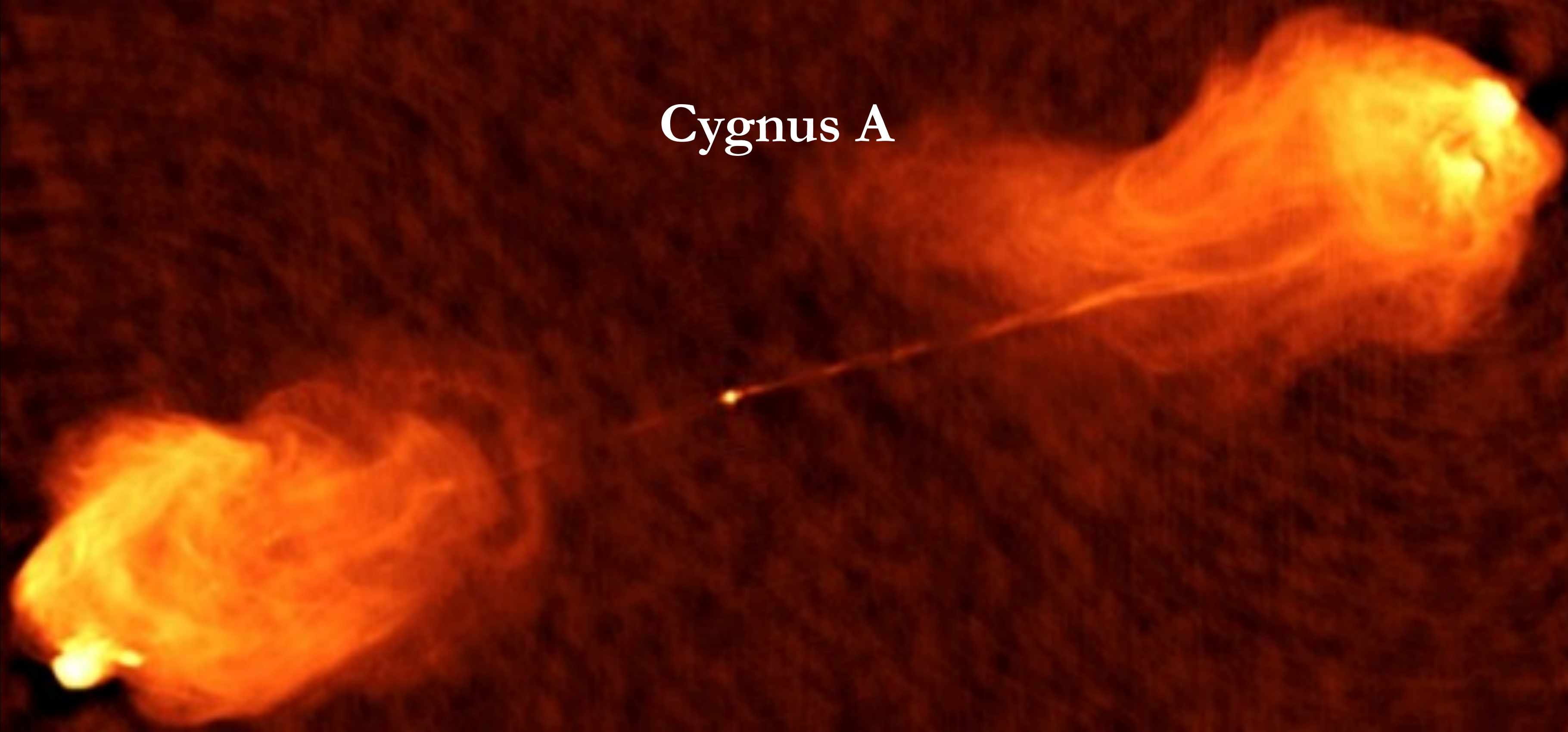
单元数量: n

综合孔径等效口径: $d * \sqrt{\eta_{coh}} \sqrt{\sqrt{n \times (n - 1)}}$





Very Large Array 1980 落成

A radio map of the Cygnus A galaxy cluster, showing two large, bright, irregularly shaped lobes of radio emission. The lobes are connected by a faint, diffuse bridge of emission. A thin, straight line of emission, likely a jet, extends from the central region between the lobes towards the bottom center of the image. The background is dark with some faint, diffuse emission.

Cygnus A

Quasars

(Carilli, 6cm, **VLA** / NRAO)



发现 · 宇宙微波背景辐射

CMB

20世纪天文发现



No. 1, 1965

LETTERS TO THE EDITOR

419

high pressure, such as the zero-mass scalar, capable of speeding the universe through the period of helium formation. To have a closed space, an energy density of 2×10^{-19} gm/cm³ is needed. Without a zero-mass scalar, or some other "hard" interaction, the energy could not be in the form of ordinary matter and may be presumed to be gravitational radiation (Wheeler 1958).

One other possibility for closing the universe, with matter providing the energy content of the universe, is the assumption that the universe contains a net electron-type neutrino abundance (in excess of antineutrinos) greatly larger than the nucleon abundance. In this case, if the neutrino abundance were so great that these neutrinos were degenerate, the degeneracy would have forced a negligible equilibrium neutron abundance in the early, highly contracted universe, thus removing the possibility of nuclear reactions leading to helium formation. However, the required ratio of lepton to baryon number must be $> 10^9$.

May 7, 1965

PALMER PHYSICAL LABORATORY
PRINCETON, NEW JERSEY

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Dicke, R. H., Berlinger, R., Kyhl, R. L., and Vane, A. B. 1946, *Phys. Rev.*, **70**, 340.

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Hoyle, F. 1948, *M. N.*, **108**, 372.

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Lifshitz, E. M., and Khalatnikov, I. M. 1963, *Adv. in Phys.*, **12**, 185.

Oort, J. H. 1958, *La Structure et l'Évolution de l'univers* (11th Solvay Conf. [Brussels: Éditions Stoops]), p. 163.

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Penzias, A. A., and Wilson, R. W. 1965, private communication.

Wheeler, J. A., 1958, *La Structure et l'Évolution de l'univers* (11th Solvay Conf. [Brussels: Éditions Stoops]), p. 112.

——— 1964, in *Relativity, Groups and Topology*, ed. C. DeWitt and B. DeWitt (New York: Gordon & Breach).

Zel'dovich, Ya. B. 1962, *Soviet Phys.—J.E.T.P.*, **14**, 1143.

A MEASUREMENT OF EXCESS ANTENNA TEMPERATURE

AT 4080 Mc/s

Measurements of the effective zenith noise temperature of the 20-foot horn-reflector antenna (Crawford, Hogg, and Hunt 1961) at the Crawford Hill Laboratory, Holmdel, New Jersey, at 4080 Mc/s have yielded a value about 3.5° K higher than expected. This excess temperature is, within the limits of our observations, isotropic, unpolarized, and

LETTERS TO THE EDITOR

Vol. 19

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free from small variations (until April, 1965). A possible explanation for the observed excess temperature is that given by Dicke, Peebles, Roll, and Wilkinson (1965) in a companion letter in this issue.

The total antenna temperature measured at the zenith is 6.7° K of which 2.3° K is due to atmospheric absorption. The calculated contribution due to ohmic losses in the antenna back-lobe response is 0.9° K.

The radiometer used in this investigation has been described elsewhere (Penzias and Wilson 1965). It employs a traveling-wave maser, a low-loss (0.027-dB) waveguide switch, and a liquid helium-cooled reference antenna (Penzias 1965). Measurements were made by switching manually between the antenna and the reference termination. The antenna, reference termination, and radiometer were well matched so that a round-trip return loss of more than 55 dB existed throughout the measurement; thus errors in the measurement of the effective temperature due to impedance mismatch can be neglected. The estimated error in the measured value of the total antenna temperature is 0.3° K and comes largely from uncertainty in the absolute calibration of the reference termination.

The contribution to the antenna temperature due to atmospheric absorption was obtained by recording the variation in antenna temperature with elevation angle and employing the secant law. The result, $2.3^\circ \pm 0.3^\circ$ K, is in good agreement with published values (Hogg 1959; DeGrasse, Hogg, Ohm, and Scovill 1959; Ohm 1961).

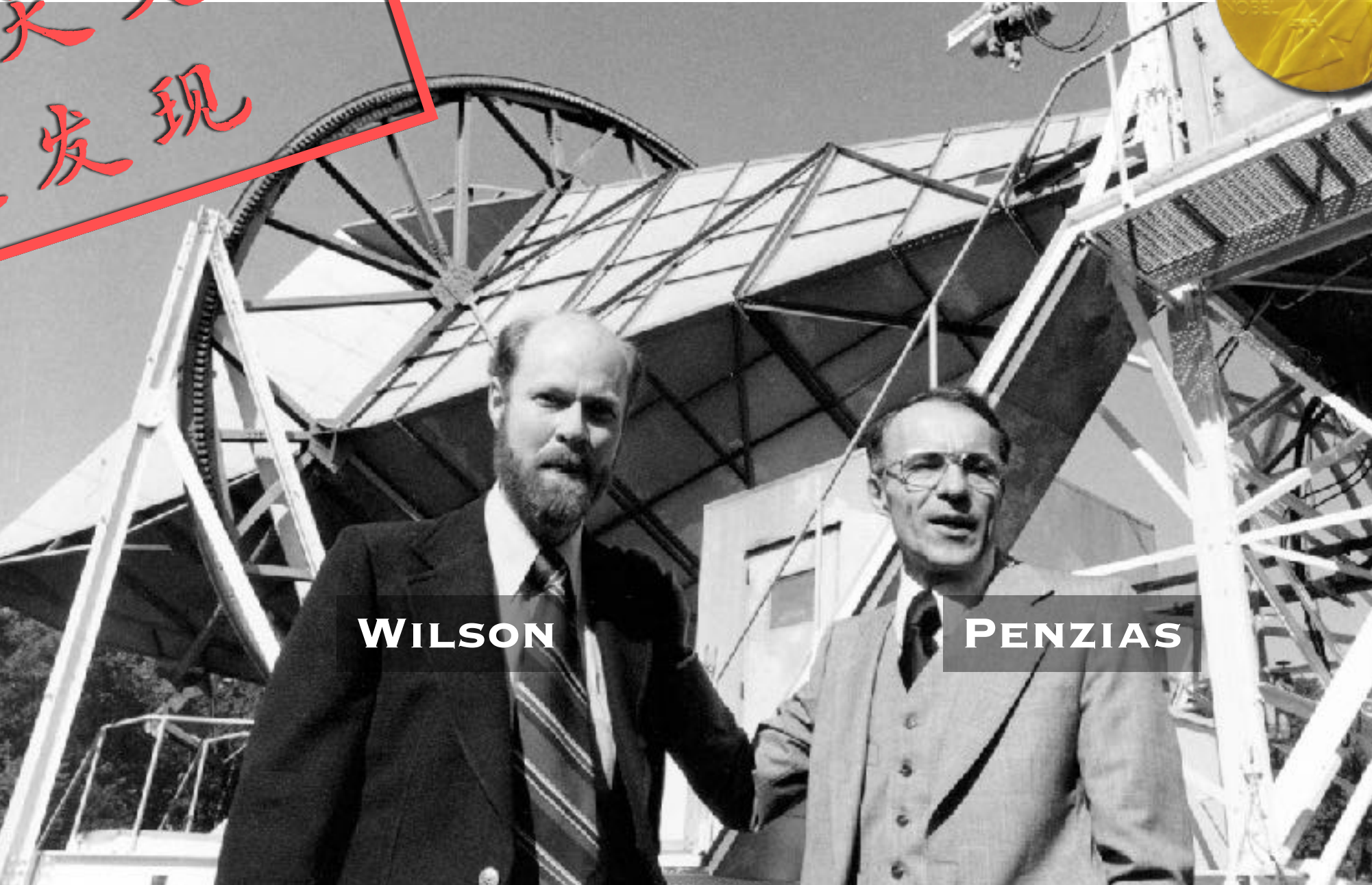
The contribution to the antenna temperature from ohmic losses is computed to be $0.8^\circ \pm 0.4^\circ$ K. In this calculation we have divided the antenna into three parts: (1) two non-uniform tapers approximately 1 m in total length which transform between the 24-inch round output waveguide and the 6-inch-square antenna throat opening; (2) a double-choke rotary joint located between these two tapers; (3) the antenna itself. Care was taken to clean and align joints between these parts so that they would not significantly increase the loss in the structure. Appropriate tests were made for leakage and loss in the rotary joint with negative results.

The possibility of losses in the antenna horn due to imperfections in its seams was eliminated by means of a taping test. Taping all the seams in the section near the throat and most of the others with aluminum tape caused no observable change in antenna temperature.

The backlobe response to ground radiation is taken to be less than 0.1° K for two reasons: (1) Measurements of the response of the antenna to a small transmitter located on the ground in its vicinity indicate that the average back-lobe level is more than 30 db below isotropic response. The horn-reflector antenna was pointed to the zenith for these measurements, and complete rotations in azimuth were made with the transmitter in each of ten locations using horizontal and vertical transmitted polarization from each position. (2) Measurements on smaller horn-reflector antennas at these laboratories, using pulsed measuring sets on flat antenna ranges, have consistently shown a back-lobe level of 30 db below isotropic response. Our larger antenna would be expected to have an even lower back-lobe level.

From a combination of the above, we compute the remaining unaccounted-for antenna temperature to be $3.5^\circ \pm 1.0^\circ$ K at 4080 Mc/s. In connection with this result it should be noted that DeGrasse *et al.* (1959) and Ohm (1961) give total system temperatures at 5650 Mc/s and 2390 Mc/s, respectively. From these it is possible to infer upper limits to the background temperatures at these frequencies. These limits are, in both cases, of the same general magnitude as our value.

We are grateful to R. H. Dicke and his associates for fruitful discussions of their results prior to publication. We also wish to acknowledge with thanks the useful comments and advice of A. B. Crawford, D. C. Hogg, and E. A. Ohm in connection with the problems associated with this measurement.

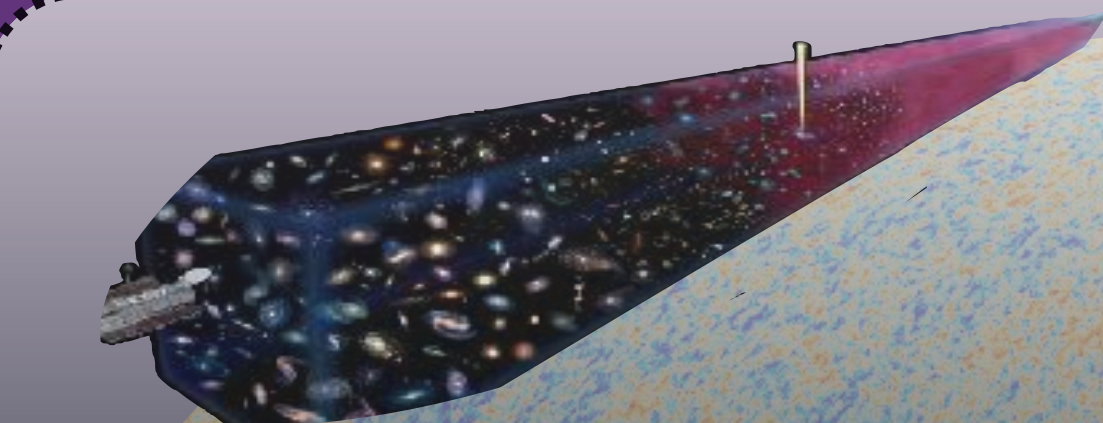


WILSON

PENZIAS

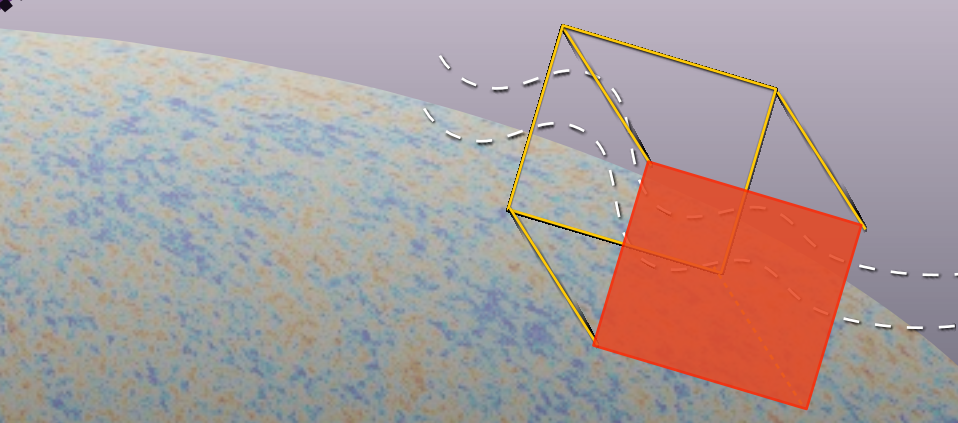
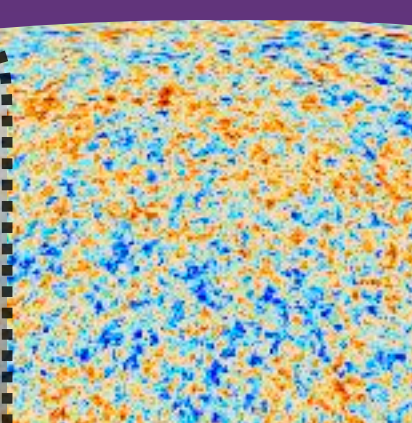
Penzias & Wilson 1965 ApJL

13.7 BILLION YRS



Matter

物质



作用场

Field

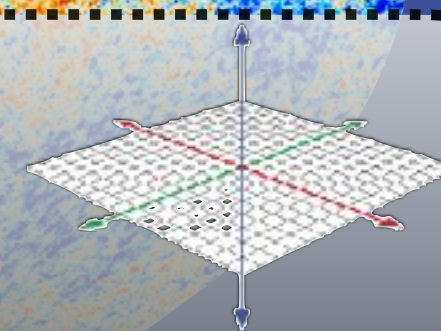
$$0 \equiv \frac{1}{\infty}$$

宇宙
量子化

Cosmos $< \infty$
Quantization

时间前沿

TIME FRONTIER



GALILEO

Cosmic Physics $< = >$ Radio Astronomy

HERTZ

发现

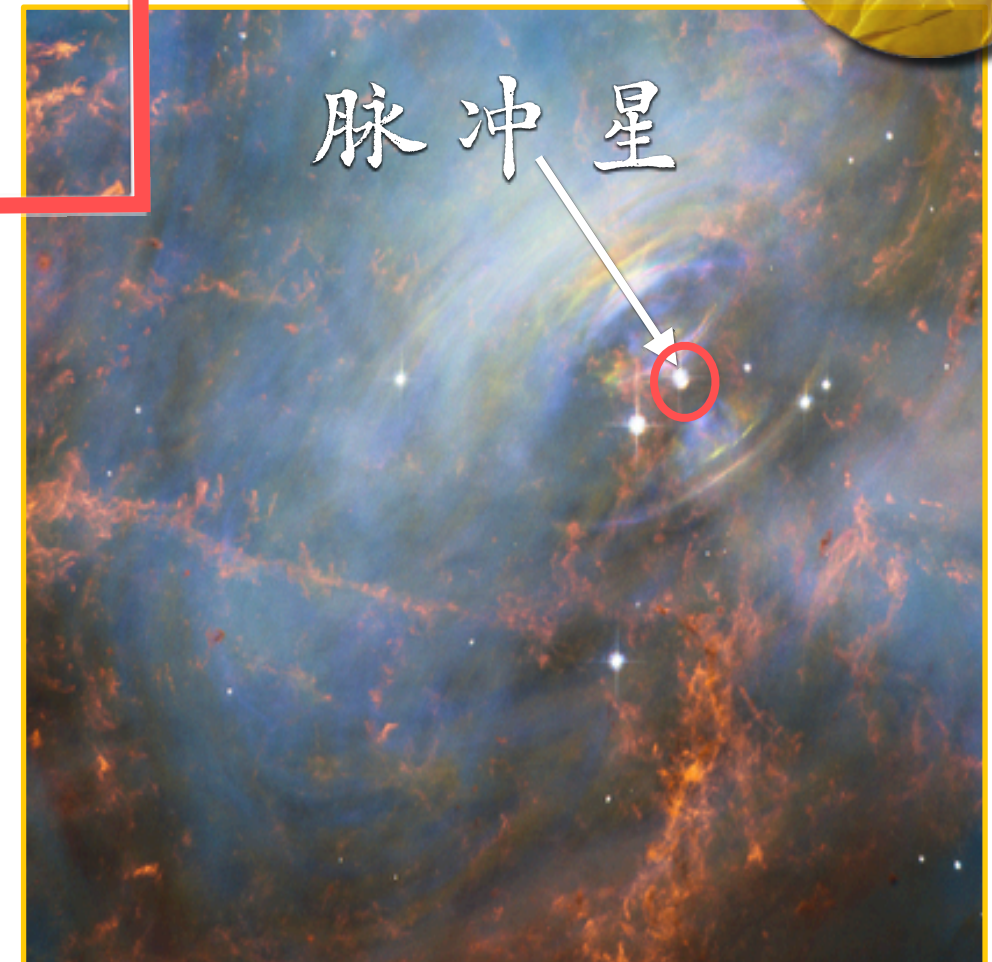
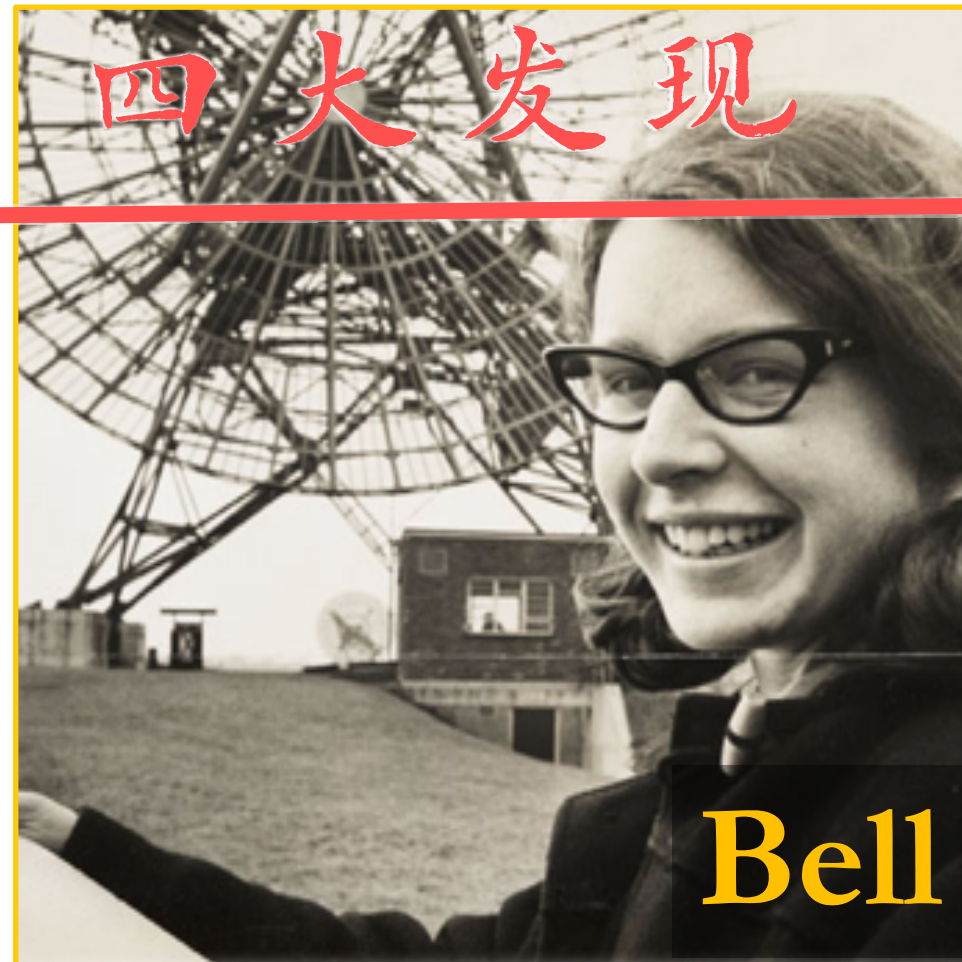
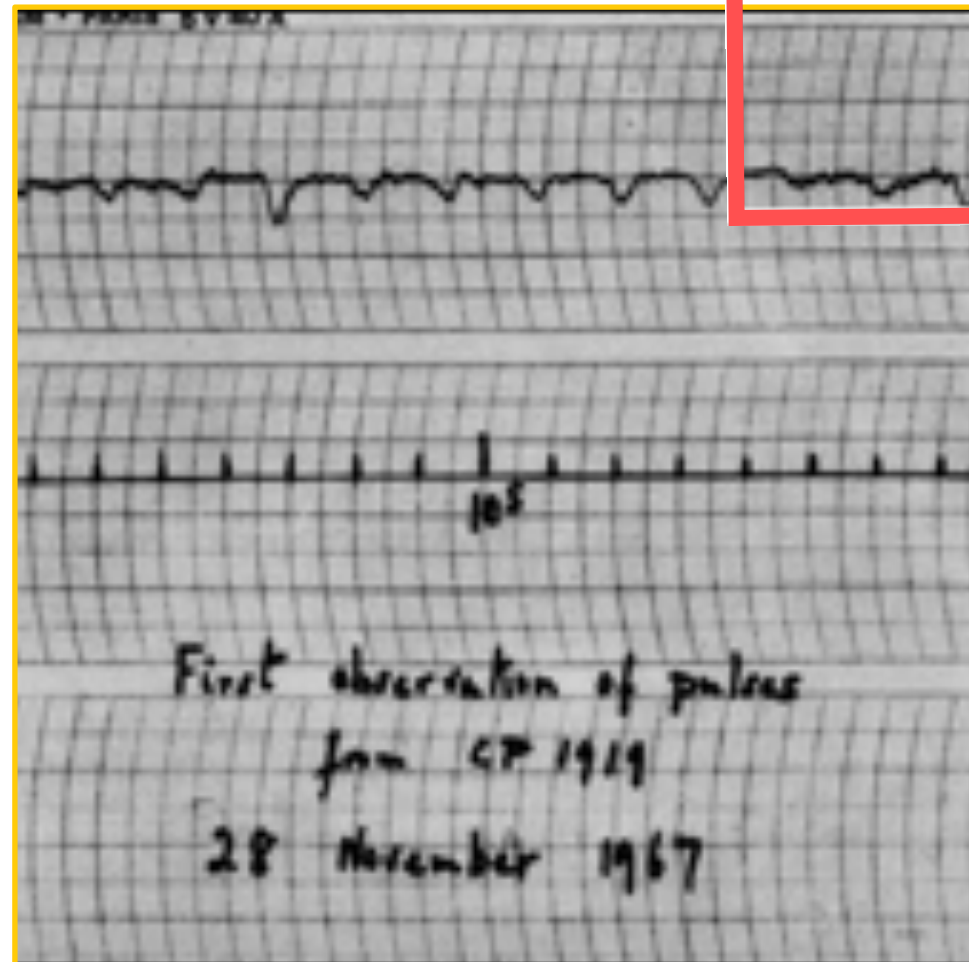
原理

发现 · 脉冲星 Pulsar

1967

20世纪天文学

四大发现



Hewish, Bell, Pilkington et al. **Nature**

白矮星：致密星新物态、压力



CHANDRASEKHAR



FOWLER

NOBEL PHYSICS

CHANDRASEKHAR / FOWLER

1983

恒星结构与演化；核反应形成元素

非相对论电子简并气体：

$$P = K_{nr} \rho^{5/3}$$

极端相对论极限：

$$P = K_r \rho^{4/3}$$

质量上限：

$$M \approx 1.44 (2/M_e)^2 M_\odot$$

- FOWLER：电子简并压支撑白矮星，恒星核素合成。
- CHANDRASEKHAR：相对论质量上限。
- 问题：超过上限后的终态是什么？





“巨型原子核” - 中子星



LEV LANDAU

1932 发表恒星理论
《ON THE THEORY
OF STARS》



JAMES CHADWICK

1932
发现中子

Landau 的高密度星核：
恒星中心可能进入类似巨大原子核的状态。

Chadwick：
中子让“neutron star”成为可计算对象。



NOBEL PHYSICS

CHADWICK

1935

发现中子



NOBEL PHYSICS

LANDAU

凝聚态理论
、液氦

1935

- 严格说，LANDAU 不是现代中子星模型；它是概念前身。
- 中子的实验发现把坍缩终态从类比变成核物理对象。



超新星通向中子星



WALTER
BAADE

SUPERNOVA /
NEUTRON STAR



FRITZ ZWICKY

SUPERNOVA /
COSMIC RAYS

普通恒星 → 超新星 → 中子星
恒星演化、爆发现象和高密度残骸放进同一因果链。

Remarks on Super-Novae and Cosmic Rays

of our complete ignorance with respect to the evolution of the universe. As the subject of super-novae is probably very unfamiliar we give here a few more details which

3. *Ions in super-novae*

If super-novae are giant analogues to ordinary stars, we may expect that ionized gas shells are expelled at great speeds. If this assumption is correct, cosmic rays should consist of protons and heavy nuclei. Direct tests by cloud chamber experiments at various altitudes are desirable in order to test this conclusion. Also the problem suggests itself to investigate how much energy corpuscular particles lose on their long journey through space. On the picture of an expanding universe this loss has been computed by R. C. Tolman.

These three systems are located within a sphere of radius

4. *Fluctuations of cosmic rays*

In our original papers we have calculated the change in intensity of cosmic rays caused by flare-ups of super-novae in nearby galaxies. The estimates given are perhaps too optimistic in view of the fact that the velocities of different particles are different. If various particles are ejected simultaneously at the time $t=0$ from a galaxy which is 10^6 light years away the times of arrival on the earth are

$t = 10^6$ years for light if its velocity does not depend on the frequency.

$t_1 = 10^6$ years + 410 seconds for 10^{11} volt electrons.
 $t_2 = 10^6$ years + 47.6 days for 10^{10} volt protons.
 $t_3 = 10^6$ years + 44 years for 10^{11} volt protons.

a neutron star.

5. *The super-nova process*

We have tentatively suggested that the super-nova process represents the transition of an ordinary star into a neutron star. If neutrons are produced on the surface of an ordinary star they will "rain" down towards the center if we assume that the light pressure on neutrons is practically zero. This view explains the speed of the star's transformation into a neutron star. We are fully aware that our suggestion carries with it grave implications regarding the ordinary views about the constitution of stars and therefore will require further careful studies.

W. BAADE
F. ZWICKY
W. Baade and F. Zwicky, Proc. Nat. Acad. Sci. May, 1934.
Mt. Wilson Observatory and
California Institute of Technology, Pasadena.
May 28, 1934.



蟹状星云

凡十一日没三年三月乙巳出東南方大中祥符四年正月丁丑見南斗魁前天禧五年四月丙辰出軒轅前星西北大如桃速行經軒轅太星入太微垣掩右執法犯次將歷屏星西北凡七十五日入濁没明道元年六月乙巳出東北方近濁有芒彗至丁巳凡十三日没至和元年五月己丑出天關東南可數寸歲餘稍没熙寧二年六月丙辰出箕度中至七月丁卯犯箕乃散三年十一月丁未出天囷元祐六年十一月辛亥出參度中犯掩側星壬子犯九游星十二月癸酉入奎至七年三月辛亥乃散紹興八年五月守婁



我们都是星尘。。。"
"We are all made of stardust ..."



射电脉冲星 = 旋转中子星



THOMAS GOLD

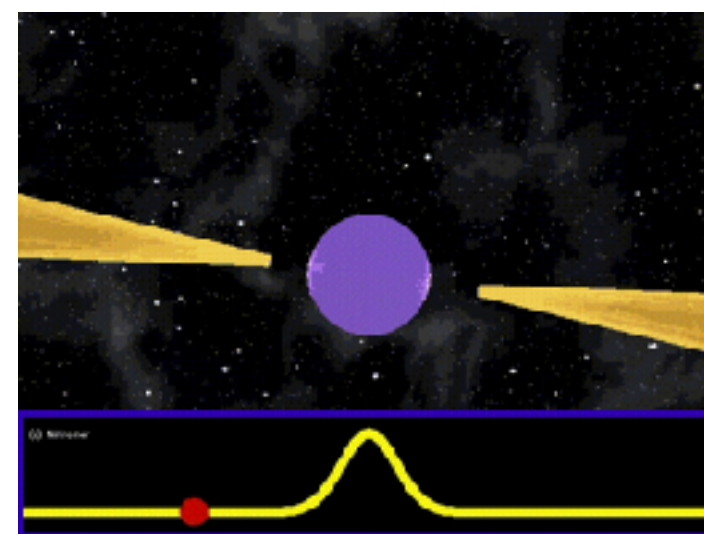


**CORNELL
ASTROPHYSICIST**

稳定周期 $\approx$ 普通恒星振荡；
能量来自中子星的自转变慢。

LIGHTHOUSE MODEL

磁轴扫过视线 $\rightarrow$ 周期性射电脉冲



- 1968 年，GOLD 提出 ROTATING NEUTRON STAR。
- 1969 年，CRAB PULSAR 的 $\dot{P} > 0$ 支持自转能损。
- PULSAR 辐射问题转化为中子星磁层问题。



中国科学院国家天文台

NATIONAL ASTRONOMICAL OBSERVATORIES, CAS



国际天文学联合大会
2012@北京

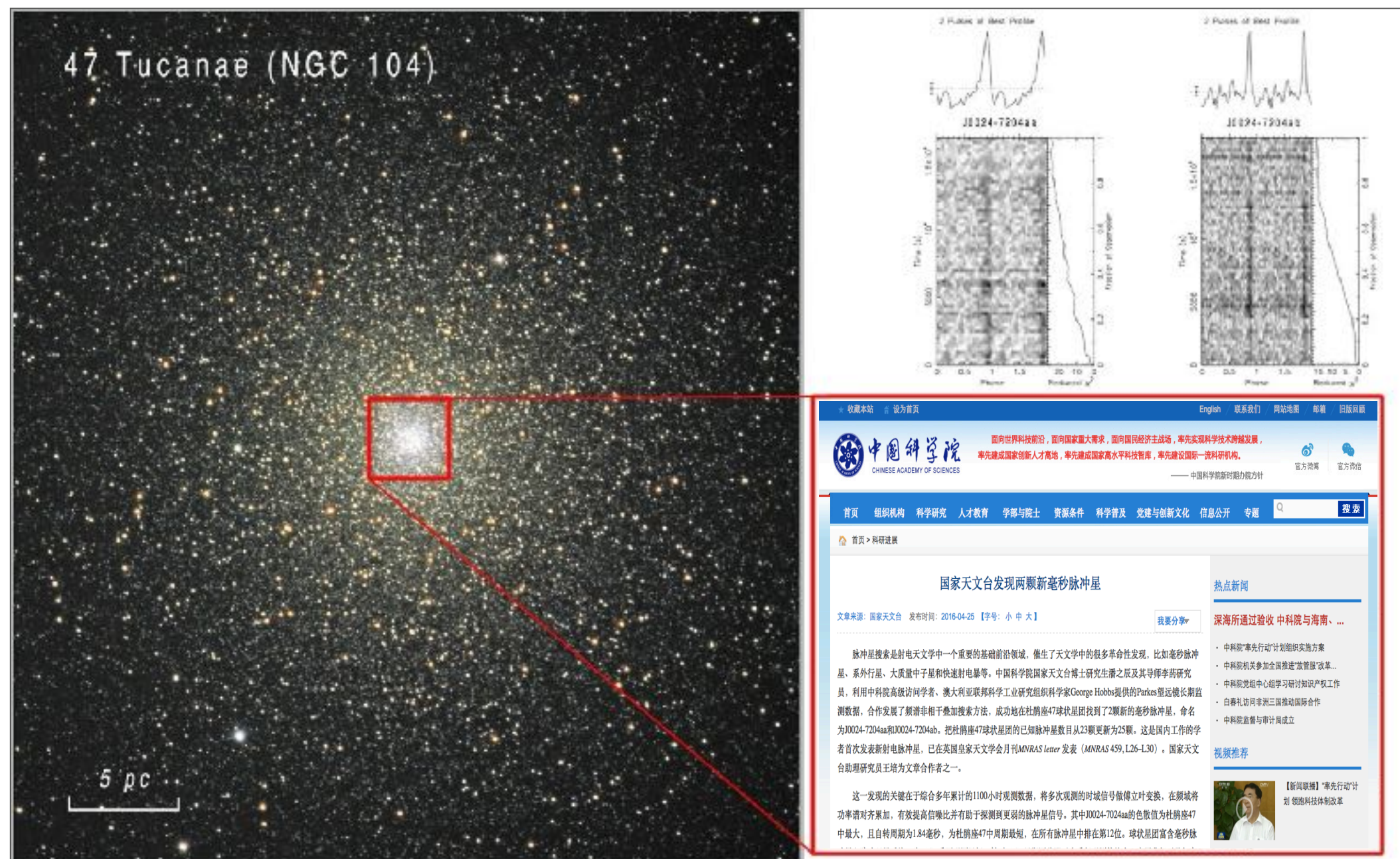


国际天文学联合大会
2015@夏威夷



学术讨论
2017@国家天文台

发现 · 毫秒脉冲星



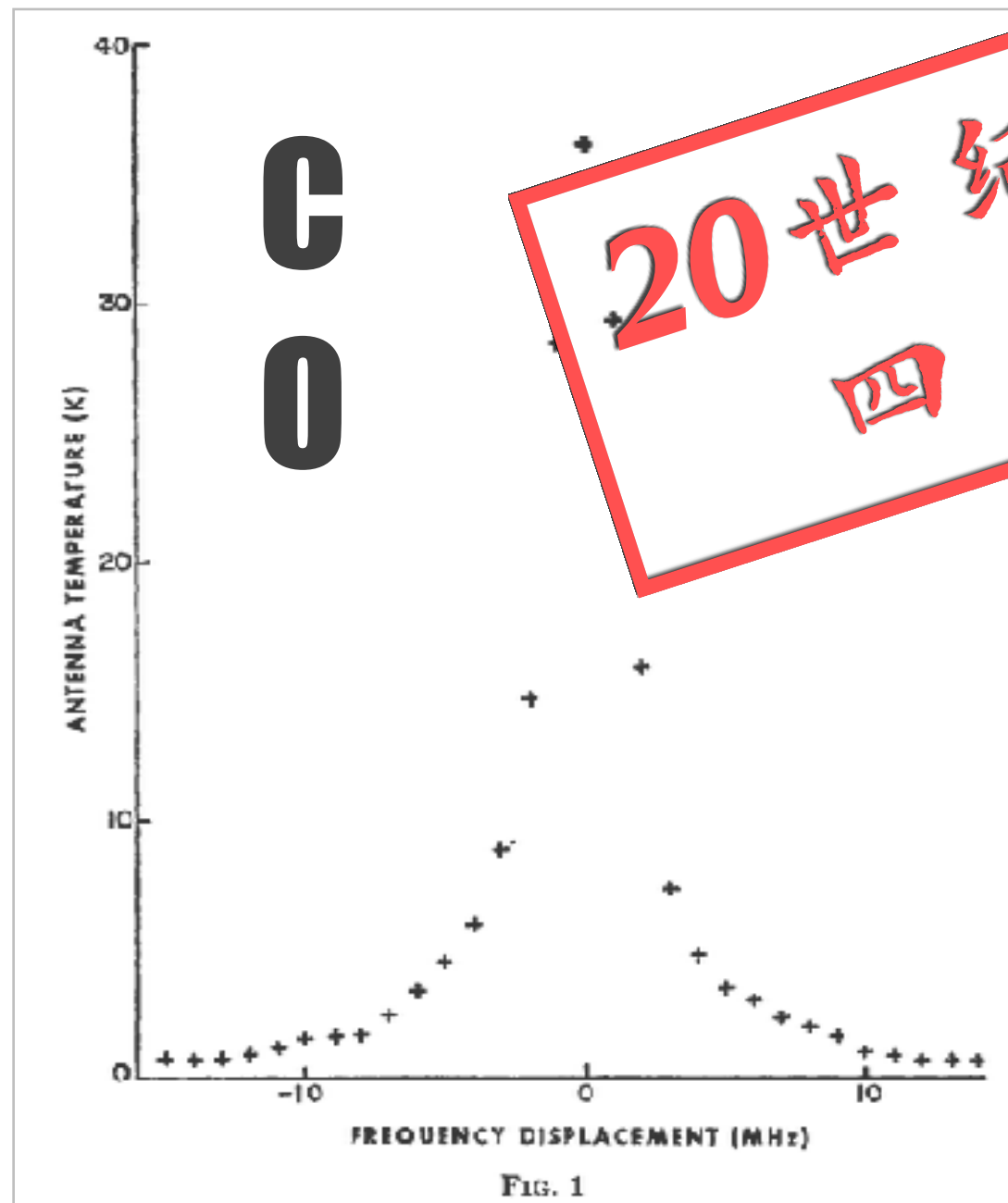
Monthly Notices ROYAL ASTRONOMICAL SOCIETY			
MNRAS 459, L26–L30 (2016) Advance Access publication 2016 March 16			
Discovery of two new pulsars in 47 Tucanae (NGC 104)			
Z. Pan, ¹ ★ G. Hobbs, ² D. Li, ^{1,3} A. Ridolfi, ⁴ P. Wang ¹ and P. Freire ⁴			
Pulsar Name	Possible Flux When Appears (mJy)	DM	Rotation Period (ms)
J0024-7204aa	0.1	24.869	1.8453804735
J0024-7204ab	0.05	24.376	3.704639405

中国团组
首次
发现新射电脉冲星

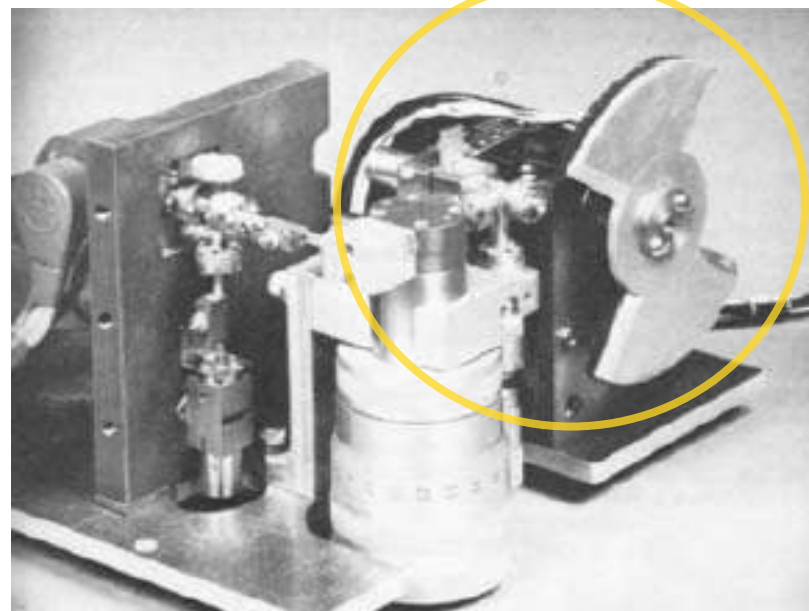
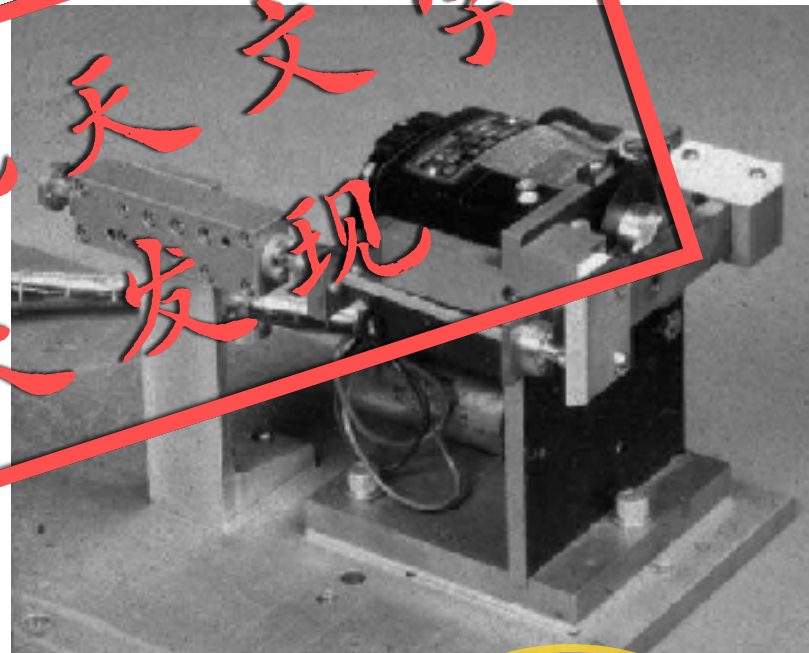
PAN, HOBBS, LI ET AL.
2016 MNRAS

发现 · 射电分子宇宙

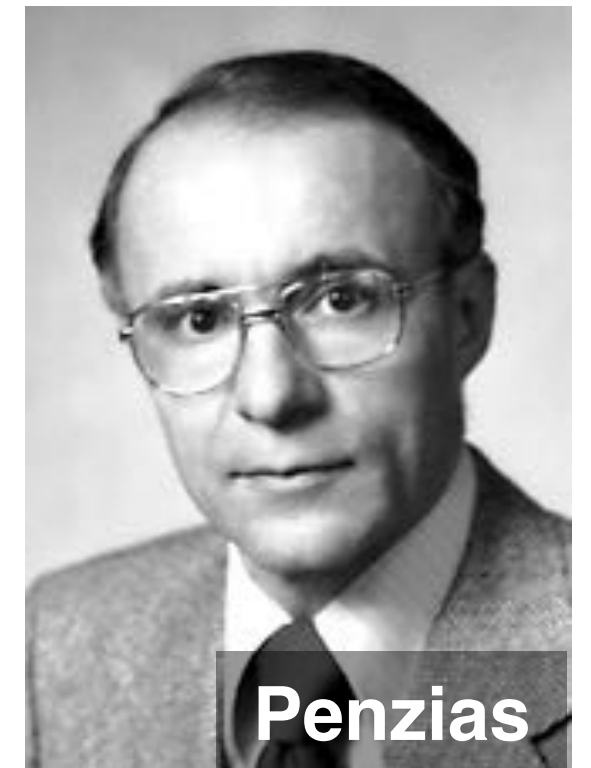
Interstellar Mols



20世纪天文学
四大发现



Wilson



Penzias

旋转轮定标等
毫米波天文技术

Penzias, Jefferts, Wilson 1970 *ApJL*

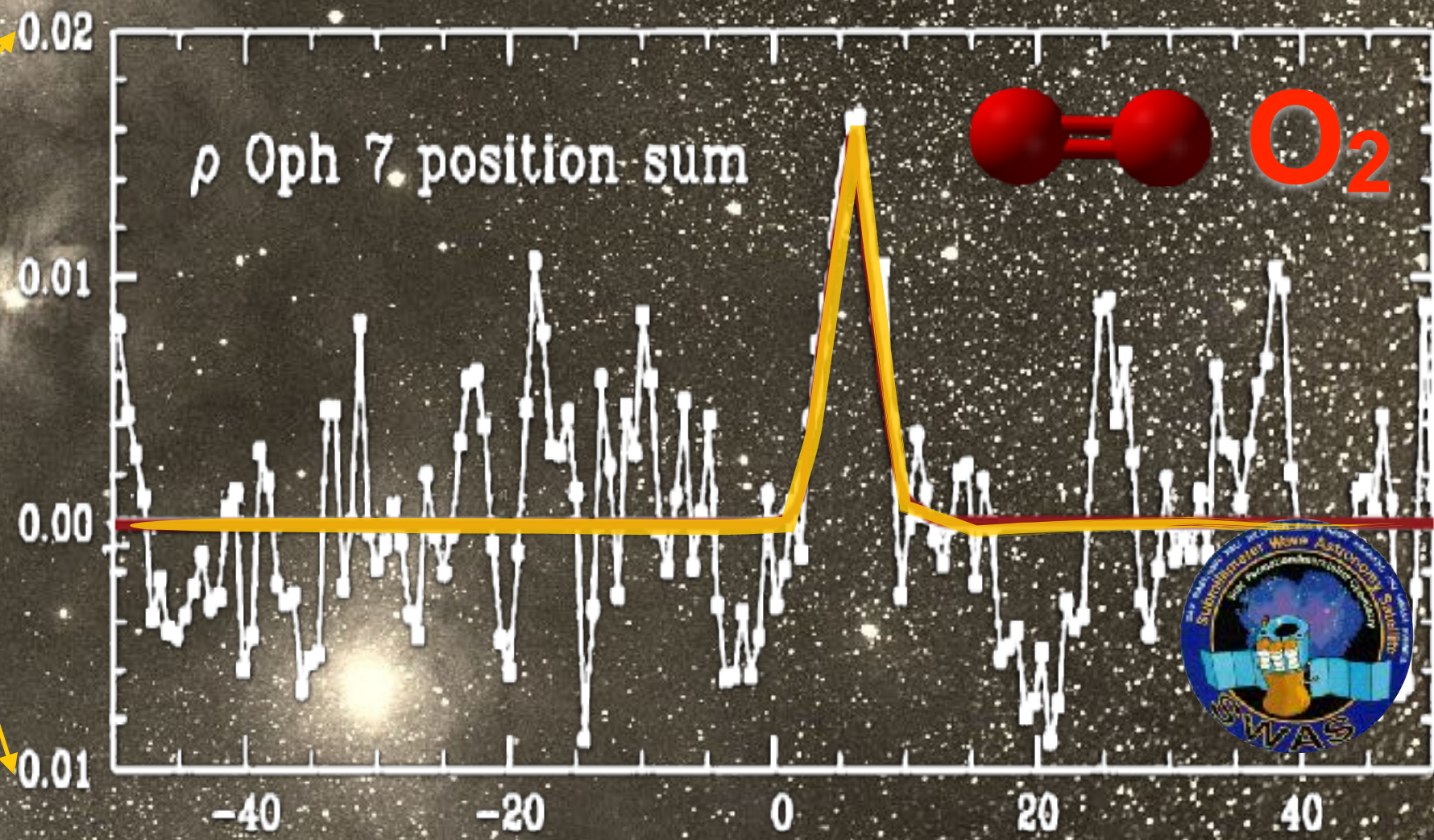
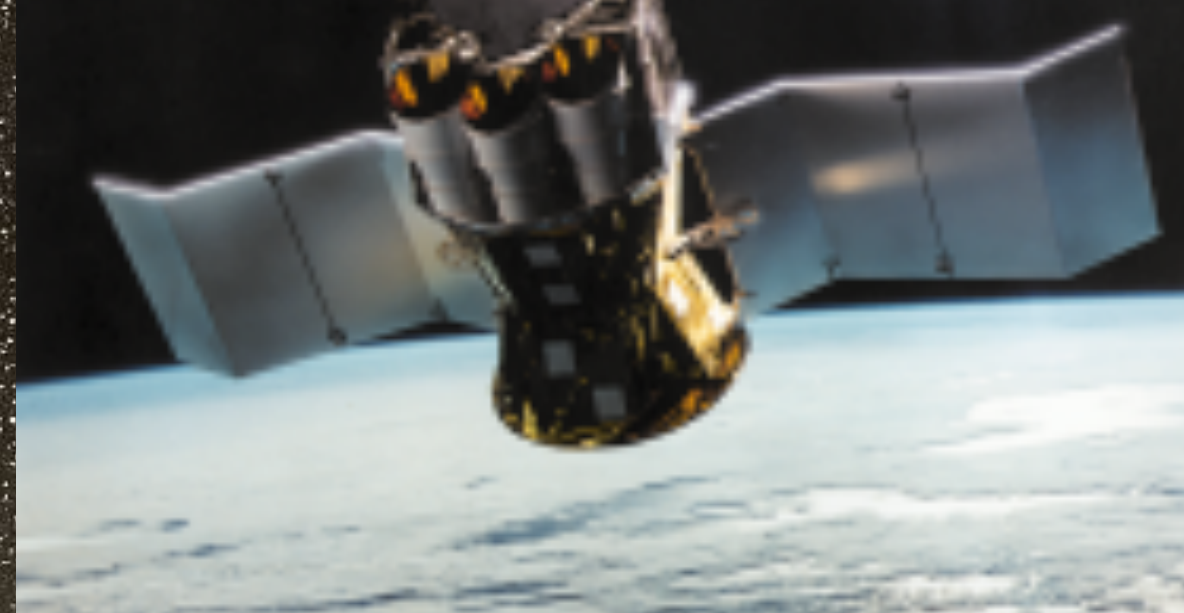
蛇夫座分子云

首次探测星际氧气分子

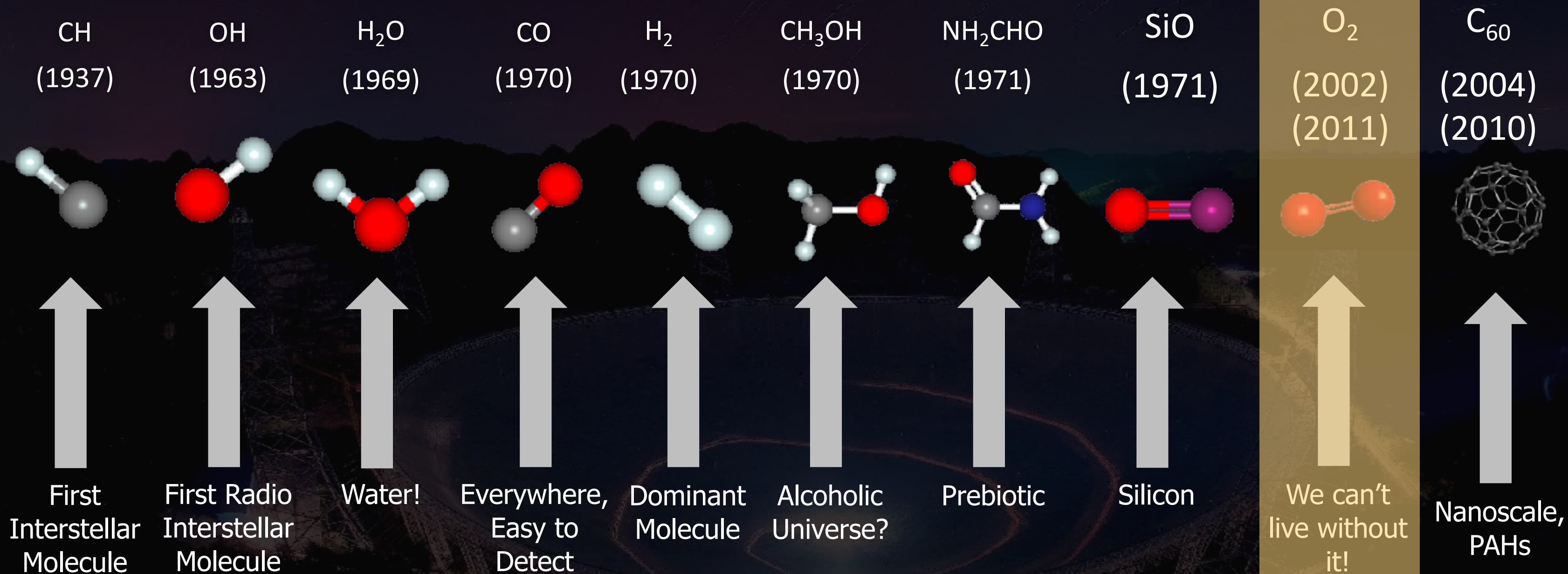
Goldsmith & Li et al. 2002 ApJ, 576, 814

SWAS 望远镜

第一代太赫兹空间望远镜



分子宇宙发现历程



ALMA



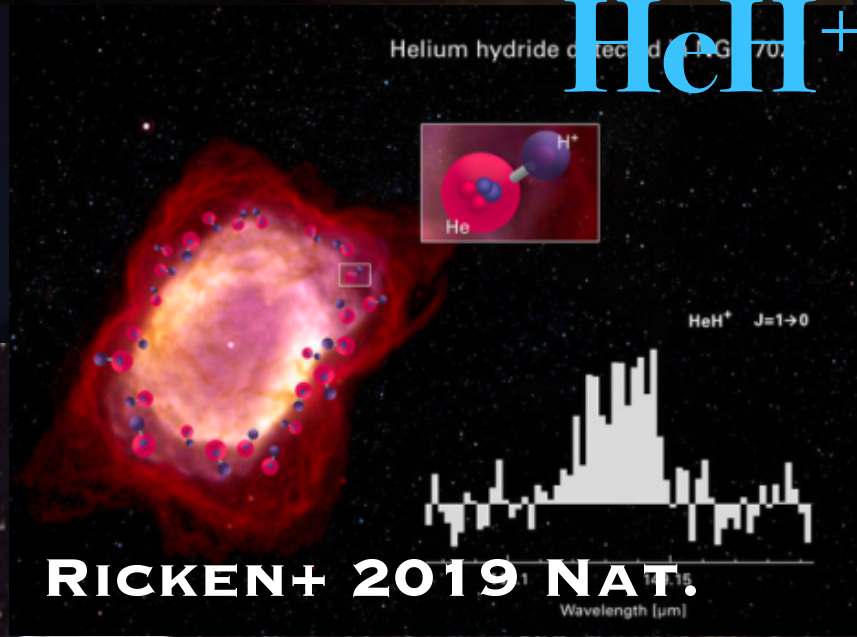
PH₃



GREAVES+ 2020
NAT. ASTRO.

分子宇宙

HeH⁺

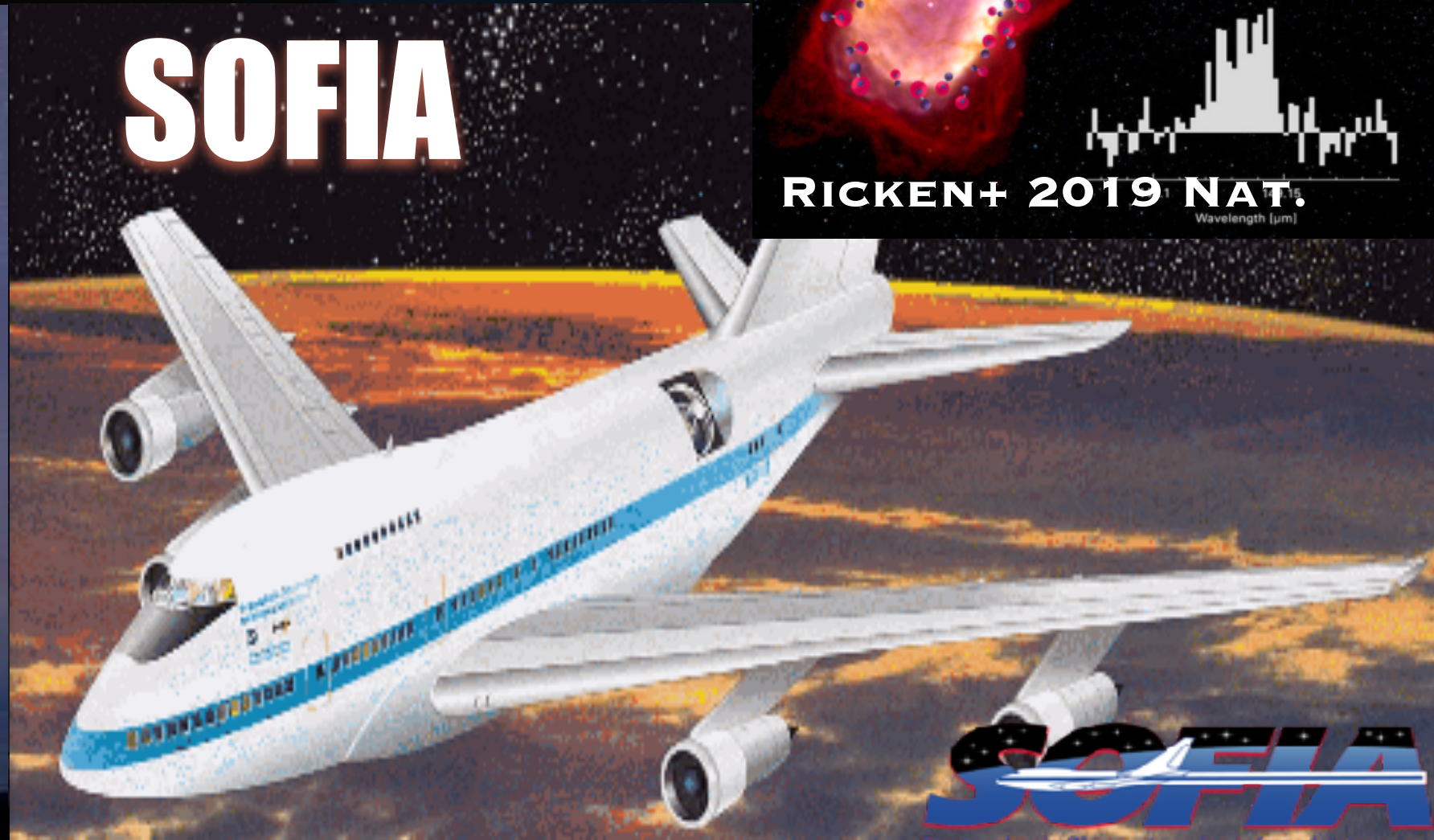


RICKEN+ 2019 NAT.

JCMT



SOFIA



阿雷西博望远镜

(1963 - 2020)

超感巨目

1963.11 落成

1965 首测水星自传、1973 双中子星(脉冲星)、1996 太阳系外行星

1993 年获得诺贝尔物理学奖

2020.12.1 倒塌

阿雷西博望远镜 2.0



岳楠楠

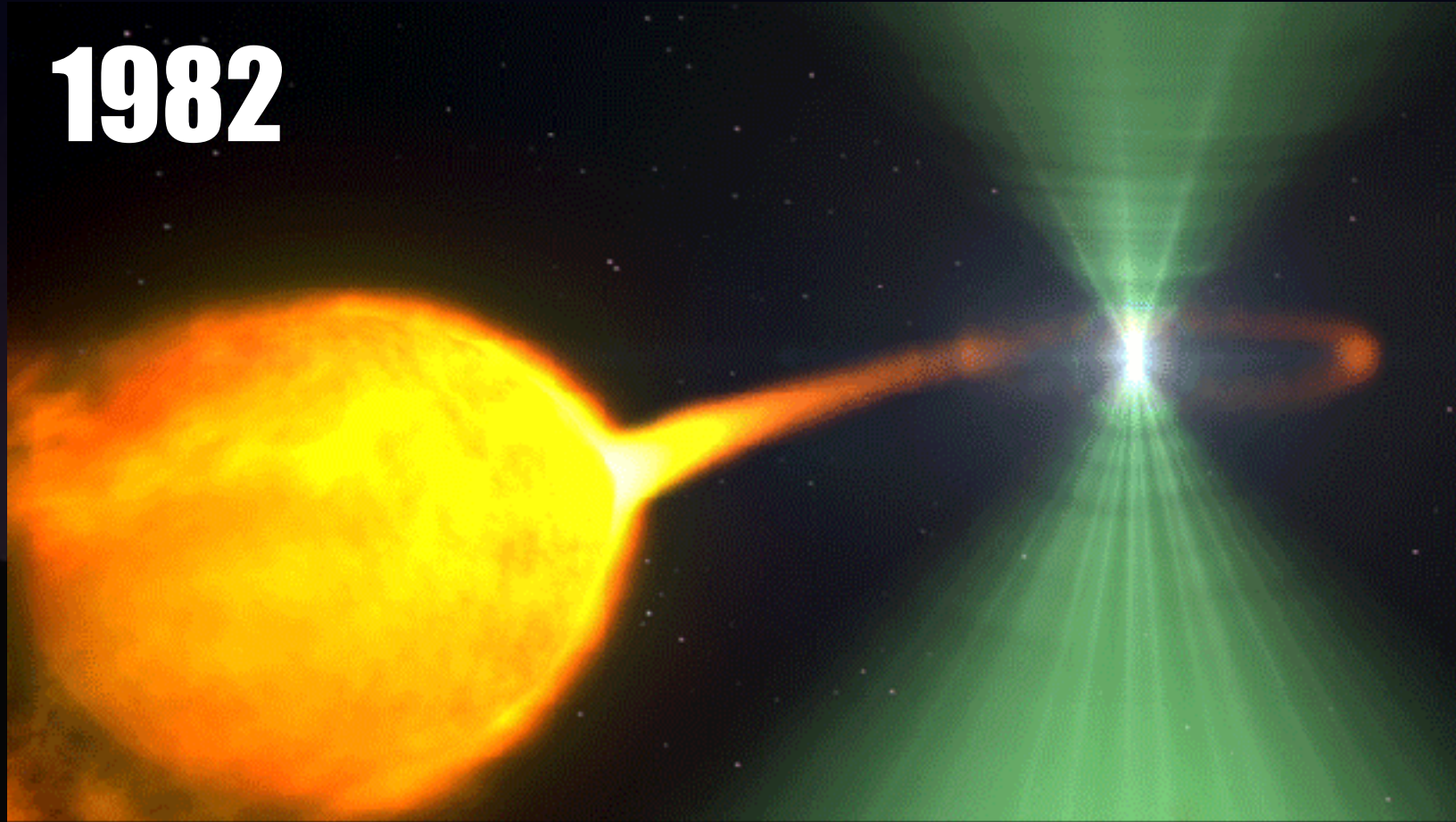
2013



中国科学院国家天文台
NATIONAL ASTRONOMICAL OBSERVATORIES, CHINESE ACADEMY OF SCIENCES

阿雷西博望远镜里程碑

1982



Backer
(1943-2010)



Kulkarni



Heiles

“A millisecond pulsar”

D. C. Backer, Shrinivas R. Kulkarni, Carl Heiles et al. 1982 Nature

“Professor Shrinivas R. Kulkarni and professor Carl Heiles (together with the late Professor Donald C. Backer) discovered the first millisecond pulsar-B1937+21 in 1982 using the Arecibo telescope. They achieved observation of a celestial object with one of the **highest cadence** possible at that time...The studies of millisecond pulsars have profoundly impacted and advanced astronomy, physics, and cosmology. We owe these scientific developments to the ingenuity...”



Shri Kulkarni

获得2024年 邵逸夫天文学奖

for his ground-breaking discoveries about millisecond pulsars, gamma-ray bursts, supernovae, and other variable or transient astronomical objects. His contributions to time-domain astronomy culminated in the conception, construction and leadership of the Palomar Transient Factory and its successor, the Zwicky Transient Facility, which have revolutionised our understanding of the time-variable optical sky.



2024.05

阿雷西博望远镜里程碑

物理驱动天文研究

发现双中子星
(DNS)



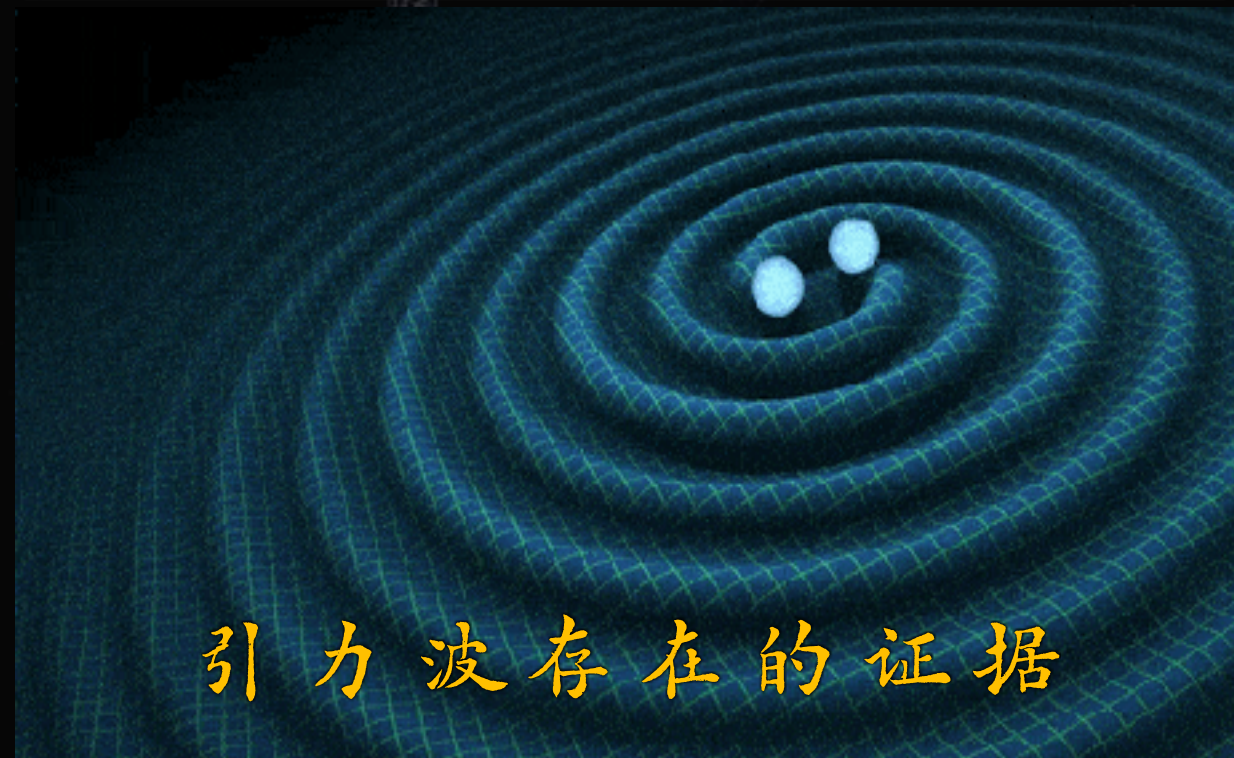
泰勒

“We find that Einstein’s theory passes this extraordinarily stringent test with a fractional accuracy better than 0.4%.”

“It necessarily follows that gravitational radiation exists and has a quadrupolar nature.”

——Nobel speech by J. Taylor (1993)

September 15, 1974
Dear Joe -
Well, here at long last is the write-up I promised to go with the 16 channel 001 data. The data tape was mailed today also, but I suppose it may take a little longer to arrive than this will.
I've been observing the 59 msec pulsar at every available opportunity for the past few days, and am now pretty sure that the period variability is due to an orbital doppler shift - the first pulsar in a binary! Will require several more days observations to get the full velocity curve, and as there's a 3 day ionosphere run in progress now (who won't give up any of his time), I'm stalled observationally for a little while. The reason I think that's the answer is Sunday night's data finally had the period bottom out and start back up - ^{and} in addition to that fact that all the data I have so



引力波存在的证据

1996

南仁东

邱育海

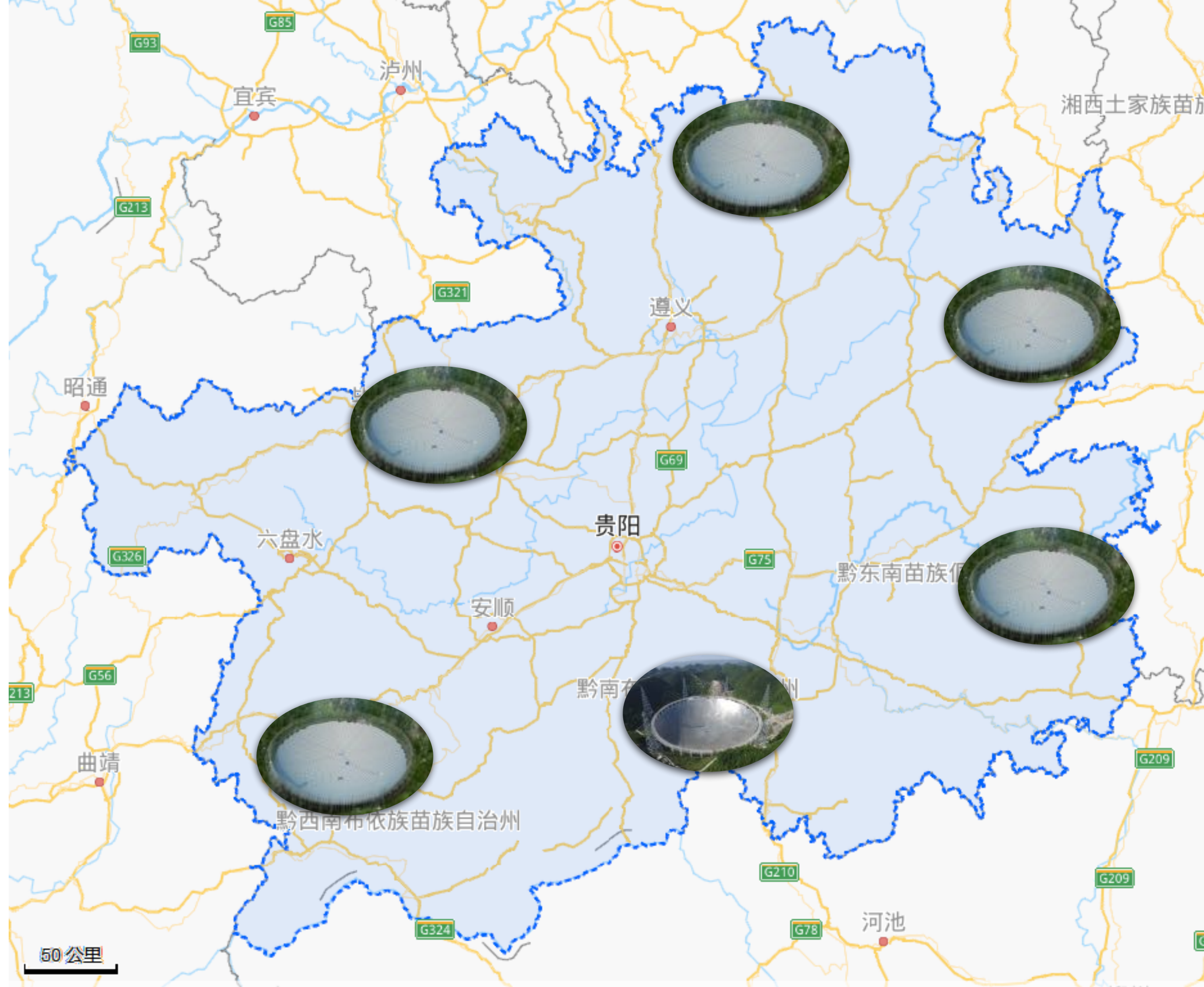
SHOT ON MI 9
PHOTO BY QIU



FASTA

6*FAST

$$d^* \sqrt{\eta_{coh}} \sqrt{\sqrt{n \times (n-1)}}$$



2015



2016



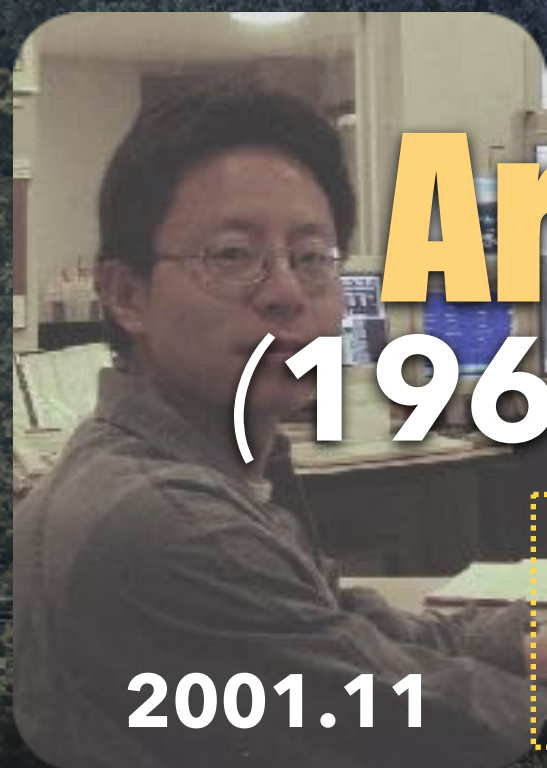
2018

杨振宁



2022





Arecibo

(1963 - 2020)

Hydrogen Self Absorption
(*Li & Goldsmith 2003 ApJ*)

2001.11

HINSA

原创星际介质冷原子探针



Nan

2012.02

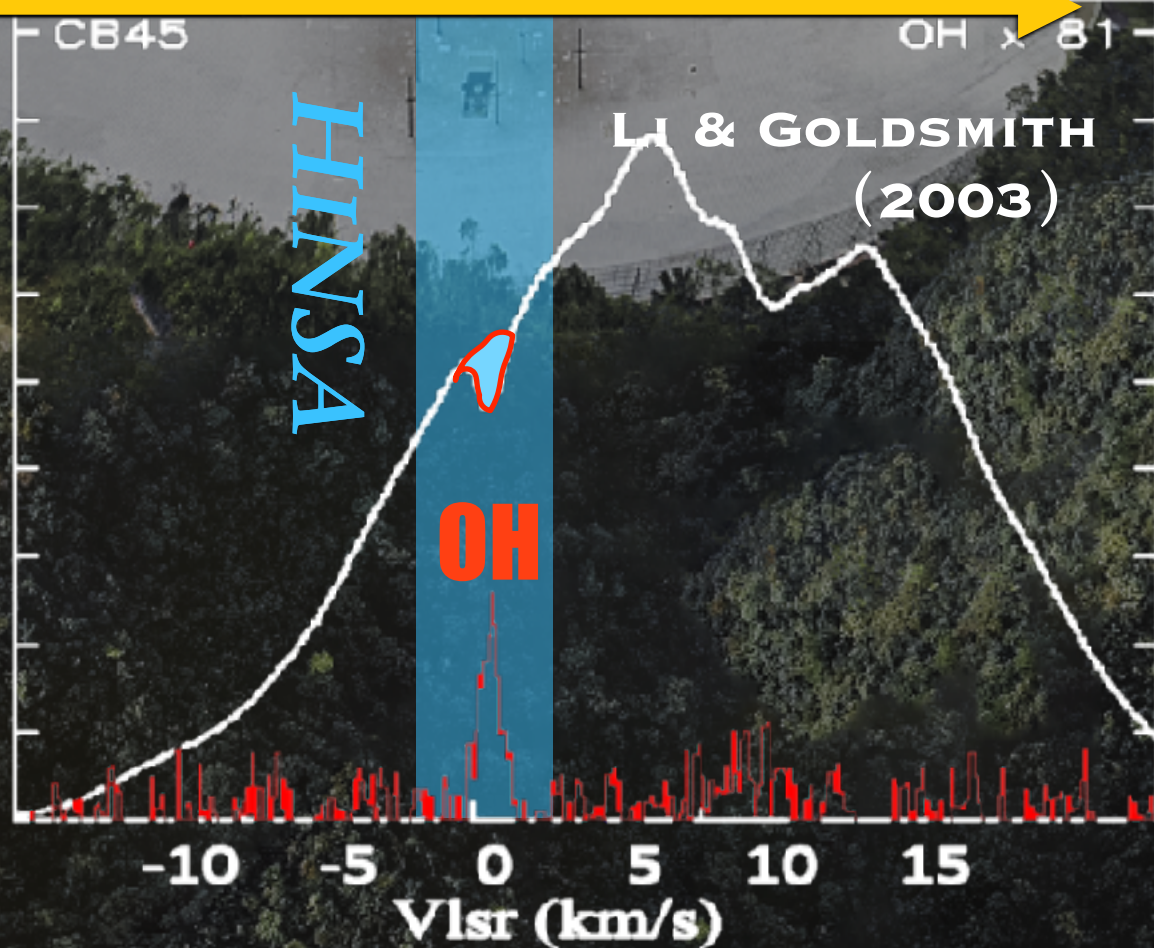


Heiles

2014

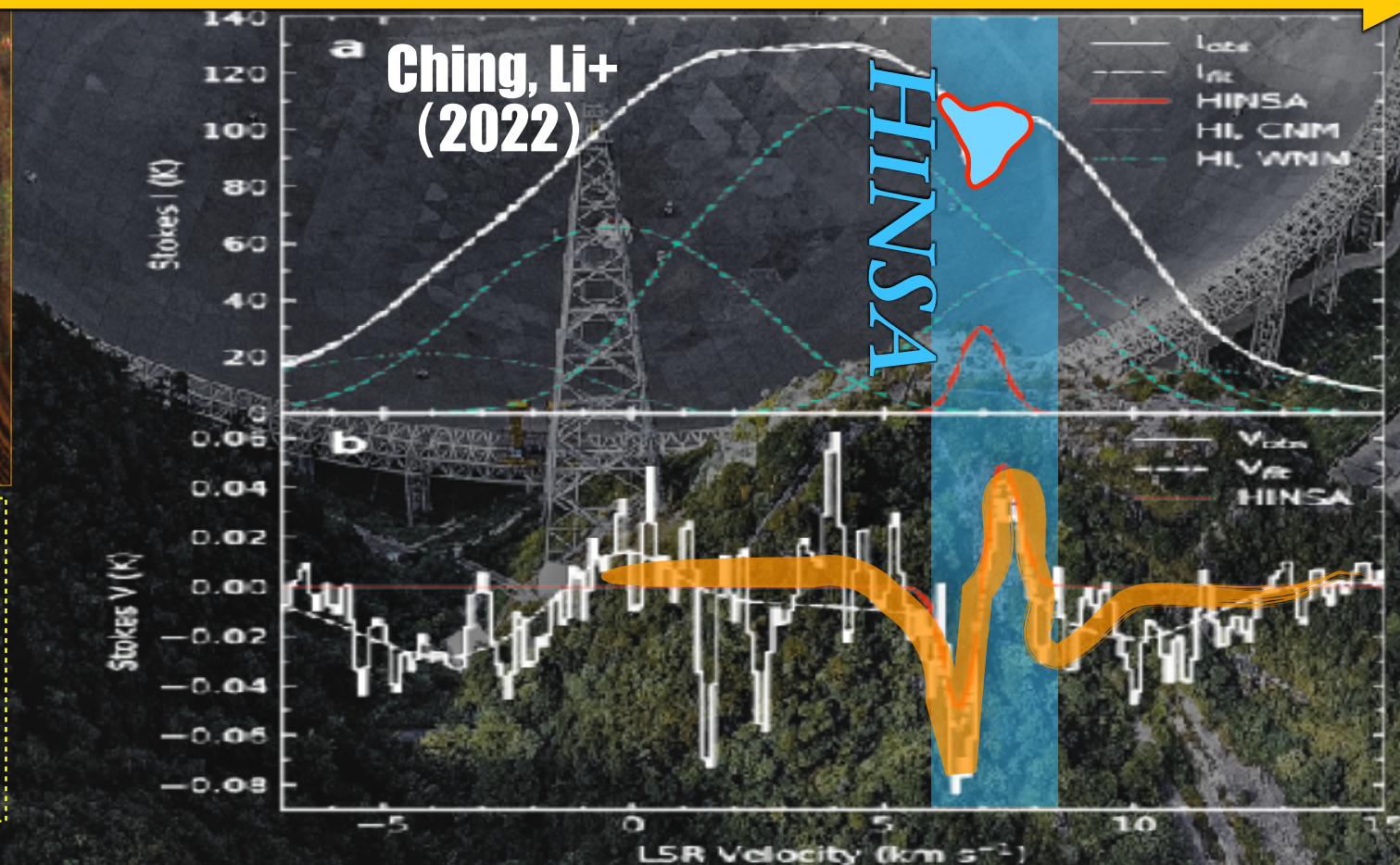
300m

A
r
e
c
i
b
o



Ching & Li* et al.
2022, *Nature*
“revolutionary”
Science news

精确测量星际磁场
挑战恒星形成经典理论



恒星形成驱动低能宇宙线

FERMI

PROTOSTARS

Low-E CRS



COLD ATOMS
(HINSA)

Tang & Li et al. 2026 ApJ*

2026.07

DI LI TSINGHUA UNIV.



清华大学天文系
Department of Astronomy, Tsinghua University

FAST

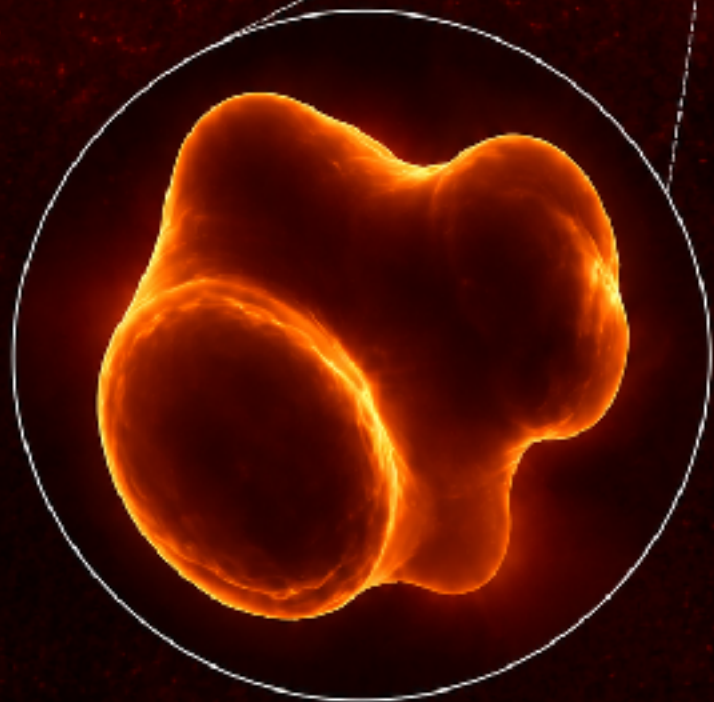


"中国天眼"首次揭示低能宇宙线起源新证据
7月10日 15:11 北多阵雨或雷阵雨天气。 CCTV 新闻 截至今日9时, 全国15条河

SNe Drive Galactic Turbulence

Meng ... Li 2026 Nat. Astro. accepted*

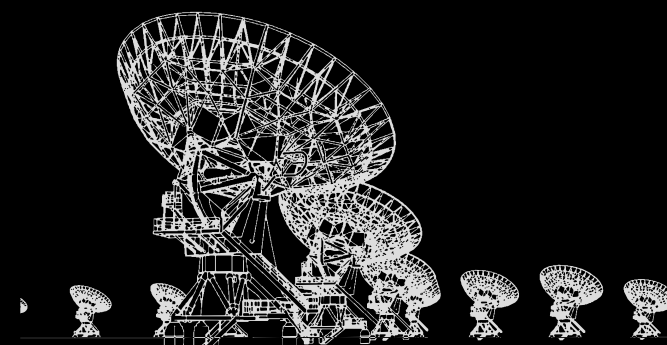
- ▶ **118 superbubbles** up to the age limit of detectable SNe bubbles (~ 40 Myr).
- ▶ **~ 7000 SNe** are required for blowing these bubbles
- ▶ $\sim 10\%$ volume filling factor matches the expected fraction of total number of SNe
- ▶ SNe sufficient in driving galactic scale turbulence



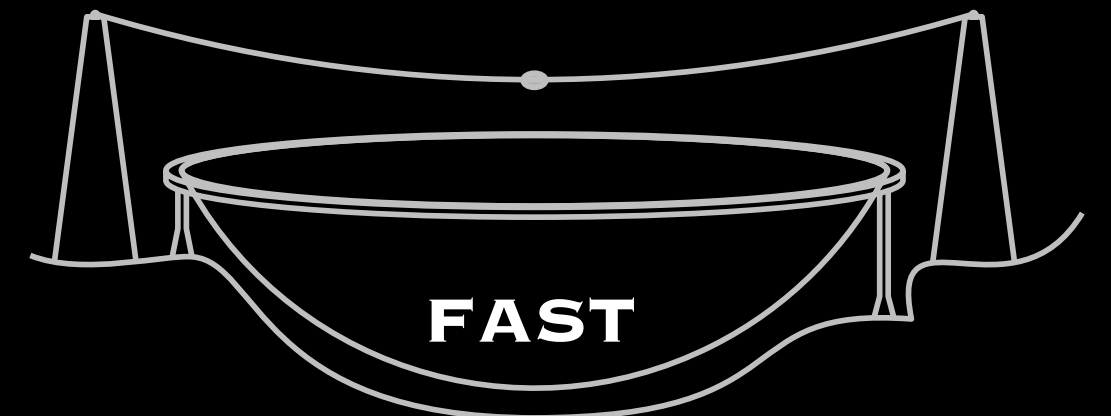
Bubbles in
the Andromeda galaxy

New observations reveal
giant structures in M31

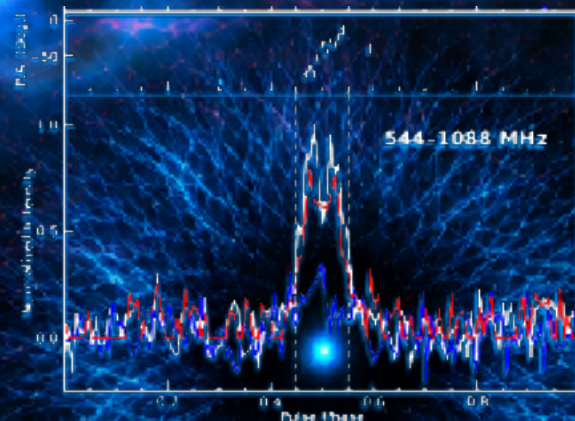
JVLA



FAST



Central Compact Object



CCO 1E1207.4-5209

THE “BLUE-EYE” PULSAR

MEERKAT + X-RAY COMPOSITE IMAGE

nature astronomy



Blinking
Blue Eye

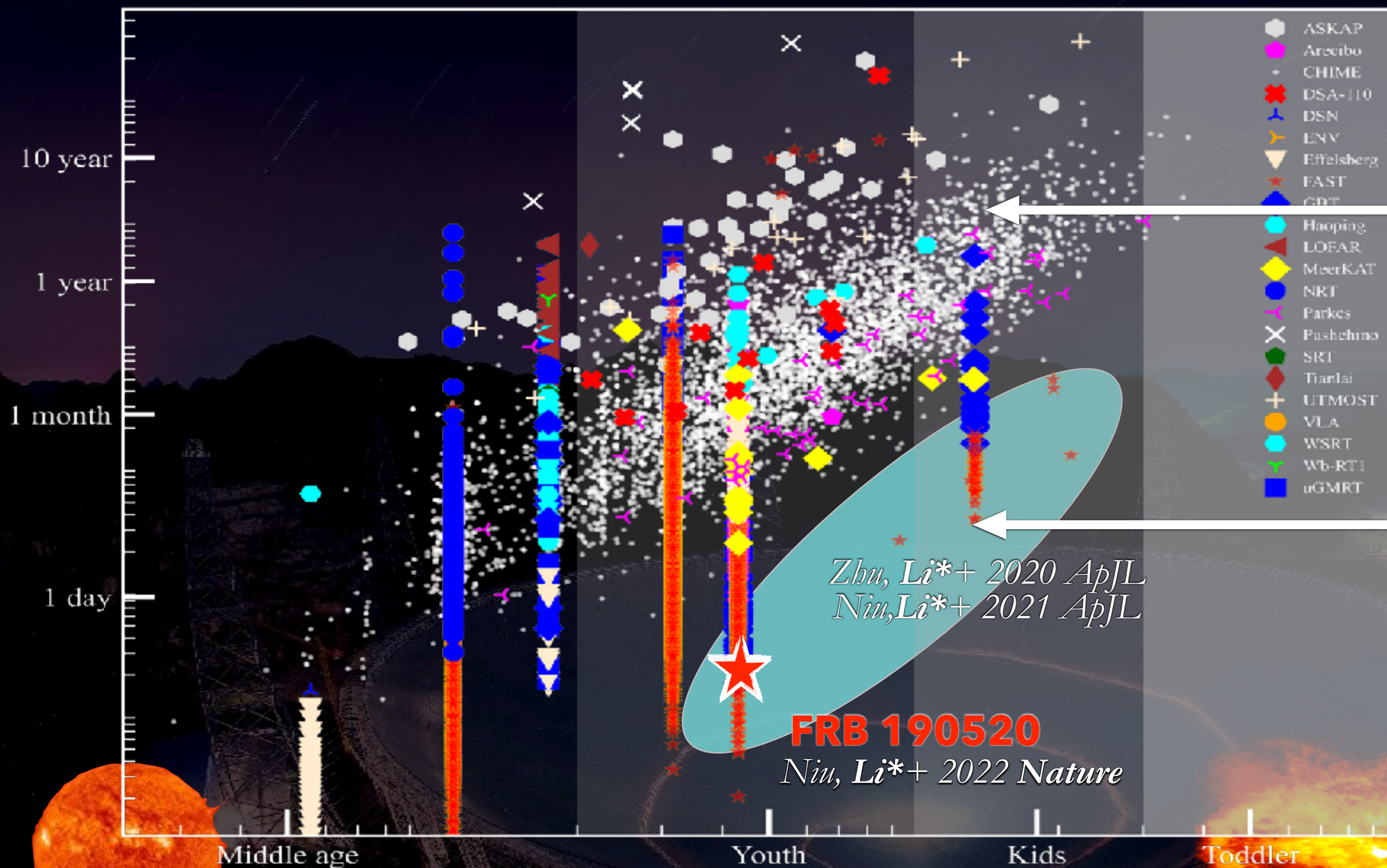
Zhang, Li*+ 2026 Nat. Astro.

FRB event rate $>120K \text{ day}^{-1} 4\pi^{-1}$



CRAFTS
The Cosmological Radio Astronomy FAST Survey
FAST 多科学目标同时扫描巡天

Equivalent Solar Energy



Canada
CHIME

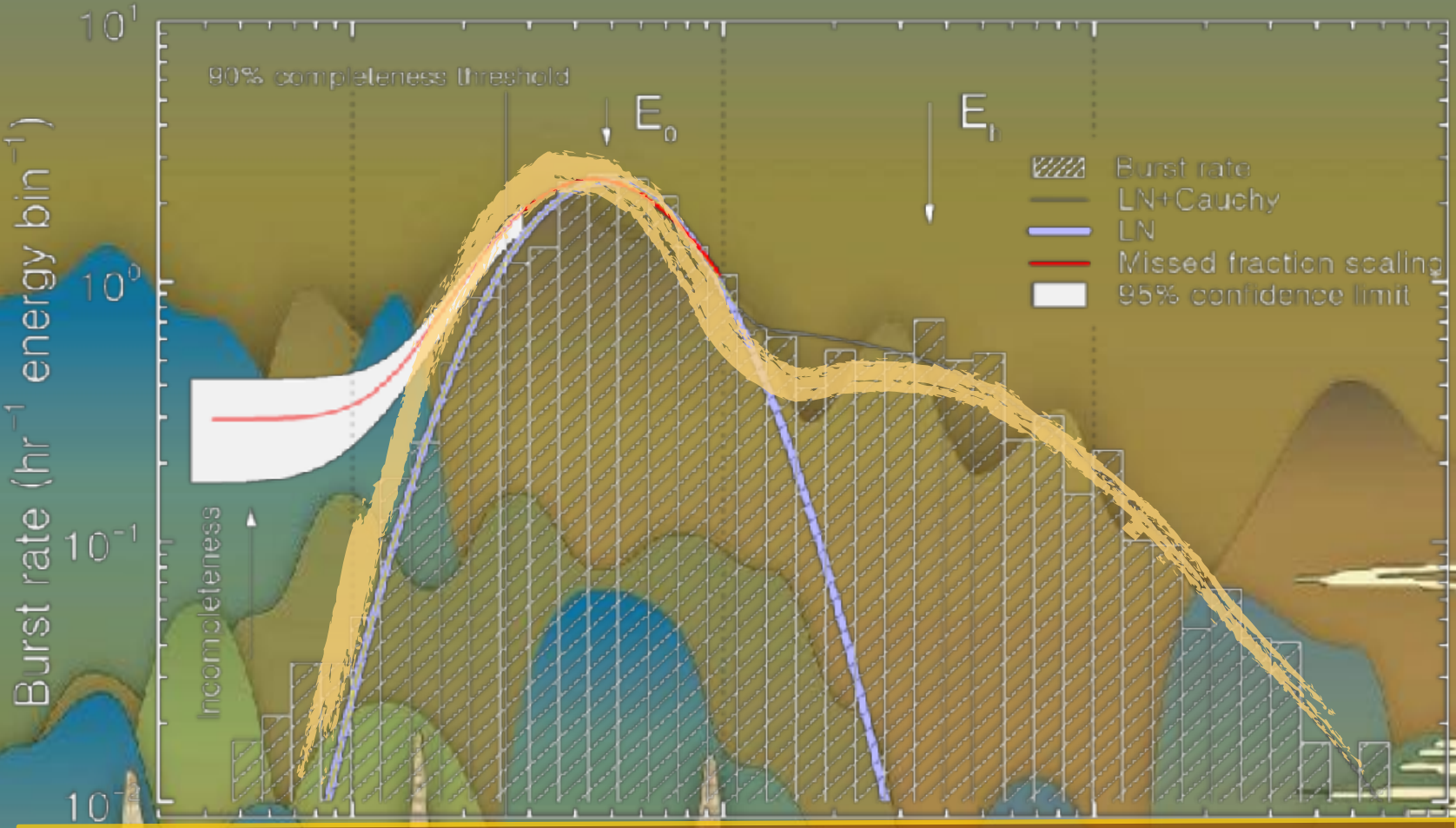
CRAFTS

Li et al. 2018

Cosmic Age

**BIG
BANG**

1st complete FRB burst-rate energy spectrum



“月半千辉”

1652 bursts in 50 days

FRB 121102

$$N(E) = \frac{N_0}{\sqrt{2\pi}\sigma_E E} \exp\left[-\frac{(\log E - \log E_0)^2}{2\sigma_E^2}\right] + \frac{\epsilon_E}{1 + (\frac{E}{E_0})^{\alpha_E}}$$

Universal E_{FRB} : bimodal lognormal+Lorentz
(LI+ 2021 NATURE; ZHANG+ 2024 RAA)

1113 A.D. 《Endless Rivers and Mountains》>>
仿王希孟 《千里江山图》

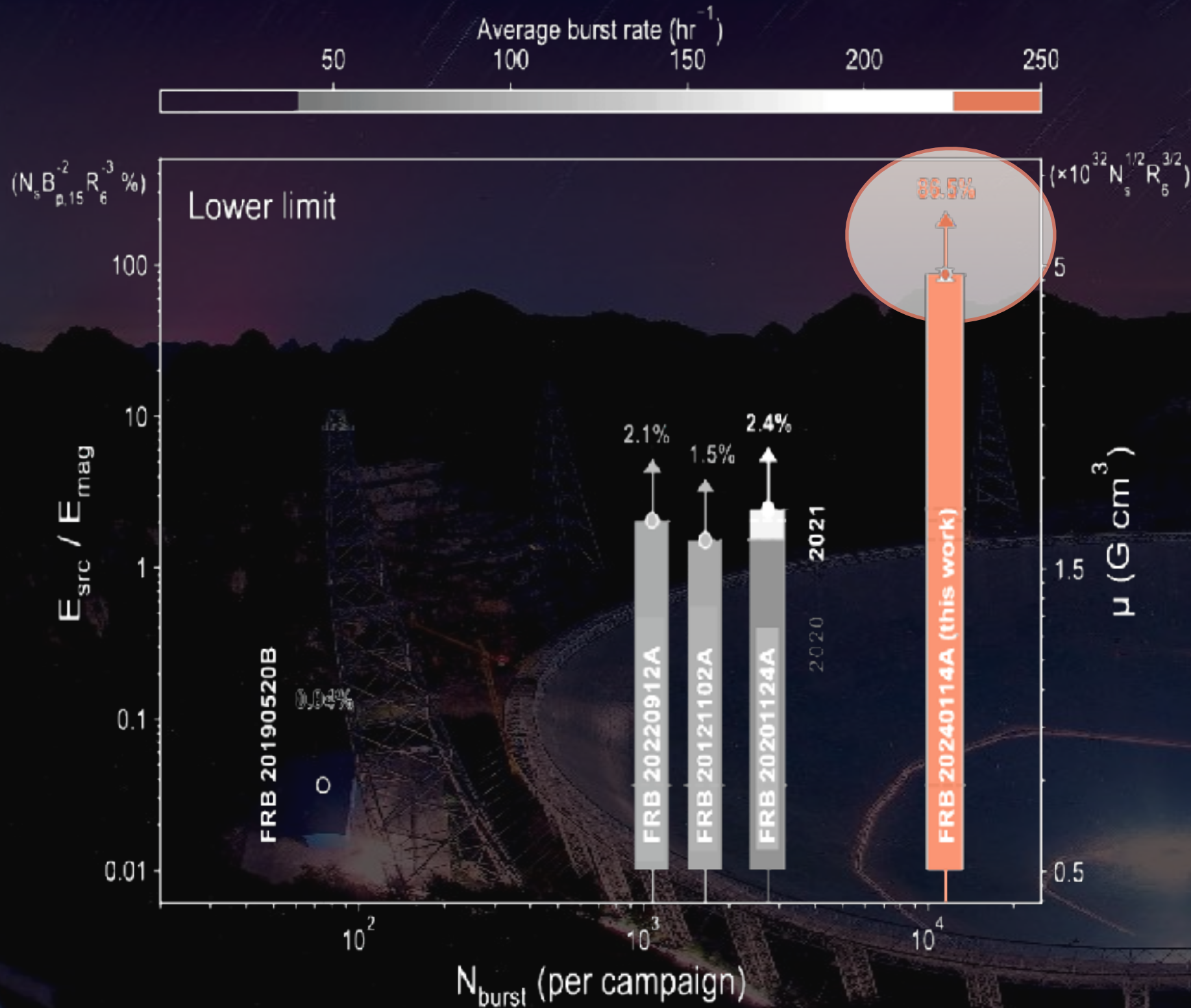
A bimodal burst energy distribution of a repeating fast radio burst source
nature Li, Wang, 2021 DOI : 10.1038/s41586-021-03878-5

CRAFTS webpage: <https://crafts.bao.ac.cn/>





STRINGENT CONSTRAINT OF FRB ENGINE'S MAGNETIC ENERGY



- FRB 20240114A discovered by CHIME
- FAST: ~ 60 hr, spanning 1.5 years
- Milestone: **>17,500** bursts the largest sample of FRB bursts
- Burst rates have temporal evolution

$$E_{\text{iso}}(z) = \sum \frac{4\pi}{(1+z)} \left(\frac{D_L}{10^{28} \text{cm}} \right)^2 \left(\frac{\mathcal{F}_\nu}{\text{Jy ms}} \right) \left(\frac{\Delta\nu}{\text{GHz}} \right) \eta_r^{-1} \zeta^{-1} f_b \ 10^{39} \text{erg}$$

$E_{\text{iso}} = 2.6 \times 10^{47} \text{ erg} > B^2 R^3 / 6 \sim 1.7 \times 10^{47} \text{ erg}$
now **>100%** ! challenges FRBs' magnetar origin

($z=0.13, f_b=0.5, \eta_r=10^{-4}$)
Total magnetic energy of a typical magnetar

Zhang ... Wang*, Li* 2026 Nat. Astro. (accepted)

第一完成人荣获奖励

- 2024年 获第十七届 马塞尔-格罗斯曼奖
- 颁奖理由：“为最灵敏射电望远镜科学规划做出开拓性贡献...推动快速射电暴领域进入大样本统计时代”
- 2022年 中国科学院杰出成就奖
“FAST精细刻画活跃重复快速射电暴”，第一完成人
- 2022年 中国科学十大进展
快速射电暴研究集体， 第一完成人
- 2021年 中国科学十大进展
“FAST捕获世界最大快速射电暴样本”，第一完成人
- 2018年 担任 FAST 首席科学家
- 2015年 任中国科学院国家天文台FAST工程副总工程师
- 2008年 任FAST项目科学家

代表作第一作者：李菂（1，4），冯毅（2），庆道冲（3），牛晨辉（5），王培（6）

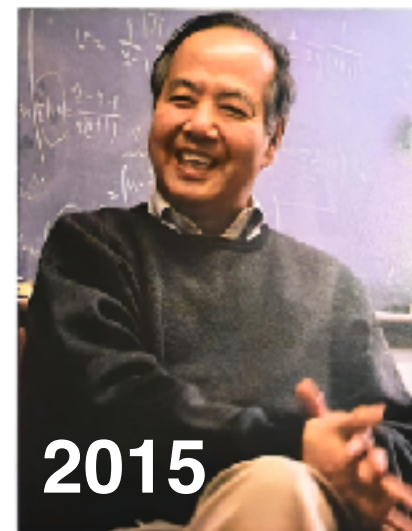
Marcel Grossmann Award

(1985-2024 共17届)



T.D. LEE

"For his work on white dwarf pulsations, Enrico Fermi's return to astrophysics and guiding the dark understanding of neutron star matter and fields"



2015



"... Returning to the main topic of Fermi and astrophysics, it is interesting that according to T.D. Lee Fermi's original critical attitude expressed in his Trento lecture on the interior of stars was evolving towards the end of his life. As recalled by T.D. Lee in a talk held at a joint meeting of the APS and AAPT in February, 2010 "Remembering Enrico Fermi," Fermi was beginning to warm up towards astrophysics in his final years: Fermi asked Lee during his Ph.D. thesis the approximate temperature of the Sun at its center. Lee replied, "Ten million degrees." Fermi asked



2024

历届获奖者含8位诺贝尔奖得主

萨利姆（1985）钱德拉塞卡（1994）贾科尼（2000）彭罗斯（2000）**李政道（2015）杨振宁（2015）**温伯格（2021）胡夫特（2021）以及霍金（1991）邱成桐（2018）等

Individual Awards

Goes to

DI LI

"For his groundbreaking contributions to the scientific definition of the most sensitive radio telescope and his numerous innovations in characterizing the dynamic universe, resulting in precise measurements of the interstellar magnetic field and advancing the field of fast radio bursts into a high-statistics era".



科学

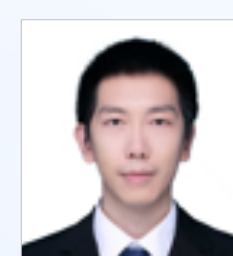
创新

王培



庆道冲

冯毅



牛晨辉

李菂







ASTRONOMY

All-sky radio telescopes ditch the dish

Arrays of simple antennas hunt for nearby fast radio bursts

DENNIS NORMILE

Think of a radio telescope, and you may picture a massive dish, tens or even hundreds of meters across. That's the classic design, which gathers radio waves from space and focuses them onto an antenna above the dish, creating a field of view that resembles a narrow beam.

The Bustling Universe Radio Survey Telescope in Taiwan (BURSTT), a humble-looking device nestled among the trees at the Fushan Botanical Garden south of Taipei, does away with the dish. Instead, it packs 256 antennas, shaped like miniature pine trees, into a so-called phased array to catch radio waves directly. Computers digitally combine the signals from the antennas, synthesizing multiple beams that can view roughly half of the visible sky at once. The array has no moving parts, but the beams can be steered electronically to view other parts of the sky. "There's no common nomenclature for this gizmo yet," says University of California, Berkeley radio astronomer Dan Werthimer. "I call them all-sky, all-the-time telescopes."

BURSTT, which is expected to begin its sky surveys in the coming months, showcases the hottest new technology in radio astronomy. Three similar arrays are due to come online by the end of the year in China, the Netherlands, and California (see table, p. 333). "I see this kind of array design becoming central to radio astronomy in the coming years and decades," says Liam Connor, an astrophysicist at the Center for Astrophysics | Harvard & Smithsonian who is co-principal investigator for the Coherent All-Sky Monitor (CASM), an array being deployed at the Owens Valley Radio Observatory in California.

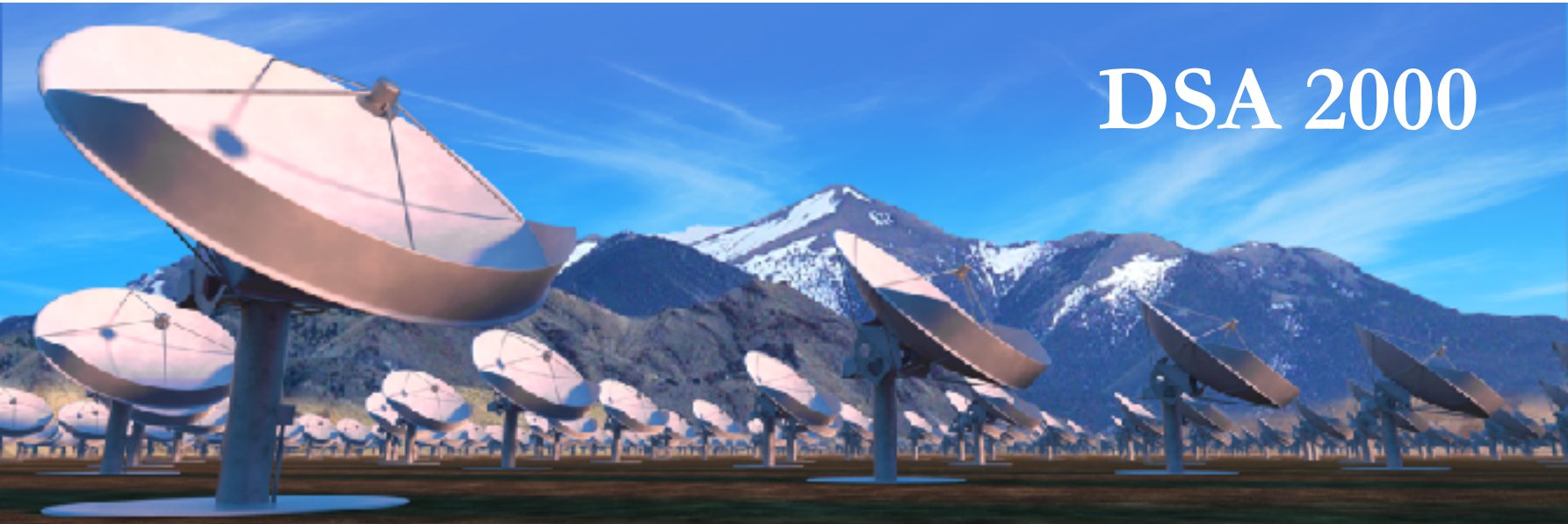
The downside of the approach is that, without a dish, the instrument's sensitivity drops. The arrays will likely detect only the brightest radio sources in the Milky Way and neighboring galaxies. Researchers are embracing that limitation, however. They are using the all-sky telescopes to hunt for fast radio bursts (FRBs), which are orders of magnitude more luminous than any other radio sources in the sky.

Since FRBs were first discovered in 2007, astronomers have identi-

Downloaded from https://www.science.org on July 25, 2025

PHOTO: KAIHONG LIN/AAAS

JULY 26 2025, SCIENCE



All ears

One of the hottest trends in radio astronomy is using antennas to capture a wide field of view without a dish. Four facilities are set to come online in the coming months.

NAME	LOCATION	SPONSOR	START OF SCIENCE OPERATIONS
Bustling Universe Radio Survey Telescope in Taiwan	Fushan Botanical Garden	Academia Sinica	To be determined
Cosmic Antennae	Hangzhou, China	Zhejiang Lab	August
Arthropod	Westerbork observatory	ASTRON, the Netherlands Institute for Radio Astronomy	September
Coherent All Sky Monitor	Owens Valley Radio Observatory in California	California Institute of Technology; Center for Astrophysics Harvard & Smithsonian	Fall

倾听星空

宇宙触角CA

阿雷西博

中国天眼FAST

赫兹

央斯基 欧文

