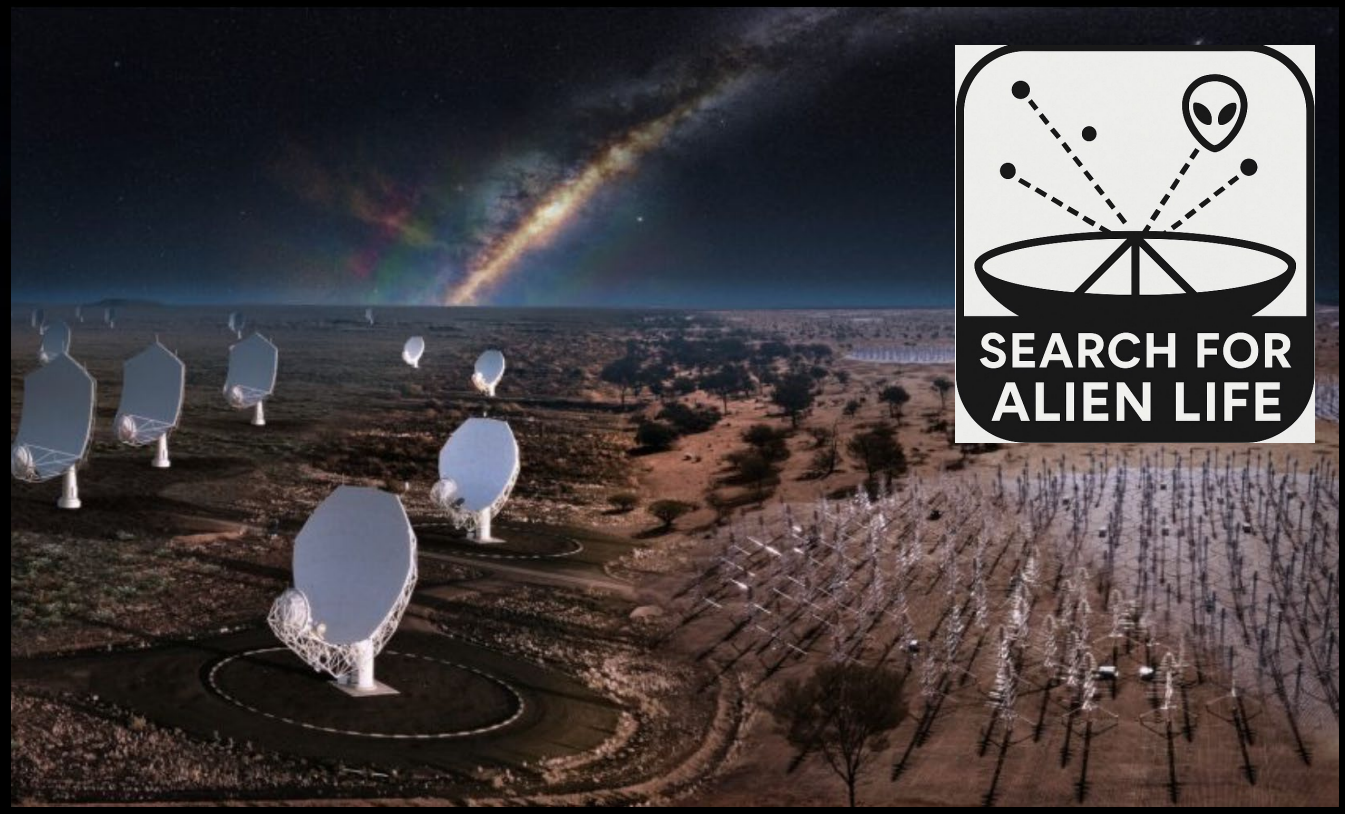
SKA项目发布
生命摇篮之地外文明搜寻(SETI)

- 张同杰
- 北京师范大学 物理与天文学院
- 天文与天体物理前沿科学研究所

- 2025年8月1日 大连

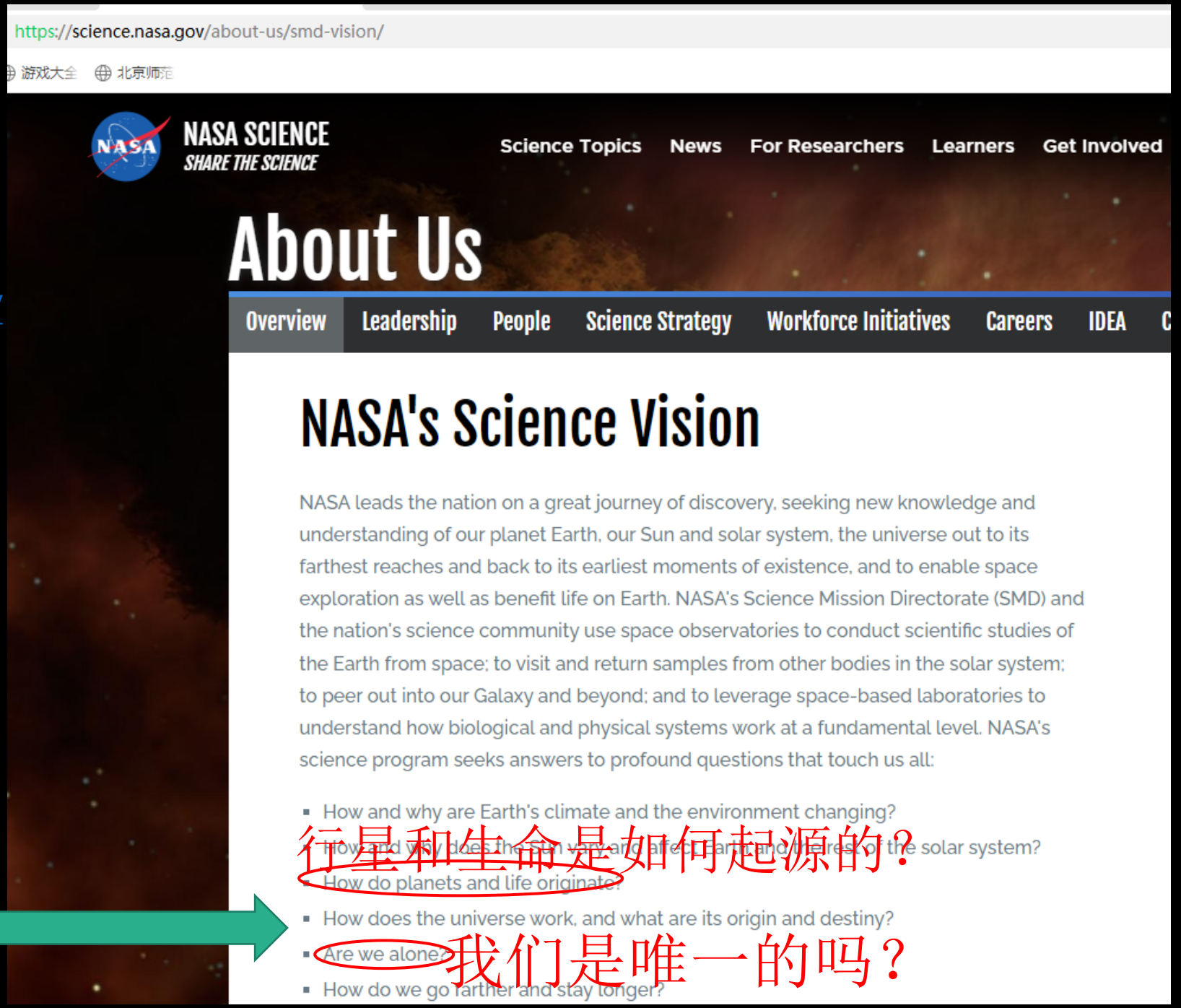
2025年中国SKA科学研讨会：背景



美国国家航空和航天局科学愿景
NASA's Science Vision

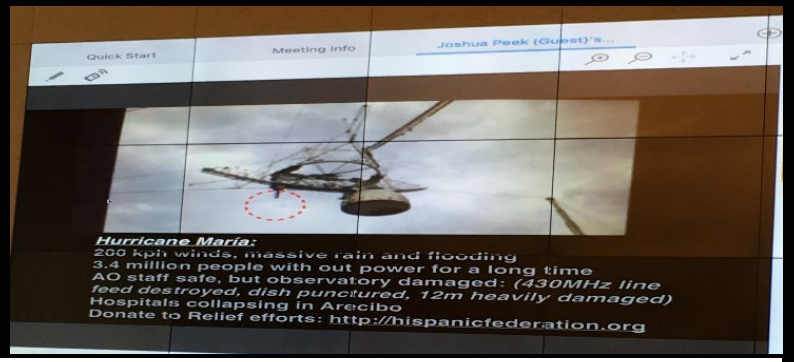
- https://science.nasa.gov/about-us/smd-vision/

- six questions
  - Are we alone?
  - 我们是唯一的吗？
- SETI



美国下一代阿雷西博望远镜(Next Generation Arecibo Telescope)

- 2020年12月1日崩塌, **悲壮的一幕**，结束使命!
- 下一代望远镜：搜寻宇宙中高等生命



THE FUTURE OF THE ARECIBO OBSERVATORY:

THE NEXT GENERATION ARECIBO TELESCOPE

White Paper, ver 2.0, 02-01-2021

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Affiliations are listed after the acknowledgements, immediately before the appendices.

SKA项目发布： The Cradle of Life [生命摇篮]

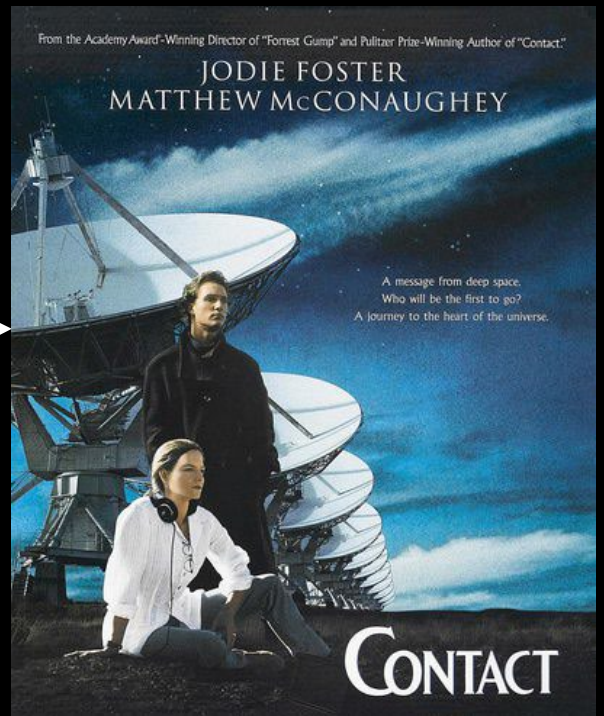
- SKA 的科学目标之一.

PROCEEDINGS OF SCIENCE

The Cradle of Life and the SKA

M. G. Hoare*[1], . Jimenez-Serra[5,7], P. Zarka[8], A.
P. V. Siemion[9] rd[14], G. Anglada[15], A. Belloche[16],
P. Bergman[17], ler[2], C. Codella[4], G. Hallinan[20],
J. Lazio[21], I. S , J. Tarter[24],

[1]*School of Physic K; [2]National Radio Astronomy*
Observatory, USA , UK; [4]INAF-Osservatorio
Astrofisico di Arc utory, Garching, Germany;



2014年： 未来SKA也计划实施SETI

- Andrew Siemion等人也写了SKA地外文明观测的白皮书(Tue, 16 Dec 2014年)。
- 国家天文台 金承进 研究员

PROCEEDINGS OF SCIENCE

Searching for Extraterrestrial Intelligence with the Square Kilometre Array

arXiv:1412.4867

Andrew P. V. Siemion[*1,2,3], James Benford[4], Jin Cheng-Jin[5], Jayanth Chennamangalam[6], James Cordes[7], David R. DeBoer[3], Heino Falcke[2,1,8,9], Mike Garrett[1,10], Simon Garrington[11], Leonid Gurvits[12,13], Melvin Hoare[14], Eric J. Korpela[3], Joseph Lazio[15], David Messerschmitt[3], Ian S. Morrison[16], Tim O'Brien[10], Zsolt Paragi[12], Alan Penny[17], Laura Spitler[7], Jill Tarter[18], Dan Werthimer[3]

[1]*ASTRON, NL;* [2]*Radboud University, NL;* [3]*University of California, Berkeley, US;* [4]*Microwave Sciences, US;* [5]*NAOC, CN;* [6]*Oxford University, UK;* [7]*Cornell University, US;* [8]*MPIfR, DE;* [9]*NIKHEF, NL;* [10]*Leiden University, NL;* [11]*Jodrell Bank Observatory, UK;* [12]*JIVE, NL;* [13]*Delft University of Technology, NL* [14]*University of Leeds, UK;* [15]*Jet Propulsion Laboratory, California Inst. of Technology, US;* [16]*University of New South Wales, AU;* [17]*University of St. Andrews, UK;* [18]*SETI Inst., US*

E-mail: siemion at astron.nl

The vast collecting area of the Square Kilometre Array (SKA), harnessed by sensitive receivers, flexible digital electronics and increased computational capacity, could permit the most sensitive and exhaustive search for technologically-produced radio emission from advanced extraterrestrial intelligence (SETI) ever performed. For example, SKA1-MID will be capable of detecting a

中国SKA白皮书

SKA
SQUARE KILOMETRE ARRAY
China

09 生命的摇篮

（供稿：张泳 中山大学）

不停思索生命的起源。自从彻底摒弃“地心说”后，人们越来越沮是宇宙中一颗毫不起眼的天体，那么，宇宙中是否还存在能够些生命是否能够像人类一样进化出高级文明呢？我们究竟从何问，在哲学、社会、宗教等领域有深刻的意义。在宇宙中简单育生命形成的星球，太空环境中复杂有机分子最终形成生命，因素起着决定性作用，这是科学家希望利用新一代望远镜回答文明和宇宙演化时间相比只是一瞬间，近百年科技飞速发展催为摧毁人类文明的潜在威胁。如果在茫茫宇宙中，我们能够接出的信号，这将给人类信心，能够如此文明一样战胜危机让地我们可能正处于摒弃生命科学的“地心说”的时代。

图11：行星盘与地外文明（想象）

第8届中国SKA科学大会 2025年5月13-15日 上海

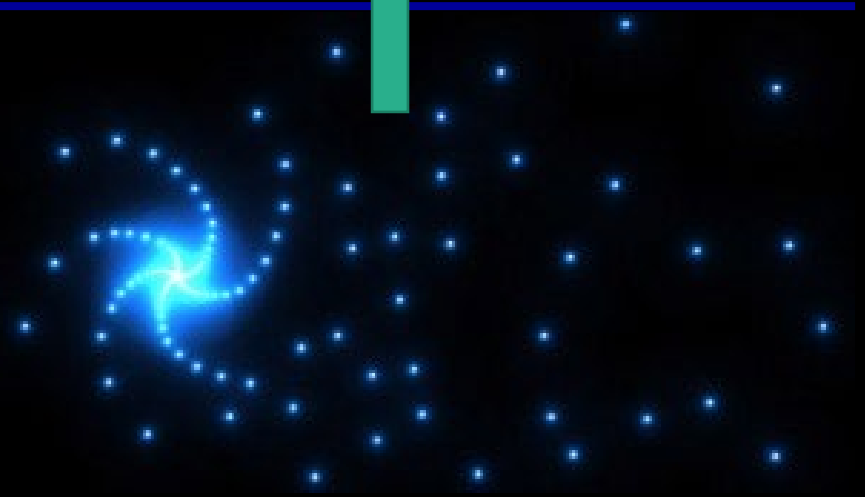
“SKA与生命摇篮”前沿

张泳

中山大学

SKA地外智慧生命搜寻
[Search for Extraterrestrial Intelligence (SETI) at SKA]

- 黄博伦 陶振钊 张同杰
- 北京师范大学 物理与天文学院
- 天文与天体物理前沿科学研究所

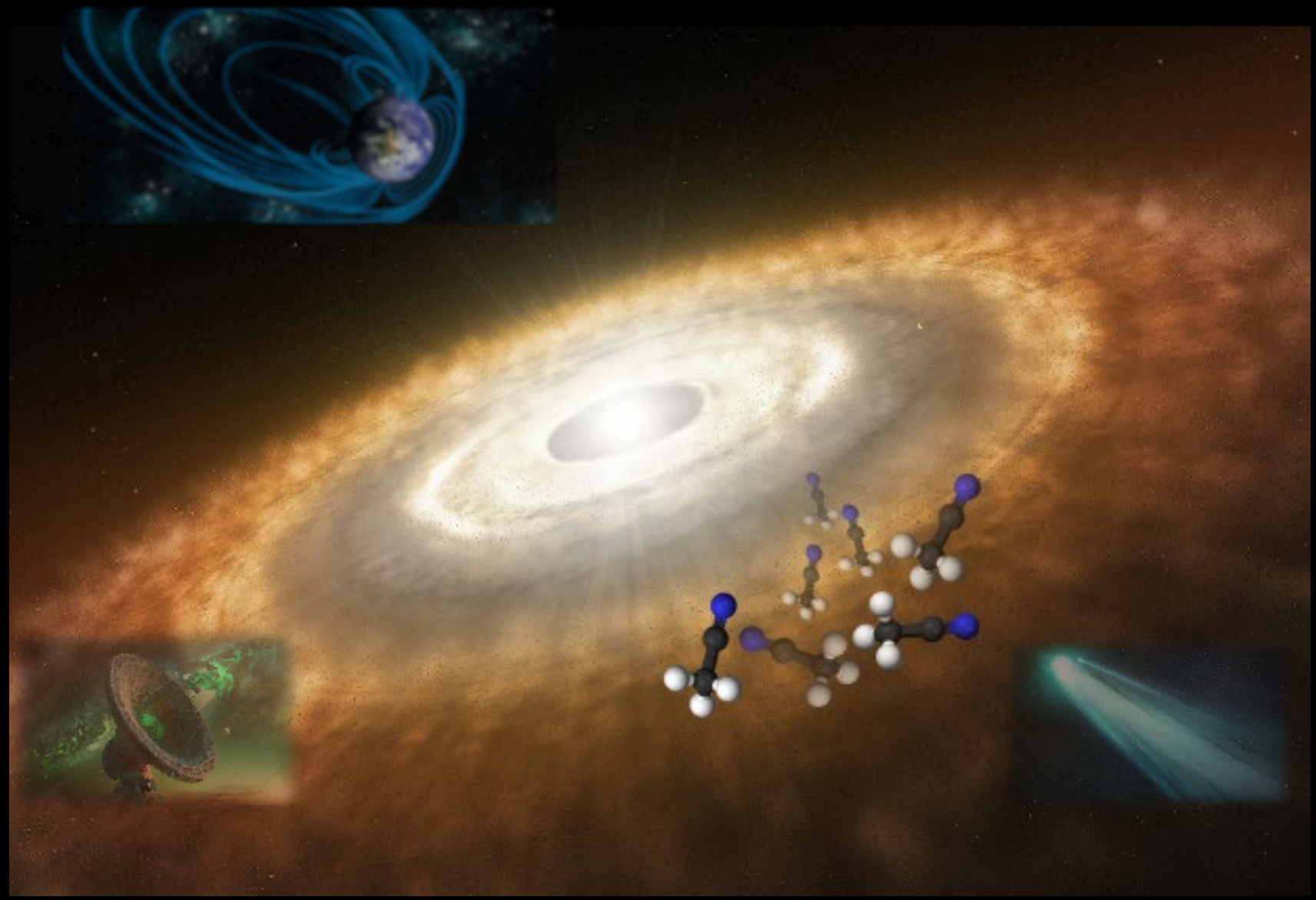


- 第8届中国SKA科学大会
- 2025年5月13-15日 上海

SKA
SQUARE KILOMETRE ARRAY
China

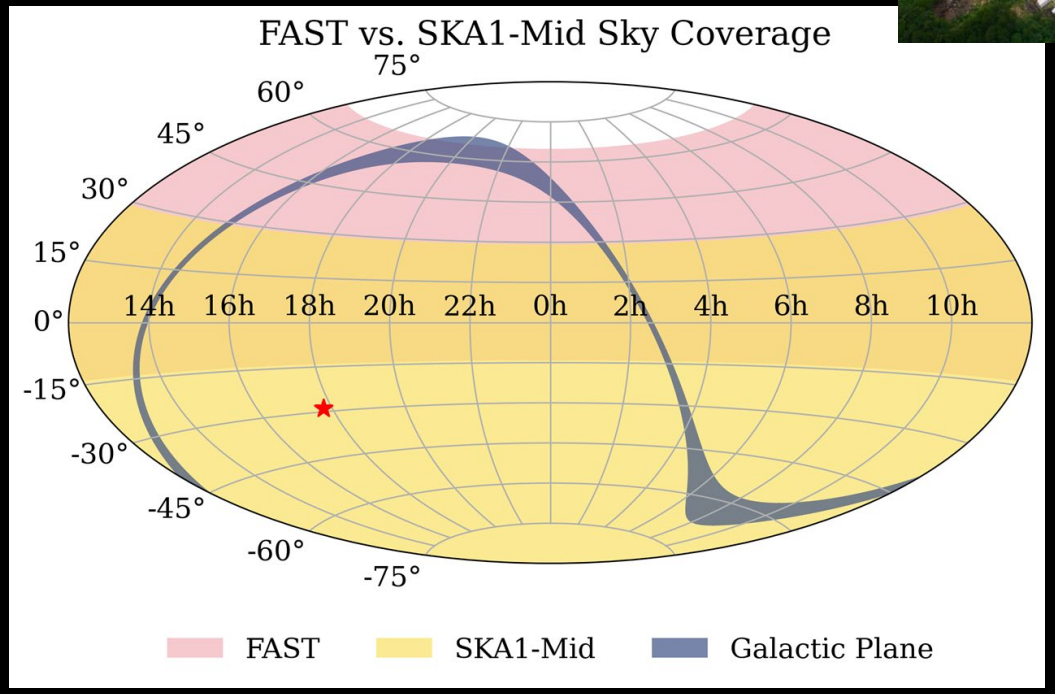
SKA生命摇篮：四个课题

- 原行星盘
- 复杂有机分子
- 行星磁场
- 地外文明



SKA干涉阵相比单碟望远镜的优势

- 局部的干扰源在长基线上不相干（压制RFI）
- 多基线同时探测可增强信号的可信度（SETI信号通常是瞬变的）
- SETI信号源的准确定位
- **与FAST可观测天区形成互补**



困难和挑战：国际竞争情况

美国：起步最早，专门建立有SETI institute (搜索地外智慧研究所); 数亿美元的私人资助项目Breakthrough Listen (主要以UCB为核心)，规模目前最大，系统目前最为完善，且已经计划MeerKat巡天；哈佛的伽利略计划；UCB的SETI@home项目（世界持续时间最久，最灵敏-现在不是了）。

英国：曼彻斯特大学、牛津大学皆有专门针对SETI的研究组。

意大利：该国天体物理研究所近期利用萨丁望远镜进行了一次射电高频的SETI搜索。

南非：凭借MeerKat，与BL有深度合作。

中国：北师大-德州学院-国台-伯克利SETI联合研究团队

SETI INSTITUTE

BERKELEY SETI RESEARCH CENTER

nature astronomy

Article

https://doi.org/10.1038/s41550-022-01872-z

A deep-learning search for technosignatures from 820 nearby stars

nature astronomy

ARTICLES

https://doi.org/10.1038/s41550-021-01508-8

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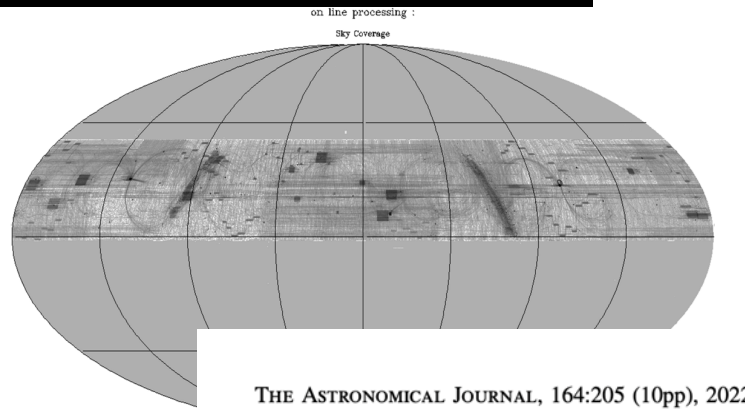
OPEN

Analysis of the Breakthrough Listen signal of interest blc1 with a technosignature verification framework

Sofia Z. Sheikh[1]✉, Shane Smith[1,2], Danny C. Price[1,3], David DeBoer[4], Brian C. Lacki[1],



021 Peter Xiangyuan Ma[1,2,3]✉, Cherry Ng[3,4,5], Leandro Rizk[3], Steve Croft[4,5],

大学皆

Publications of the Astronomical Society of the Pacific, 133:064502 (15pp), 2021 June

https://doi.org/10.1088/1538-3873/abf329

CrossMark

The Breakthrough Listen Search for Intelligent Life: MeerKAT Target Selection

The Astronomical Journal, 164:205 (10pp), 2022 November

https://doi.org/10.3847/1538-3881/ac92e7

CrossMark

Z. Sheikh[4], Bryan Brzycki[1], Sarah Buchner[5],
al Gajjar[1], Brian C. Lacki[1], Matt Lebofsky[1],
. Price[1,8], Andrew P. V. Siemion[1,9,10,11],
te Worden[6]

The First High Frequency Technosignature Search Survey with the Sardinia Radio Telescope

Lorenzo Manunza[a], Alice Vendrame[b], Luca Pizzuto[b], Monica Mulas[a], Karen I. Perez[c], Vishal Gajjar[d,e], Andrea Melis[g], Maura Pilia[g], Delphine Perrodin[g], Giambattista Aresu[g], Marta Burgay[g], Alessandro Cabras[g], Giuseppe Carboni[g], Silvia Casu[g], Tiziana Coiana[g], Alessandro Corongiu[g], Steve Croft[e,d,i], Elise Egron[g], Owen A. Johnson[e,k], Adelaide Ladu[g], Matt Lebofsky[e], Francesca Loi[g], David MacMahon[e], Emilio Molinari[1], Matteo Murgia[g], Alberto Pellizzoni[g], Tonino Pisanu[l], Antonio Poddighe[g], Erika Rea[h], Andrew Siemion[e,d,i,j], Paolo Soletta[g], Matteo Trudu[g], Valentina Vacca[g]

Search for Extraterrestrial Intelligence with the ngVLA

, C. Mannion[5], and E. F. Keane[5,6]
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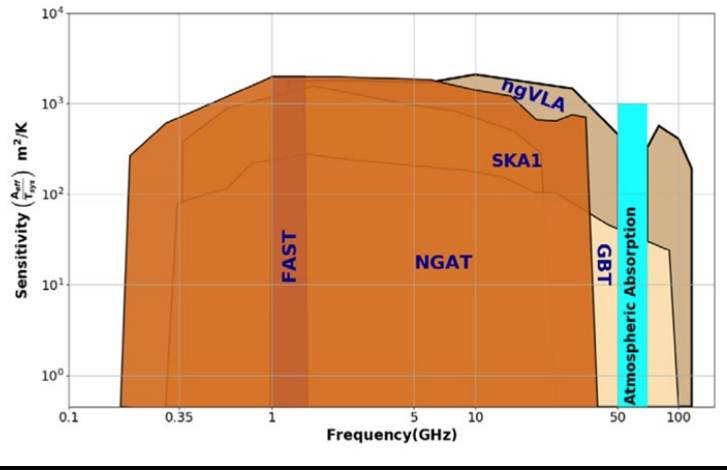
rsity of California Berkeley, Berkeley, CA 94720, USA
itute, Mountain View, CA, USA
cs, University of Toronto, 50 St. George Street, Toronto, ON M5S 3H4, Canada
niversity of Ireland Galway, University Road, Galway, H91 TK33, Ireland
niversity of Dublin, College Green, Dublin 2, D02 PN40, Ireland

gust 18; accepted 2022 August 25; published 2022 October 20



地外文明搜寻将引发广泛的思考

天体

- 心理学
- 伦理学
- 社会学
- 政治学
- 流行文化
- 法学
- 宗教
- 传媒学

帮助人类认识自己

地外生命探寻对人类未来的影响

探索地外生命不仅仅是一项科学任务，它还可能对人类社会和未来发展产生深远影响。

- **重新定义人类在宇宙中的位置**：如果未来某一天我们在外星发现了生命迹象，甚至是智慧生命，人类对自身在宇宙中的独特性认知将被彻底改变。这将引发哲学、伦理学等领域的广泛讨论，也会影响人类未来的文明发展方向。
- **推动地球环境保护意识**：通过对外星球的研究，我们可以更加清晰地认识到地球环境的独特性和珍贵性。这将促使人类更加关注生态环境的保护，推动全球可持续发展。
- **激发人类的太空移民与深空探索欲望**：随着地外生命探寻的深入，人类对太阳系和系外行星的了解将大大提升，这可能加速未来人类移民火星或其他行星的进程。长期来看，地外生命探寻将为人类打开移居外星的大门。

6. 结语

地外生命探寻无疑是科学前沿最为吸引人也最具挑战性的领域之一。通过我国《国家空间科学中长期发展规划（2024-2050年）》的实施，我国将有机会在全球地外生命探寻领域取得重要突破。这不仅关乎科学知识的扩展，还将推动多个学科的发展，带动航天科技的创新。随着未来探索任务的推进，人类距离解开“我们是否孤单”这一宇宙难题的答案也将越来越近。

深层目的和意义

- 科学层面：验证在宇宙中 生命是否普遍存在？回答地球生命是宇宙中的孤例(Are we alone in the universe?)，还是宇宙化学演化的必然结果？生命能否在不同环境（如非碳基、非水基）中诞生？这将改写对生物学、宇宙学的认知，甚至重新定义“生命”的内涵。
- 技术层面 催生革命性创新-尖端技术的孵化器
  SETI 对高精度观测设备（如射电望远镜、太空望远镜）、海量数据处理（如机器学习筛选信号）、深空通信技术的需求，推动了相关技术的迭代。例如，SETI 开发的信号分析算法已应用于医疗数据分析，而射电望远镜的改进也助力了脉冲星探测等基础研究。
- 哲学层面：重构人类在宇宙中的定位

1. 打破人类中心主义的局限
   人类视自己为宇宙的“唯一智慧存在”的认知深刻影响了宗教、伦理和价值观。SETI 若取得突破，将促使人类重新审视自身的地位 — 我们可能只是宇宙中众多文明之一，这既可能引发对文明脆弱性的警觉，也可能催生更广阔的宇宙共同体意识。
2. 推动跨学科思维的融合
   SETI 需要天文学、生物学、信息学、工程学等领域的协作，其研究过程本身就促进了学科交叉。例如，破译外星信号可能涉及数学、语言学的普适规律，而分析宜居行星则依赖大气科学与地质学的结合。

国家空间科学中长期发展规划（2024—2050年）

国家空间科学中心　2024年10月15日 11:31　北京

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将开展地外生命探寻

国家空间科学中长期发展规划（2024—2050年）

中国科学院 国家航天局 中国载人航天工程办公室
联合发布

2024年10月

为贯彻落实党的二十大和二十届二中、三中全会精神，推动空间科学、空间技术
全面发展，制定本规划，作为当前和今后一个时期指导我国空间科学任务部署、
学研究的依据。

一、发展目标

（一）总目标

梯次布局和论证实施国家空间科学任务，统筹和强化任务驱动的基础研究，打造空间科学高水平人才队伍，不断取得具有重大国际影响力的标志性原创成果，实现空间科学高质量发

“17个优先发展方向”

我国空间科学发展目标

拟突出17个优先发展方向

暗物质与极端宇宙
宇宙起源与演化
宇宙重子物质循环
空间引力波探测
地球循环系统
地月综合观测
空间天气探测
太阳立体探测
日地空间探测
可持续发展
太阳系考古
行星圈层刻画
地外生命探寻
系外行星探测
微重力科学
量子力学与广义相对论
空间生命科学

中国SETI的基础和优势-I

深度国际合作

自五年前（2019年）SETI在国内起步，本团组与世界上其他重要团组展开合作：

- SETI@home：自阿莱西博望远镜坍塌，我们组接过了其十余年的数据，并在后端、数据处理与观测上深度合作。
- Breakthrough Listen：早期即开始合作，一同测试了新的观测策略与探索与传统SETI不同的信号类别。

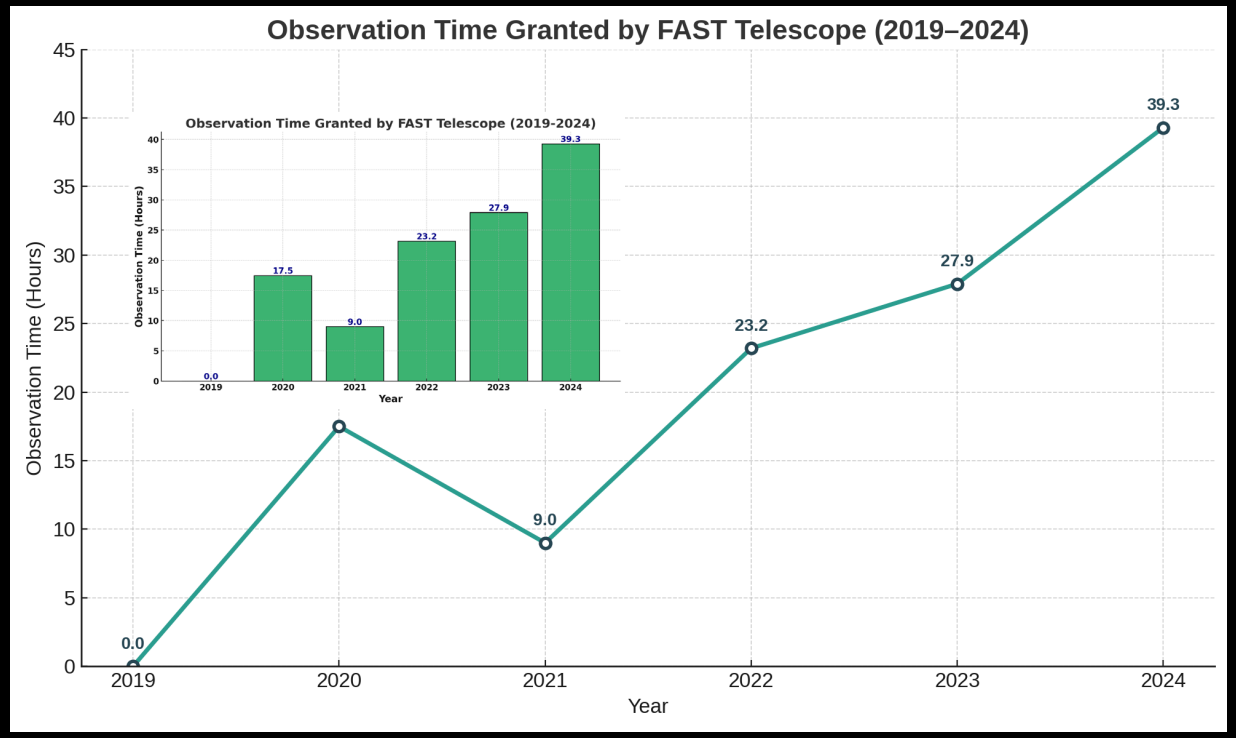
2018-2019年 中美联合SETI

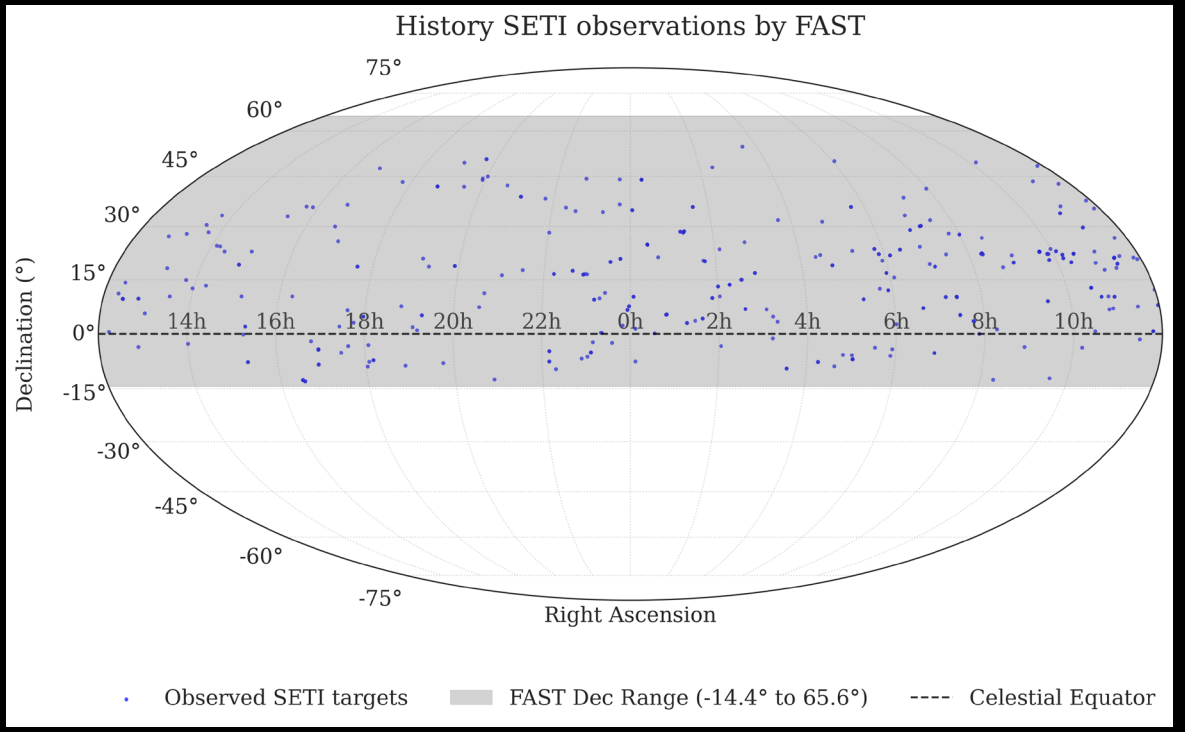
跨越40年的北师大SETI

中国SETI的基础和优势-II

在超高灵敏度设备上的实践经验

- 我们在处理多波束并行采集、每秒数十 GB 级别原始数据流方面积累了宝贵经验。
- 我们在 FAST 平台上积累了在高灵敏度环境下搜寻极弱窄带信号的核心技术。





SETI系外行星FAST观测时间：五次共计116.9个小时
国际评审人的评语　第三次(2022年)

- 发件人:fast-proposal-support@bao.ac.cn
  发送时间:2022-07-31 14:01:53 (星期日)
  收件人: tjzhang@bnu.edu.cn
  主题: The results of the FAST proposal review in 2022

  Dear Tong-Jie Zhang,

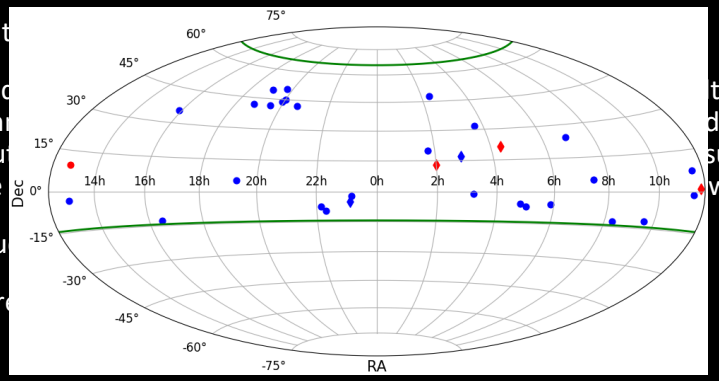
- Thank you for submit

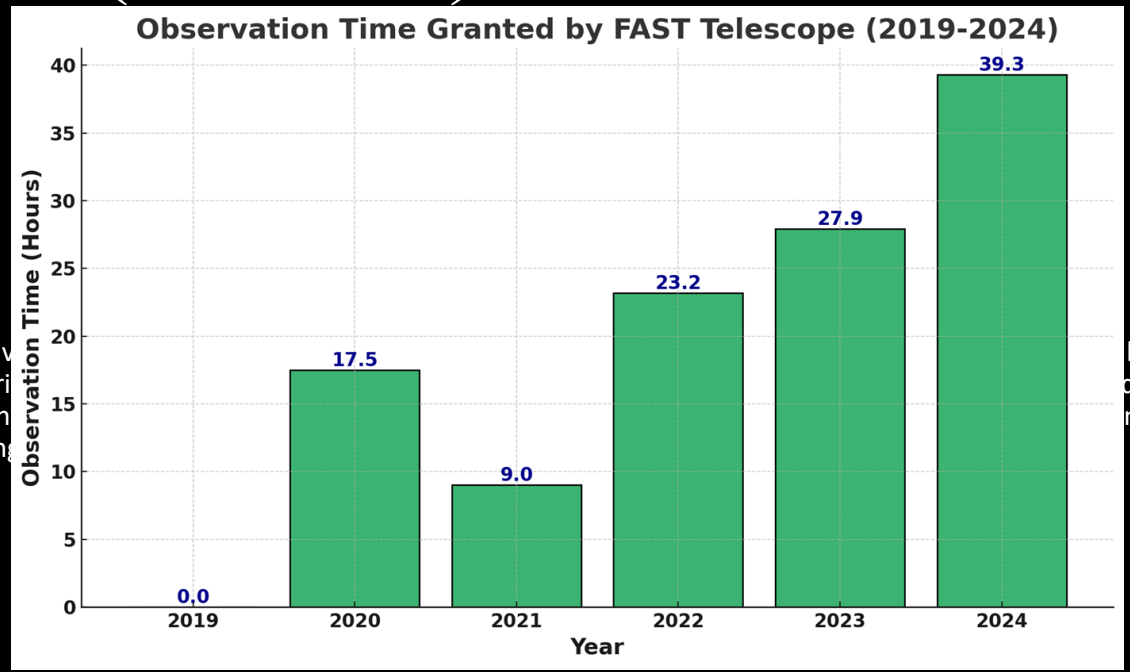
- This year we received ting an av by the FAST Time Allocation Com d wi riori d observing time would be execu subs tion ng 7.8, we also specify the time win nking

- B （23.2 hours, inclu

- Please find below a r

- Strengths:





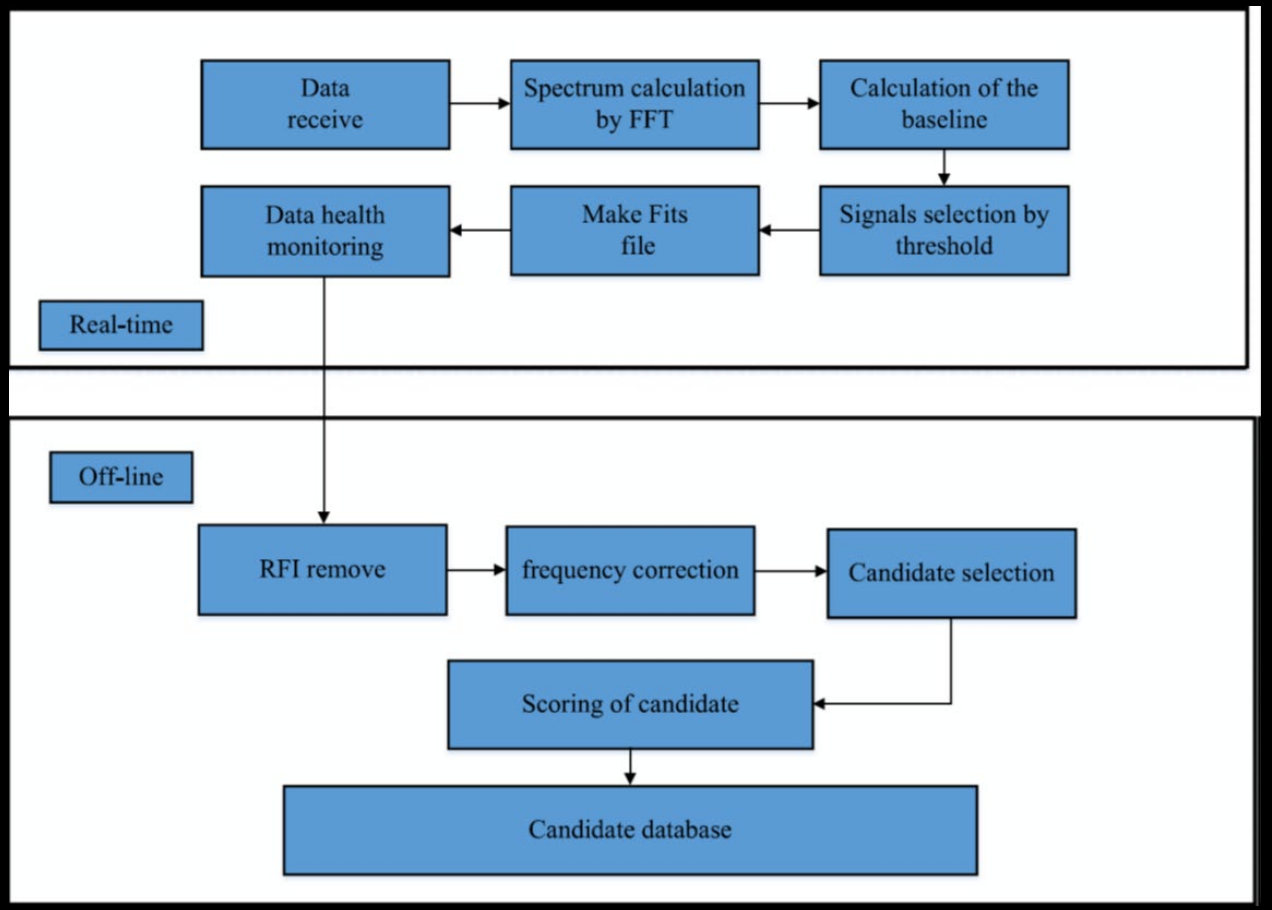
- This is a recurring proposal from a previously approved program, and it propo s to conduct targeted SETI study, which is one of the five key science goals of the FAST. They updated their SETI strategy based on observations in the last two years. They propose search for periodical signals, which is a new approach. While this project could fall under the broad description of "fishing expedition", it is worthwhile trying it, as detecting a p le artificial signal would be a breakthrough discovery.

- ***这是FAST的五个关键科学目标之一。他们根据过去两年的观测结果更新了SETI策略。他们建议寻找周期性信号，这是一种新的方法。虽然这个项目可以被广泛地描述为“捕鱼探险（或者大海捞针）”，但它值得一试，因为探测到可能的人工信号将是一个突破性的发现。

中国SETI的基础和优势-III

处理海量多波束数据的能力

- FAST-SETI 项目采用 19 波束接收机，使用脉冲星、谱线、SETI后端以搜索不同类型的信号。
- 在SETI观测中率先使用机械学习。
- 开发了基于 FPGA+GPU 的高效处理管线，实现了高速、实时的频谱分析（如 2 Hz 频谱分辨率）。

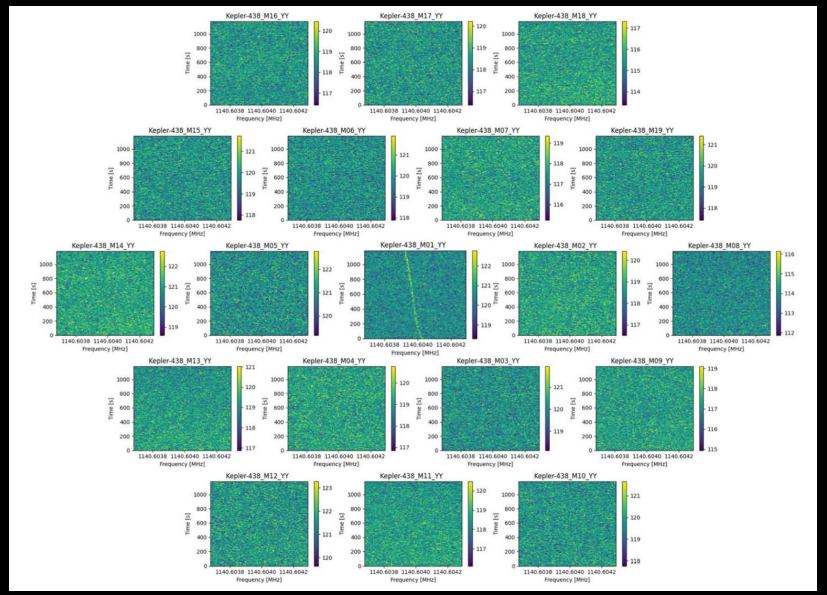


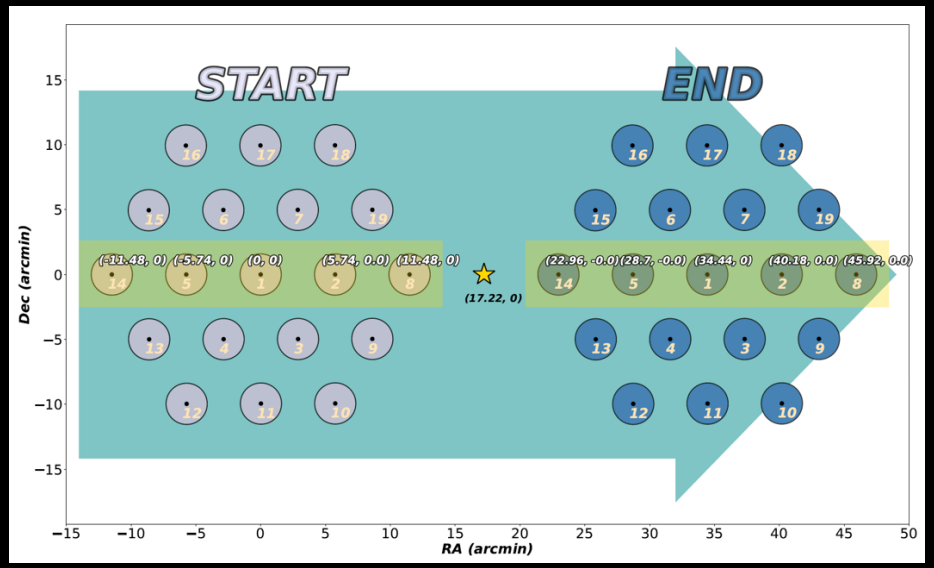
中国SETI的基础和优势-VI

开发了世界前沿的SETI信号处理算法与管线

针对多波束数据特点，开发并应用了

- MBCM 利用多波束之间对地外信号的反应差异去除地基RFI，效率显著提升。
- MBPS 点源扫描，建立了完整的对连续RFI之多参数空间交叉识别框架。
- 发展了利用偏振、频率漂移等信息增强 RFI 识别和信号判真的多维度算法。





中国SETI的基础和优势-VII
FAST的科学目标之一(2011年)

- 南仁东先生 “中国天眼之父”,FAST工程的发起者和奠基人。

1022 *R. Nan et al.*

4.6. *SETI*

The only practical way to contact distant civilizations may also be through radio waves. Most SETI searches concentrate on microwaves at 1–60 GHz, using “free space” in the microwave window, especially the narrow band between the hydroxyl

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组织机构
管理规章
人力资源
人才培养

5. 搜索星际通讯信号——寻找地外文明

寻找地外文明（Search for Extra－Terrestrial Intelligence，SETI)的学科风险是不言而喻的，但它一旦成功，将使人类所有的科学成就黯然失色。所以科学界的探索、发达国家政府与民间对SETI的投入也从未停止。

我们与地外文明通讯的唯一可行方法是寻找来自地外的“人工”无线电信号。非热银河背景噪声、量子噪声及宇宙微波背景噪声是我们银河系中无处不在的3个噪声源，地外文明社会的工程师面临同样的电噪谱，他们可能会和我们想到相同的频率窗口。

SETI专家认为人类应该将搜索集中在1—3GHz的频率范围，尤其是21厘米的中性氢线HI与18厘米羟基线OH之间。H与OH结合成水H2O，因而这一狭窄频带又称为“水洞”。水对地球生命是最基本的，地外的“水族”可能也会自然地通过水洞寻找同类。

THE FIVE-HUNDRED-METER APERTURE SPHERICAL RADIO TELESCOPE (FAST) PROJECT

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SETI进展综述2022年

科学通报
进 展
《中国科学》杂志社
SCIENCE CHINA PRESS

地外文明技术印迹射电搜寻进展

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摘要 基于哥白尼原理、德雷克公式以及大量系外行星的发现
高级智慧生命(或文明). 射电技术由于其优势而成为地外文明搜
的单天线射电望远镜, 地外文明搜寻(search for extraterrestrial i
射电L波段上极高的灵敏度对SETI有着重要意义. 基于FAST
间, 我们开展了SETI后端共时巡天观测和系外行星目标观测.
(SETI@home)和突破聆听(Breakthrough Listen)团队合作, 我们
明(extraterrestrial intelligence, ETI)信号鉴别过程更加科学完备的
ETI候选目标. 本文主要介绍国际上的SETI观测历史, 尤其是FA

关键词 地外智慧生命搜寻, 技术印迹, 射频干扰, 共时巡天观测, 系外行星

科学通报
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Chinese Science Bulletin, (2022) Free Content

地外文明技术印迹射电搜寻进展 CrossMark

Tongjie Zhang [1], Zhenzhao Tao [2], Wenfei Liu [3], Shiyu Li [4], Haichen Zhao [2], Zhisong Zhang [5], Jiankang Li [6], Yixuan Chen [2], Xiaohang Luan [2], Hongfeng Wang [7], Jianchen Zhang [7]

国家空间科学中长期发展规划（2024—2050年）

国家空间科学中心　2024年10月15日 11:31　北京

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中国科学院 国家航天局 中国载人航天工程办公室
联合发布

2024年10月

为贯彻落实党的二十大和二十届二中、三中全会精神，推动空间科学、空间技术
全面发展，制定本规划，作为当前和今后一个时期指导我国空间科学任务部署、
学研究的依据。

一、发展目标

（一）总目标

梯次布局和论证实施国家空间科学任务，统筹和强化任务驱动的基础研究，打造空间科学高水平人才队伍，不断取得具有重大国际影响力的标志性原创成果，实现空间科学高质量发

“17个优先发展方向”

我国空间科学发展目标

拟突出17个优先发展方向

暗物质与极端宇宙
宇宙起源与演化
宇宙重子物质循环
空间引力波探测
地球循环系统
地月综合观测
空间天气探测
太阳立体探测
日地空间探测
可持续发展
太阳系考古
行星圈层刻画
地外生命探寻
系外行星探测
微重力科学
量子力学与广义相对论
空间生命科学

地外智慧生命搜寻(SETI)的公众科学设想
Are we alone?

- 张同杰

- 北京师范大学 物理与天文学院
- 天文与天体物理前沿科学研究所

- 2025年8月1日 大连

报告大纲

- 一. 地外生命概述
- 二. SETI历史和国际研究近况
- 三. 国内SETI合作团队FAST观测研究进展
  四. 国际影响力
- 五. 未来的研究计划和公众科学设想

一. 地外生命概述

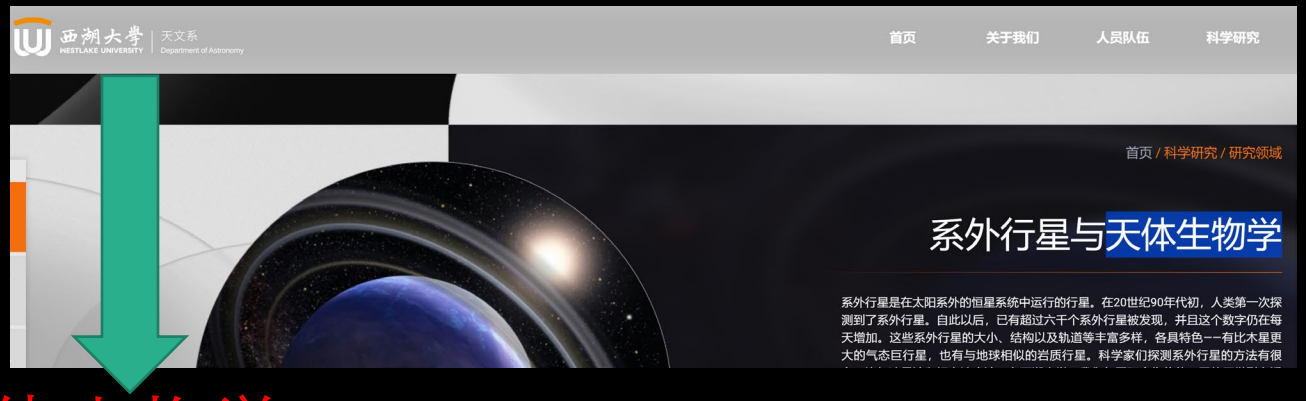
地外生命级别及其发现进程

1. 有机分子 (20世纪60年代天文学四大发现)
2. 氨基酸(2022年日本“隼鸟2号”在小行星“龙宫” 发现了氨基酸。这是首次在地球以外确认氨基酸的存在.)
3. 低级生命(蛋白质)(2025年 JWST: K2-18b, 气体二甲硫醚(DMS)和二甲基二硫(DMDS)生物标志(biosignature): 主要是微生物，如藻类等海洋浮游植物???)
4. 高级(智慧)生命(文明)(????)

地外文明或者智慧生命搜寻(SETI)

- Extra-terrestrial Intelligence (ETI: 地外文明)： 射电信号等
- Technosignature (技术印记)： 类似奥陌陌等
- Biosignature (生物印记)： 氧气等
- Search for Biosignature (搜寻生物印记)
- Search for Extra-terrestrial Intelligence: SETI (搜寻地外文明)
- Search for Technosignature (搜寻技术印记或者指纹)
- 统称: Searching for Life beyond Earth (搜寻地外生命)

地外生命探索模式



- 有机分子-氨基酸-低级生命：天体生物学

1. detection in situ of biosignatures (life and byproducts of biological processes) at sites of interest(日本小行星探测器“隼鸟2号”);

2. remote sensing of biosignatures from planetary atmospheres （韦伯望远镜和未来我国空间站望远镜等）；

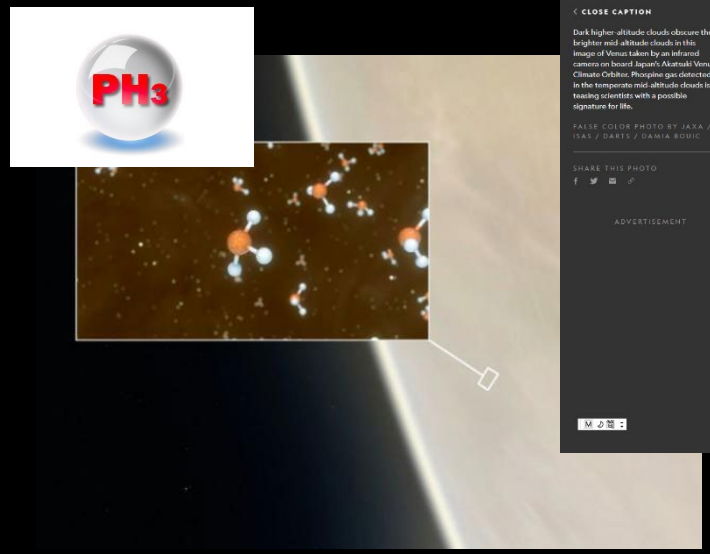
- 高级生命

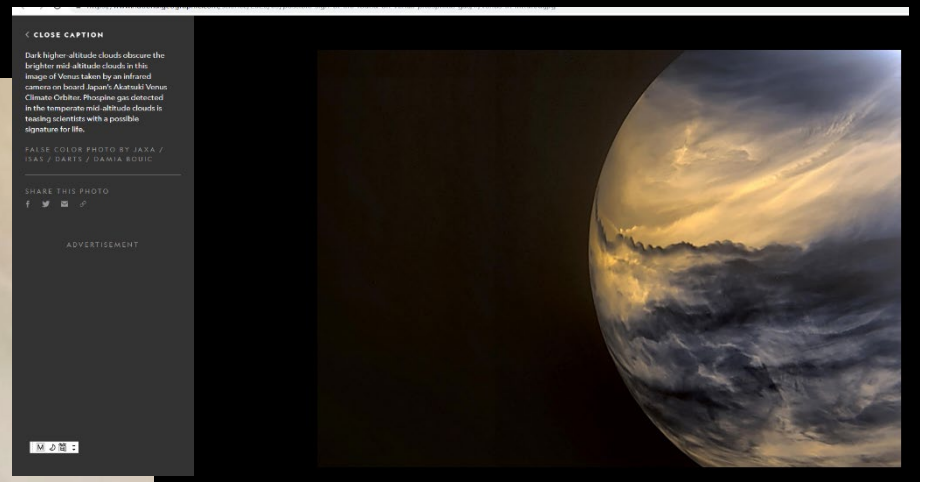
1. 天文学： 射电或者光学搜寻 the detection of technosignatures (signs of technologically sophisticated civilizations), i.e., the search for extraterrestrial intelligence (SETI).

2. 天体生物学-搜寻系外行星大气中的氧气。

低级生命发现：金星大气中发现首个地外生命存在的证据---乌龙事件

- 金星大气层-发现了磷化氢（PH_3）
- 天体生物学家将磷化氢视为“生物标志”：可能存在着生命的迹象。
- 地球以外发现了生命-微生物（低级生命）的存在！





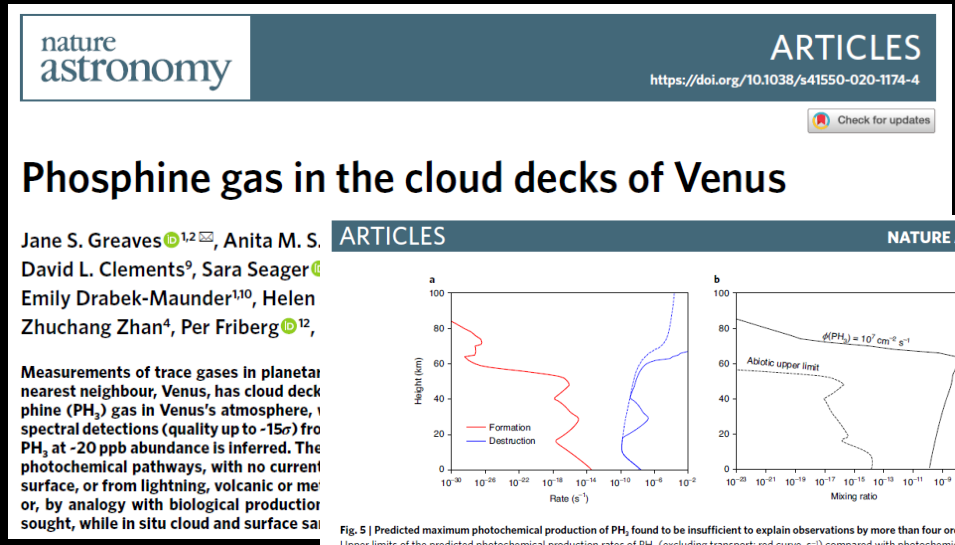
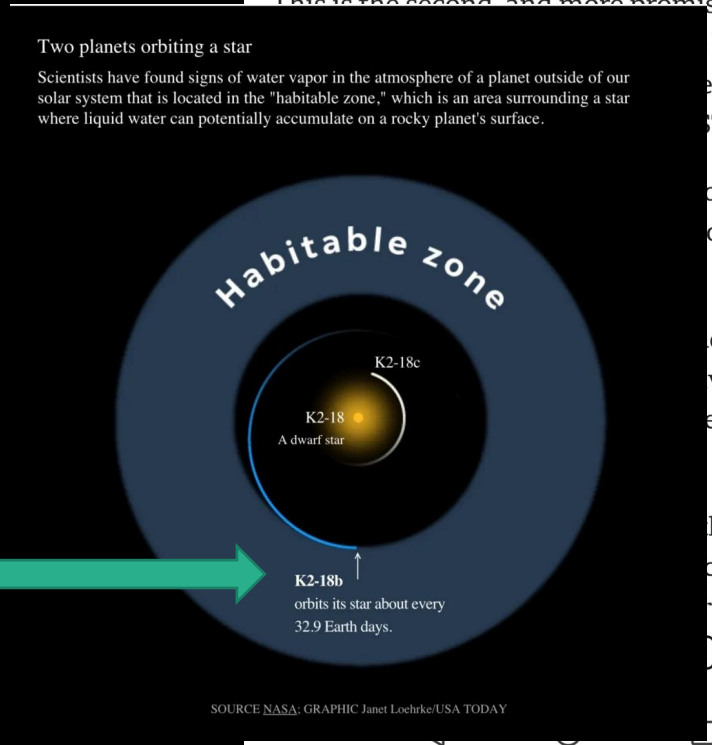


Fig. 5 | Predicted maximum photochemical production of PH_3 found to be insufficient to explain observations by more than four orders of magnitude. a, Upper limits of the predicted photochemical production rates of PH_3 (excluding transport; red curve, s^{-1}) compared with photochemical destruction rates (blue curve, s^{-1}), including radicals and atoms (blue solid) and ignoring radicals and atoms (blue dashed), as a function of height (km). See kinetic network of Extended Data Fig. 7. b, Mixing ratio of PH_3 as a function of atmospheric height (km), for a production flux ($\phi(PH_3)$) within the cloud layer (~55–65 km) of 10^7 cm^{-2} s^{-1} (solid curve), compared with the predicted steady-state abiotic upper limit (dashed curve). See kinetic network of Extended Data Fig. 7.

K2-18b后随观测已经完成

- 距离38pc，5月9日观测
- 初步结果没有发现信号！



4月1日
愚人节

- Whisky (威士忌)
- 检测到行星大气里有威士忌含量超标

Mon. Not. Roy. Scot. Astr. Soc. **29540**, 9223-9245(2025) Preprint 1 April 2025 Compiled using MNRSAS LATEX style file v3245.1

Detection of an extraterrestrial technical civilisation on the extrasolar planet GJ 1132 b

Frederic V. Hessman,[1]★ Andrew Collier Cameron,[2] and Keith Horne[2]
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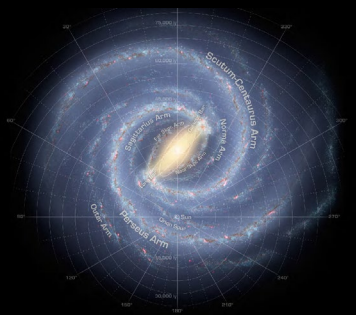
Not acceptable; received April 1

ABSTRACT

We report the detection of whisky in the atmosphere of the extrasolar super-Earth planet GJ 1132 b from transmission spectroscopic data. It is seen both in atmospheric absorption as well as in chromospheric emission, the latter probably due to the intense heating of the co-rotating planet's day-side surface. This detection cannot be explained using natural sources of alcohol, implying that there must be a technically advanced civilisation – possibly originating from the neighboring habitable planet GJ 1132 c – that is engaged in massive distilling operations accompanied by high levels of industrial pollution. The reason for the necessarily vast scale of production is either to produce rocket fuel for an interplanetary economy or, more likely, for an unusually high level of personal consumption. The latter hypothesis suggests a novel explanation for the Fermi Paradox (the lack of indirect or direct contact with extraterrestrials): a technically versed civilisation would be incapable of achieving the higher technical levels necessary for the development of a detectable radio signature – much less interstellar travel – at the suggested rates of consumption.

Key words: extrasolar planets – – chemistry : alcohol : distilled – extraterrestrials – exoclimatology

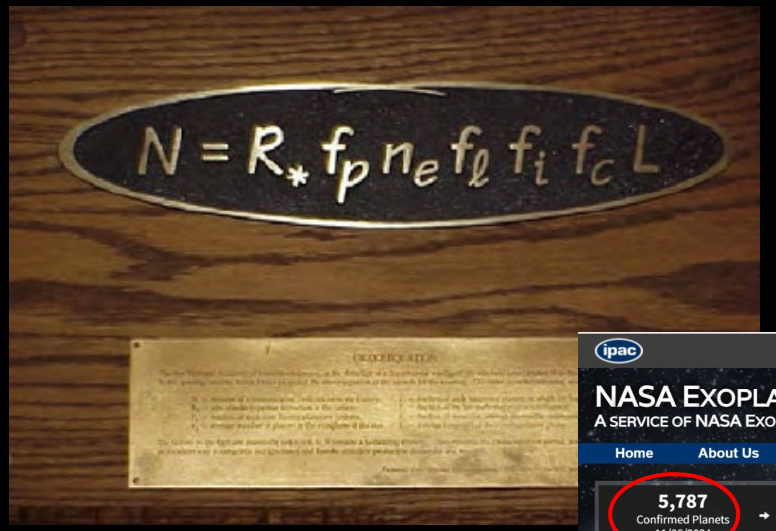
科学家相信其存在的依据之一：德雷克公式



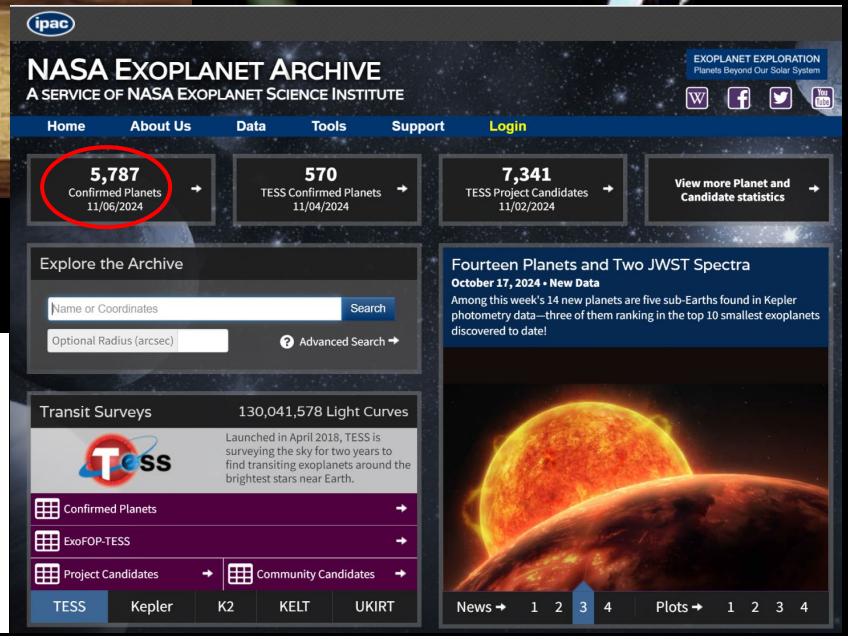
- Drake, F. D. 1961, PhT, 14, 40
- 从统计上揭示了银河系中能够与外界交流的文明的数量。

$$N = R^* \times f_p \times n_e \times f_l \times f_i \times f_c \times L$$

- N 代表银河系内可能与我们通讯的文明数量
- R 代表银河内恒星形成的速率
- f_p 代表恒星有行星的可能性
- n_e 代表位于合适生态范围内的行星的平均数
- f_l 代表以上行星发展出生命的可能性
- f_i 代表演化出高智生物的可能性
- f_c 代表该高智生命能够进行通讯的可能性
- L 代表该高智文明的预期寿命



- 银河系： ~10亿系外地球（5000多系外行星）
- 文明 ~ 亿



Publications of the Astronomical Society of the Pacific, 130:054101 (9pp), 2018 May
https://doi.org/10.1088/1538-3873/aaac6a

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Area Coverage of Expanding E.T. Signals in the Galaxy: SETI and Drake's N

Claudio Grimaldi[1], Geoffrey W. Marcy[2], Nathaniel K. Tellis[3], and Frank Drake[4]
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Received 2017 December 22; accepted 2018 January 31; published 2018 March 29

德雷克公式

Publications of the Astronomical Society of the Pacific, 131:044202 (5pp), 2019 April https://doi.org/10.1088/1538-3873/ab028e

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Carrington-class Events as a Great Filter for Electronic Civilizations in the Drake Equation

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ctober 4; accepted 2019 January 29; published 2019 March 1

1. Introduction

Drake (1961) formulated an equation to estimate the number of intelligent species in our galaxy (N_C). The Drake equation begins with the number of stars in our Galaxy and multiplies this by several fractions, each reducing the number of potential species (Tyson et al. 2016):

1. $N_S \sim 3 \times 10^{11}$ number of stars in our Galaxy;
2. $f_{HP} \sim 0.006$ fraction of stars having a habitable planet;
3. $f_L \sim 1?$ fraction of habitable planets on which life develops;
4. $f_i \ll 1$ fraction where life develops intelligence;
5. $f_C \sim 1?$ fraction where intelligent species develop interstellar communications;
6. $L_C \ll 10$ Gyr average lifetime of communicating civilizations, compared with our Galaxy's approximate age, 10 Gyr.

Multiplying these together gives the Drake equation:

$$N_C = N_S \times f_{HP} \times f_L \times f_i \times f_C \times \frac{L_C}{10\ \mathrm{Gyr}}. \quad (1)$$

Publications of the Astronomical Society of the Pacific, 130:054101 (9pp), 2018 May https://doi.org/10.1088/1538-3873/aaac6a

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Area Coverage of Expanding E.T. Signals in the Galaxy: SETI and Drake's *N*

Claudio Grimaldi[1], Geoffrey W. Marcy[2], Nathaniel K. Tellis[3], and Frank Drake[4]
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Received 2017 December 22; accepted 2018 January 31; published 2018 March 29

2020年 拉斯维加斯大学教授的德雷克公式研究

Frontiers of Physics
https://doi.org/10.1007/s11467-020-0973-5
Front. Phys.
15(5), 54502 (2020)

RESEARCH ARTICLE

A quantitative assessment of communicating extra-terrestrial intelligent civilizations in the galaxy and the case of FRB-like signals

Bing Zhang

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Received May 20, 2020; accepted June 15, 2020

A formula is proposed to quantitatively estimate the signal emission rate of Communicating Extra-Terrestrial Intelligent civilizations (CETIs) in the Galaxy. I suggest that one possible type of CETI signal would be brief radio bursts similar to fast radio bursts (FRBs). A dedicated search for FRB–like artificial signals in the Galaxy for decades may pose a meaningful upper limit on the emission rate of these signals by CETIs. The Fermi-Hart paradox is answered in terms of not having enough observing times for this and other types of signals. Whether humans should send FRB-like signals in the far future is briefly discussed.

Keywords fast radio bursts, astrobilogy

2022年北师大教授的德雷克公式研究

The Astrophysical Journal, 928:142 (10pp), 2022 April 1 https://doi.org/10.3847/1538-4357/ac561d

The Number of Possible CETIs within Our Galaxy and the Communication Probability among These CETIs

Wenjie Song and He Gao
Department of Astronomy, Beijing Normal University, Beijing, People's Republic of China; gaohe@bnu.edu.cn
Received 2021 November 5; revised 2022 January 7; accepted 2022 February 14; published 2022 April 4

Abstract

As the only known intelligent civilization, human beings are always curious about the existence of other communicating extraterrestrial intelligent civilizations (CETIs). Based on the latest astrophysical information, we carry out Monte Carlo simulations to estimate the number of possible CETIs within our Galaxy and the communication probability among them. Two poorly known parameters have a great impact on the results. One is the probability of life appearing on terrestrial planets and eventually evolving into a CETI (f_c), and the other determines at what stage of their host star's evolution CETIs would be born (F). In order to ensure the

2011年SETI会议文集

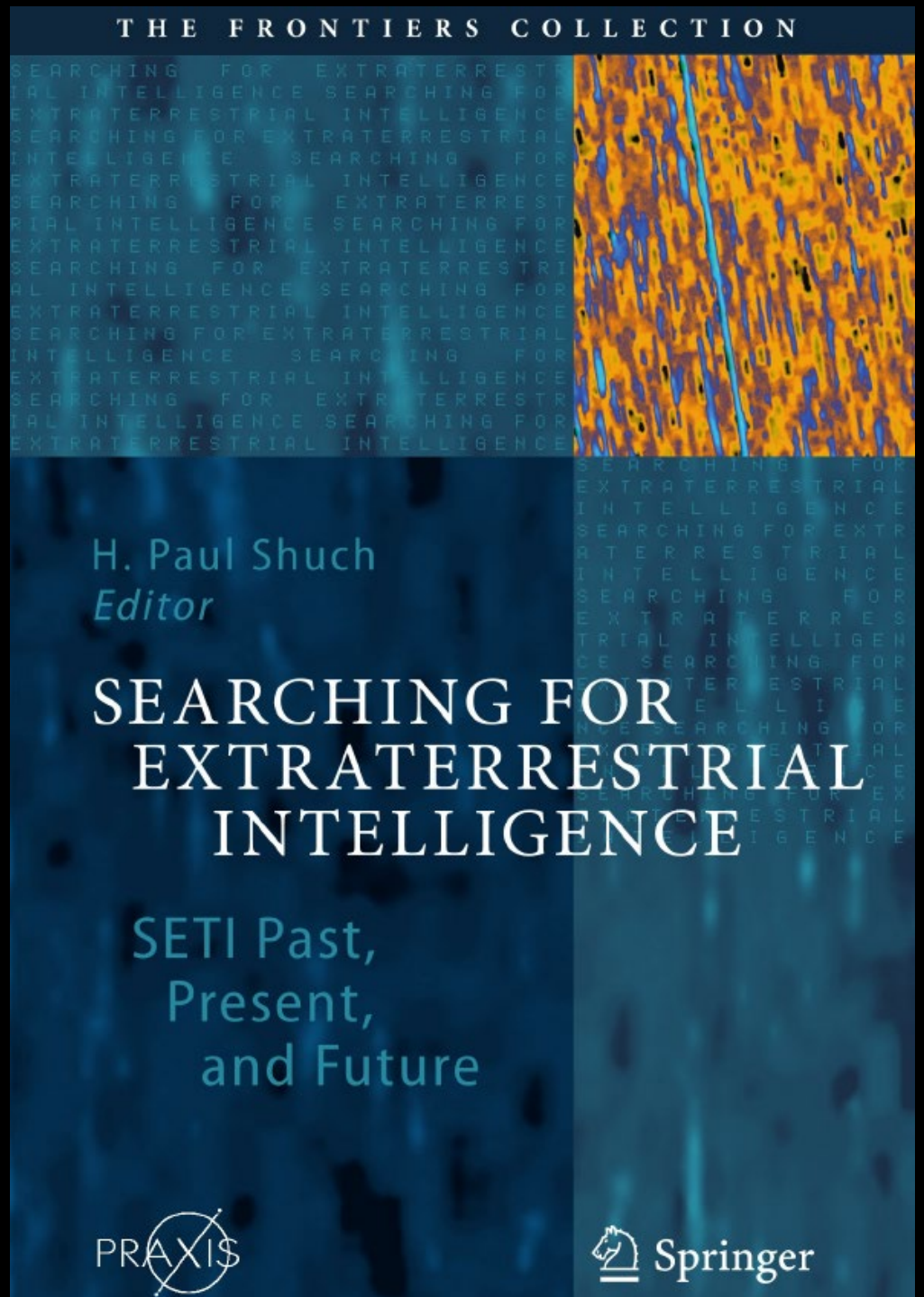
This collection of essays is presented in honor of SETI patriarch Frank D. Drake on the occasion of his 80th birthday. Its publication marks a half-century of observational SETI science.

H. Paul Shuch

Cogan Station, PA, USA

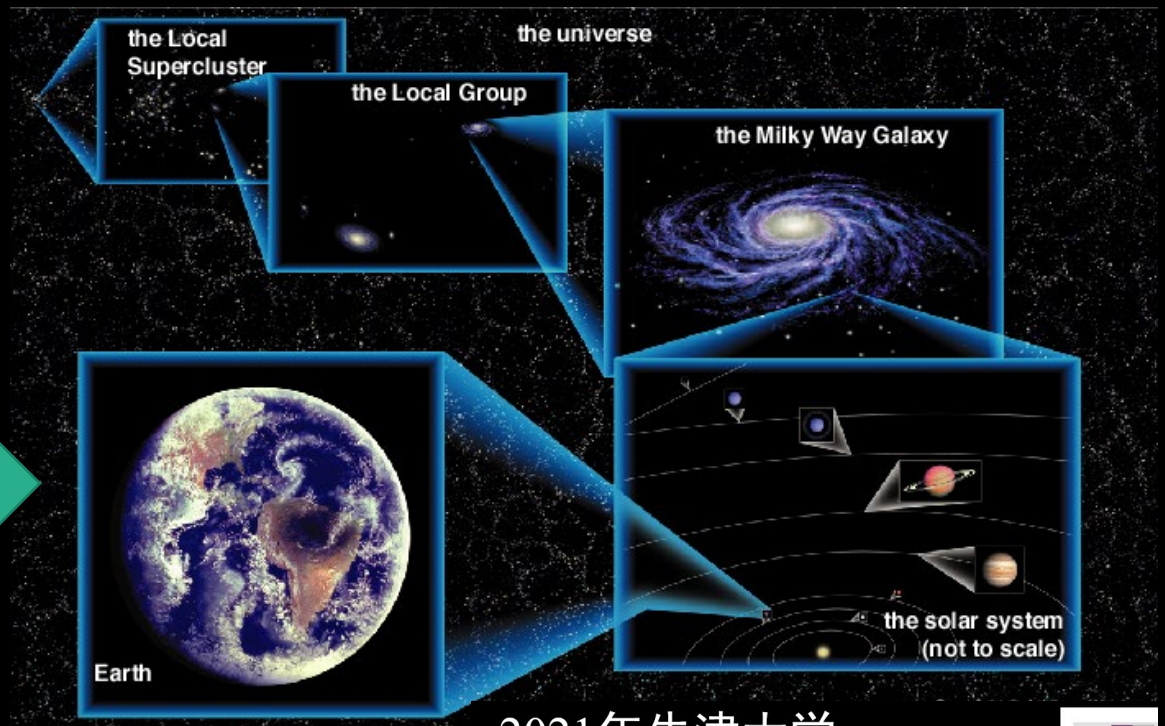
May 2010

致敬SETI创始人弗兰克·D·德雷克80岁生日。
它的发表标志着SETI观测科学的半个世纪。1959-2010



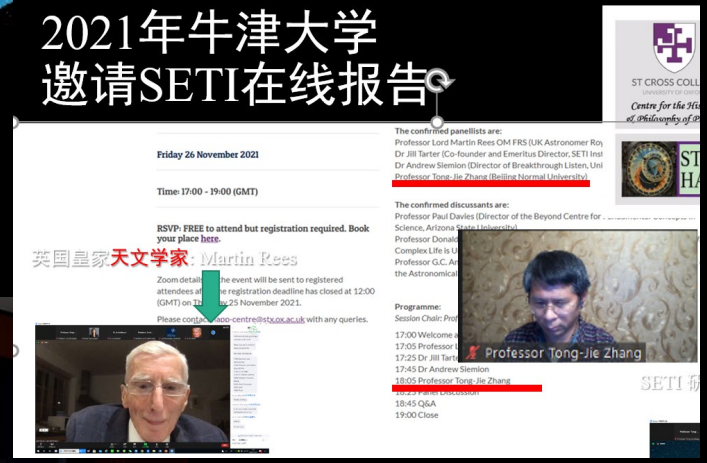
科学家相信其存在的依据之二：

The Copernican Principle (哥白尼原理)



- 每当声称地球是独一无二的时候，我们总是错的.
- 哥白尼原理：我们在宇宙中的地位没有什么特别之处!
- 宇宙别处肯定有地外生命!

2021年牛津大学邀请SETI在线报告



2025年《科学进展》：智慧生命诞生或是一种必然

SCIENCE ADVANCES | REVIEW

EVOLUTIONARY BIOLOGY

A reassessment of the "hard-steps" model for the evolution of intelligent life

Jason T Wright
Professor of Astronomy and Astrophysics
Director, Penn State Extraterrestrial Intelligence Center

Professor of Astronomy & Astrophysics
Director, Penn State Extraterrestrial Intelligence Center
宾夕法尼亚州立大学地外文明中心主任
Dan … am Frank[6], Jason T. Wright[2,3,7]

如果生命的进化并不依赖极端罕见的步骤，而是由环境门槛驱动，那么**不同类型的地球生命阶段（如类似太古代、元古代和显生宙的生物圈）应该会在系外行星中普遍存在**，并可能表现出不同的大气特征。比如，太古代（Archean-like）生物圈可能富含甲烷、二氧化碳和较低的氧气，类似于地球早期的情况。同样，智慧生命的**技术特征**技术标志（如无线电信号或大气污染物）**应该在系外行星上被探测到，而不仅仅是极少数例外**。

总之，这项最新研究为理解生命在宇宙中的普遍性提供了新的视角，也可能影响未来的天文学和地球生物学研究方向。

（本文审核专家：河南大学生命科学学院刘宇鹏教授）

Acc… anity required "successful passage through a number of inter… trinsically improbable in the time available for biological evol… echnological life an… ceed… luate core assumpt… the l… e an alternative mo… evol… an be explained vi… prob… was initially inhosp… to ce… istence, then the ti… by th… windows of habita…

参考文献

[1] Daniel B. Mills et al.,A reassessment of the "hard-steps" model for the evolution of intelligent life.*Sci. Adv.*11,eads5698(2025).DOI:10.1126/sciadv.ads5698

科 普 中 国

挑战40年权威理论，Science子刊：智慧生命诞生或是一种必然

原创 李娟 返朴 2025年03月17日 08:01 北京

加**星标**，才能不错过每日推送！方法见文末插图

地球上的人类究竟是宇宙的奇迹，还是某种必然？长期以来的主流观点认为，智慧生命的演化必须经历多个几乎不可能跨越的障碍，人类只是个幸运的例外。然而，最新发表在《科学进展》的研究挑战了这一观点，指出智慧生命的诞生或许不是一场概率上的奇迹，而是受环境变化驱动的必然结果。

二. SETI历史和国际研究近况

《自然》1959年:1.4GHz 星际通讯，

SEARCHING FOR INTERSTELLAR COMMUNICATIONS

By GIUSEPPE COCCONI* and PHILIP MORRISON†
Cornell University, Ithaca, New York

NO theories yet exist which enable a reliable estimate of the probabilities of (1) planet formation ; (2) origin of life ; (3) evolution of societies possessing advanced scientific capabilities. In the absence of such theories, our environment suggests that stars of the main sequence with a lifetime of many billions of years can possess planets, that of a small set of such planets two (Earth and very probably Mars) support life, that life on one such planet includes a society recently capable of considerable scientific investigation. The lifetime of such societies is not known ; but it seems unwarranted to deny that among such societies some might maintain themselves for times very long compared to the time of human history, perhaps for times comparable with geological time. It follows, then, that near some star rather like the Sun there are civilizations with scientific interests and with technical possibilities much greater than those now available to us.

* Now on leave at CERN, Geneva.
† Now on leave at the Imperial College of Science and Technology, London, S.W.7.

To the beings of such a society, our Sun must appear as a likely site for the evolution of a new society. It is highly probable that for a long time they will have been expecting the development of science near the Sun. We shall assume that long ago they estab
would one
look forwa
the Sun wh
society ha
What sort

Interstel
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minimum

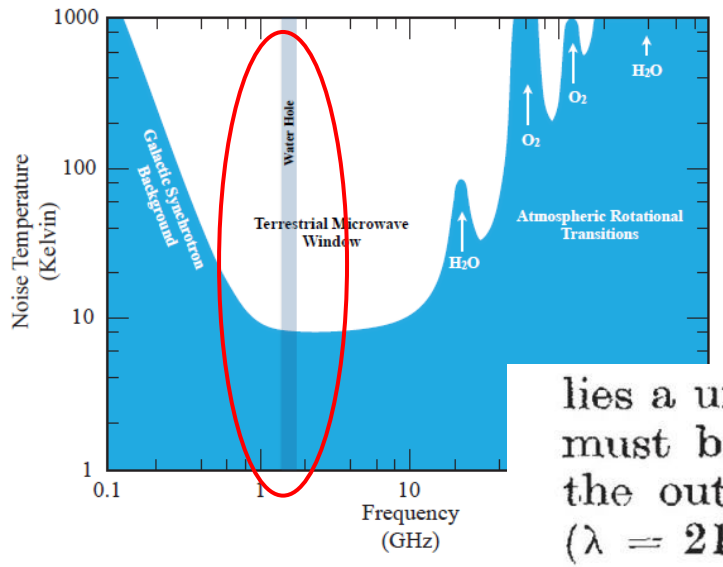
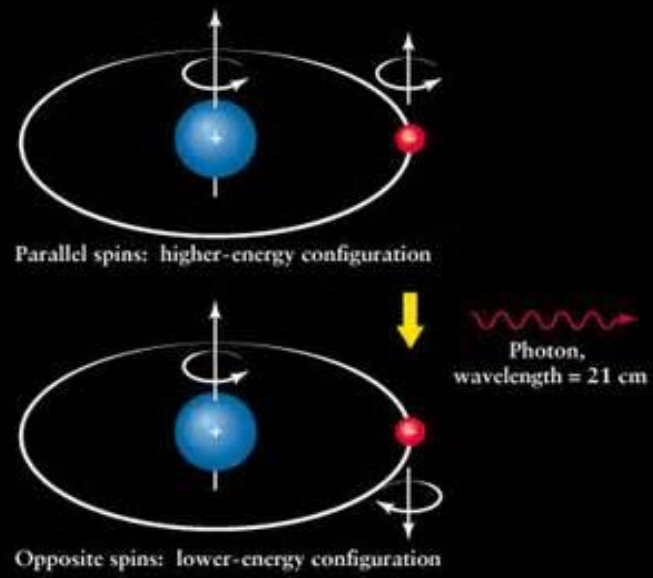


Figure 1: The "terrestrial microwave window": a relatively quiet radio wir
chrotron emission and molecular rotational transitions in the Earth's atmosph
so-called "Water Hole" bound by the frequencies of hyperfine transitions of ne
the hydroxyl radical (OH, $f_{OH} \approx 1.67$ GHz)



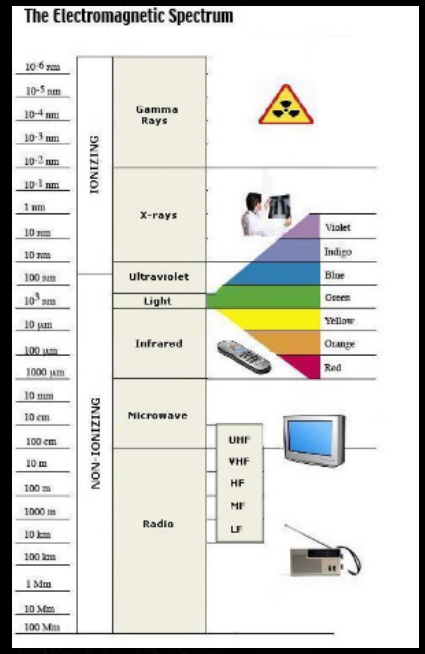
lies a unique, objective standard of frequency, which must be known to every observer in the universe : the outstanding radio emission line at 1,420 Mc./s. ($\lambda = 21$ cm.) of neutral hydrogen. It is reasonable to expect that sensitive receivers for this frequency will be made at an early stage of the development of radio-astronomy. That would be the expectation of the operators of the assumed source, and the present state of terrestrial instruments indeed justifies the expectation. Therefore we think it most promising to search in the neighbourhood of 1,420 Mc./s.

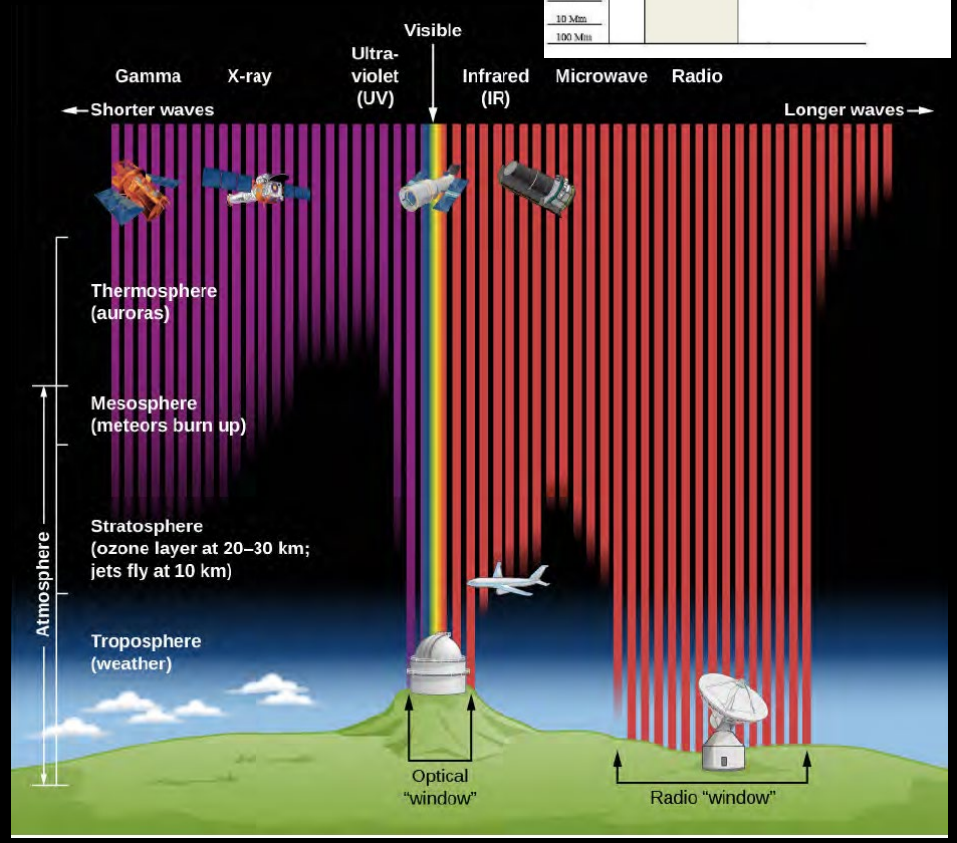
射电(radio waves)波段

- 哪一个波段最适合进行星际通讯?
- 要求：不容易被星际气体和尘埃吸收；容易穿透系外行星大气

- 设备制造足够便宜，生产可以量产-

射电波段是最佳选择.





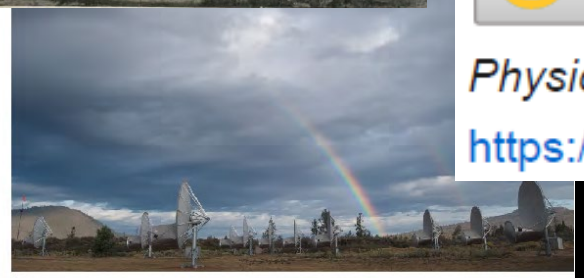
上世纪60年代初
SETI之父-早期射电观测: Project Ozma

- 1960年，康奈尔大学（美国SETI 研究所）的射电天文学家、被称为“SETI之父”的**弗兰克·德雷克**（Frank Drake）开启了第一个现代搜寻地外智慧生命（Search for Extra-terrestrial Intelligence，以下简称SETI）的实验，该实验被称为“奥慈玛计划（Project Ozma）”

PROJECT OZMA

By F. D. Drake

THE question of t... elsewhere in spac... but, until recently ... science-fiction writers. T...



(a) (b)

Project Ozma

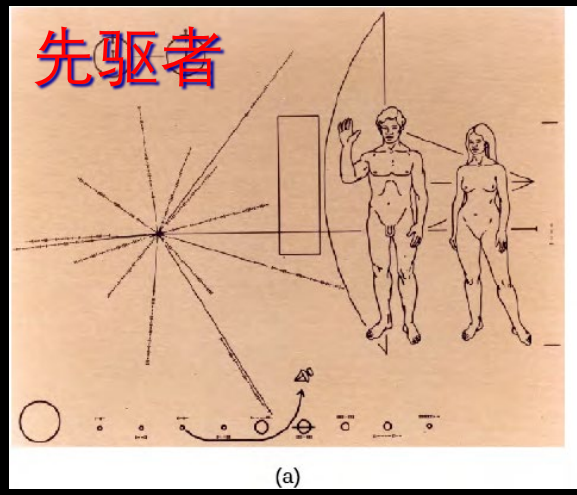
F. D. Drake

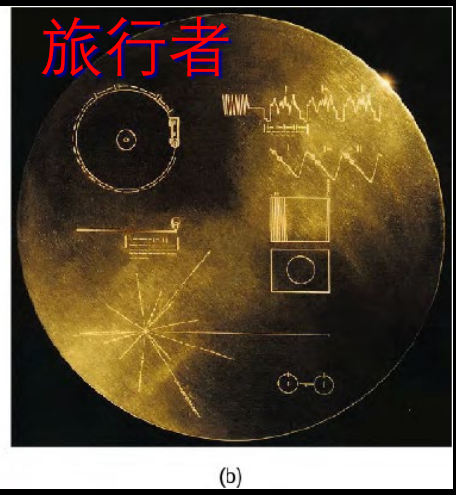
Check for updates

Physics Today **14** (4), 40–46 (1961);
https://doi.org/10.1063/1.3057500

70年代发射无人宇宙飞船去寻找

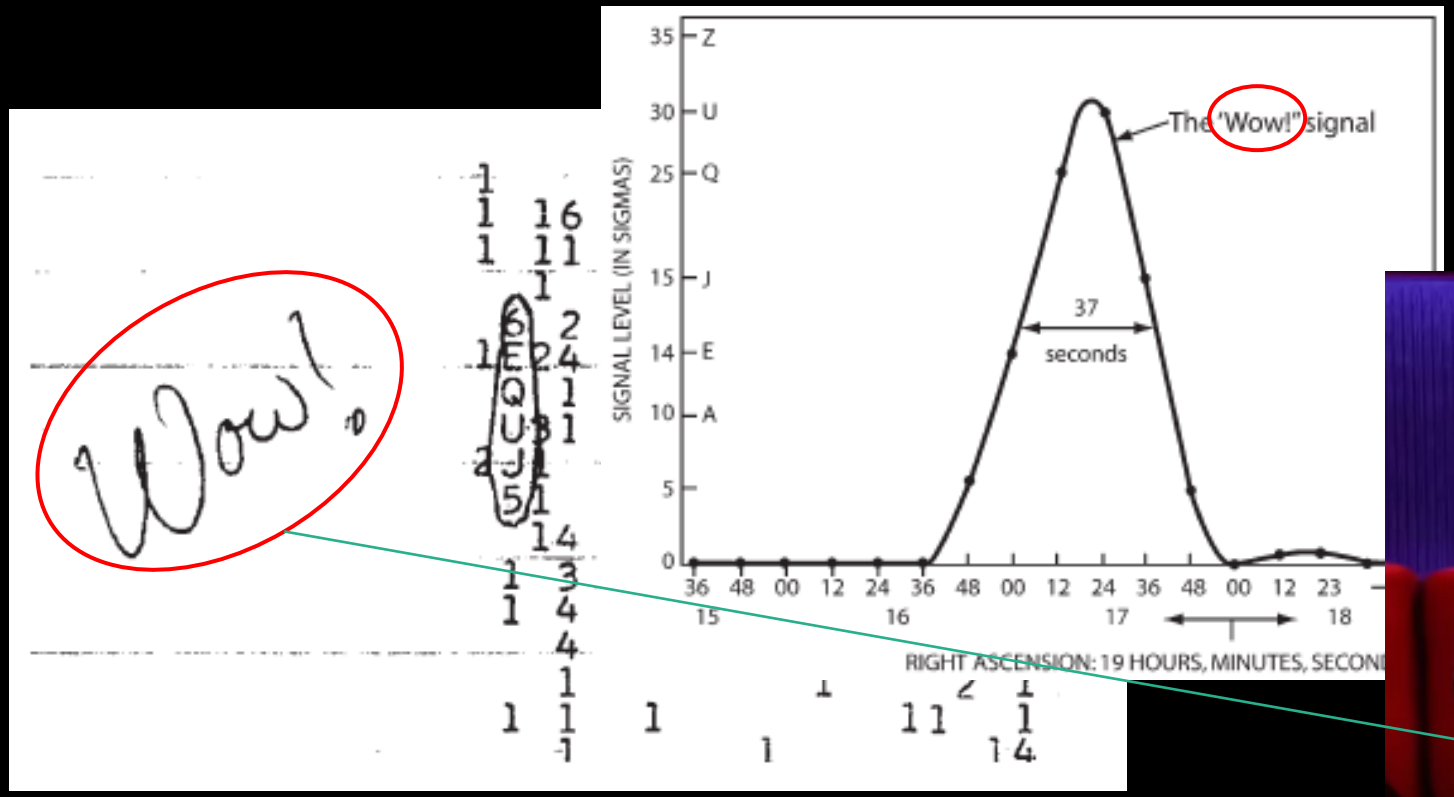
- 五位信使Interstellar Messages： two Pioneers(先驱者), two Voyagers(旅行者), and New Horizons(新视野)—现正在离开太阳系.
- Pioneer先驱者： 携带刻有图形信息的镀金铝板牌匾。
- Voyagers旅行者： 携带音频和视频唱片-118张照片、90分钟来自世界各地的精选音乐和60种语言的问候）。
- 大海里面的漂流瓶-不报任何希望的寻找!
- 成本非常昂贵!





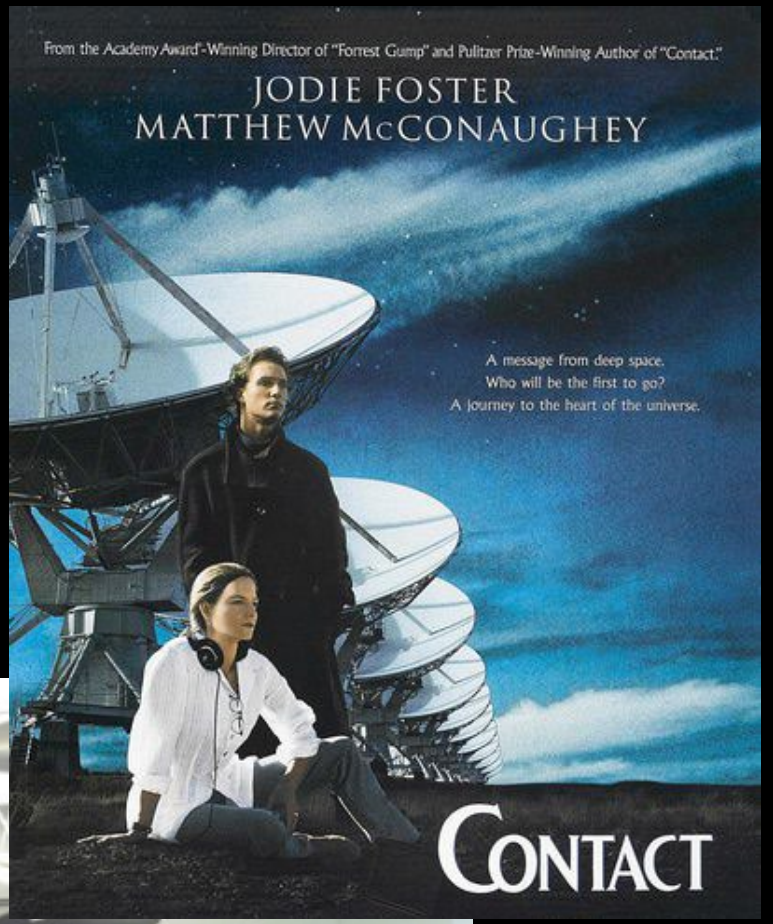
70年代WOWsignal信号

- In 1977, the Ohio State University Radio Observatory recorded a strong (30 s秒), narrowband (<10 kHz) signal near the 21 cm hydrogen line（21厘米氢线）！



上世纪80年代后

- **Jill Tarter et al. At SETI institute**
- **Dan Werthimer at UCBerkeley**



加州大学伯克利分校SETI研究 1996开始

- **Dan Werthimer**

Date	1996–
Observer(s)	Werthimer et al. (SERENDIP IV)
Site	Arecibo

BERKELEY SETI RESEARCH CENTER

Berkeley SETI

- SERENDIP(Search for Extraterrestrial Radio Emissions from Nearby Developed Intelligent Populations：**搜寻临近地球的地外智慧生命发出的射电信号**)项目是世界上运行时间最长的SETI项目

SERENDIP

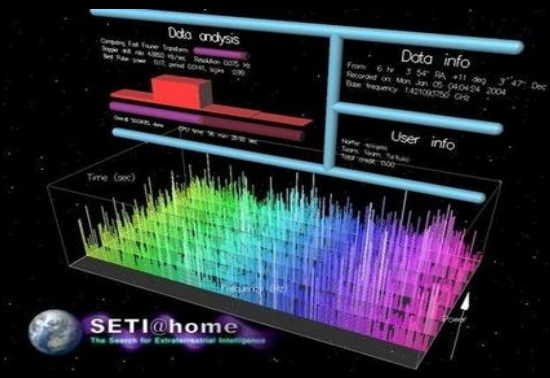
Search for
Extraterrestrial
Radio
Emissions from
Nearby
Developed
Intelligent
Populations

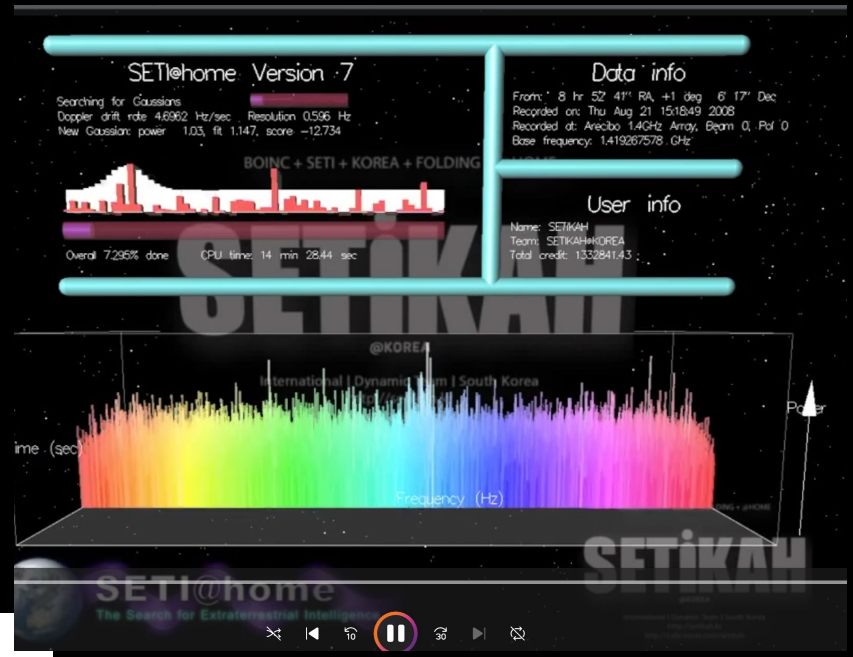
Space Astrophysics Group
University of California
Berkeley, Earth

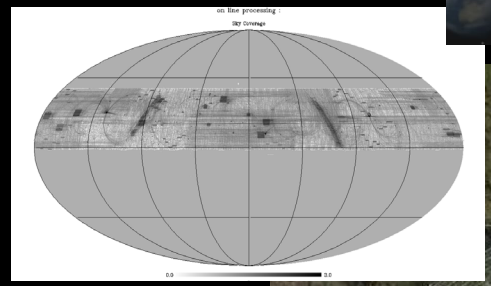
Dan: a photo of me in the late 1970 's talking to astronomers and computer scientists at Beijing Normal University about the image that Arecibo transmitted to M13。

1999开始--数据处理： 电脑屏保-SETI@home

Date	1999– 2020
Observer(s)	Werthimer and Anderson (SETI@home)
Site	Arecibo
Instrument size (meters)	305
Search frequency (MHz)	1420.405 +/–1.25 MHz







1994年- SETI institute实施Project Phoenix（凤凰计划)

- Project Phoenix（凤凰计划）：1994年美国国会终止了NASA的SETI计划；硅谷巨富、微软创始人鲍罗·艾伦投资SETI研究所，千万美元量级投资。
- 1000 Sun-like stars out to a maximum distance of about 100 ly.

the Allen Telescope Array
at Hat Creek Observatory

新世纪之初展望
SETI综述文章： Annu. Rev. Astron. Astrophys. 2001

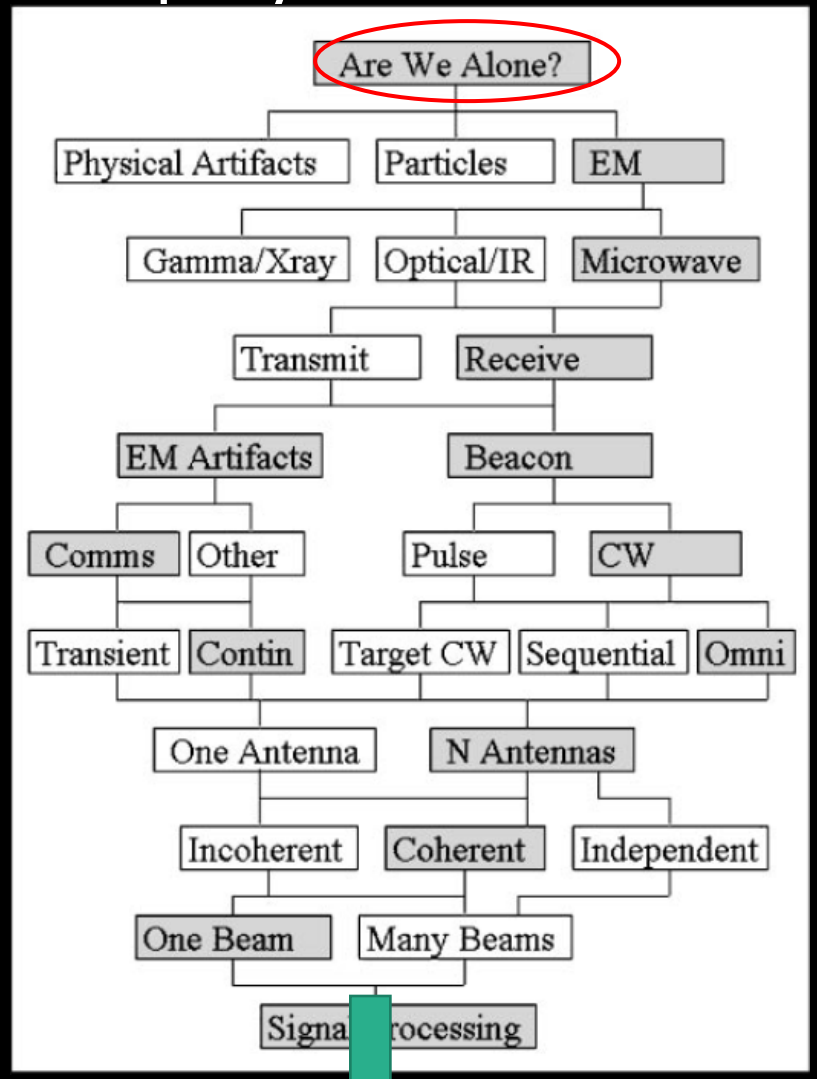
Annu. Rev. Astron. Astrophys. 2001. 39:511–48

THE SEARCH FOR EXTRATERRESTRIAL INTELLIGENCE (SETI)

Jill Tarter
SETI Institute, 2035 Landings Drive, Mountain View, California 94043;
e-mail: tarter@vger.seti.org

Key Words exobiology, astrobiology, bioastronomy, optical SETI, life in the universe

■ **Abstract** The search for evidence of extraterrestrial intelligence is placed in the broader astronomical context of the search for extrasolar planets and biomarkers of primitive life elsewhere in the universe. A decision tree of possible search strategies is presented as well as a brief history of the search for extraterrestrial intelligence (SETI) projects since 1960. The characteristics of 14 SETI projects currently operating on telescopes are discussed and compared using one of many possible figures of merit. Plans for SETI searches in the immediate and more distant future are outlined. Plans for success, the significance of null results, and some opinions on deliberate transmission of signals (as well as listening) are also included. SETI results to date are negative, but in reality, not much searching has yet been done.



Strategic decision tree for SETI

当前国际主流SETI团队

- 1. 加州大学伯克利分校-SETI@home
- 2. 加州大学伯克利分校-Breakthrough Lisen-牛津
- 3. SETI institute(研究所) Project Phoenix *Mountain View, California*
- *三个团队都在美国西部湾区！*
- *其他：英国，法国，意大利，南非*
- 国内北师大SETI团队

2014年：未来SKA也计划实施SETI

- The Square Kilometre Array (平方公里阵列射电望远镜 SKA) is the largest next-generation radio telescope；
- SKA也计划实施观测，Andrew Siemion等人也写了SKA地外文明观测的白皮书

(Tue, 16 Dec 2014年)。

PROCEEDINGS OF SCIENCE

Searching for Extraterrestrial Intelligence with the Square Kilometre Array

arXiv:1412.4867

Andrew P. V. Siemion[*1,2,3], **James Benford**[4], **Jin Cheng-Jin**[5], **Jayanth Chennamangalam**[6], **James Cordes**[7], **David R. DeBoer**[3], **Heino Falcke**[2,1,8,9], **Mike Garrett**[1,10], **Simon Garrington**[11], **Leonid Gurvits**[12,13], **Melvin Hoare**[14], **Eric J. Korpela**[3], **Joseph Lazio**[15], **David Messerschmitt**[3], **Ian S. Morrison**[16], **Tim O'Brien**[10], **Zsolt Paragi**[12], **Alan Penny**[17], **Laura Spitler**[7], **Jill Tarter**[18], **Dan Werthimer**[3]

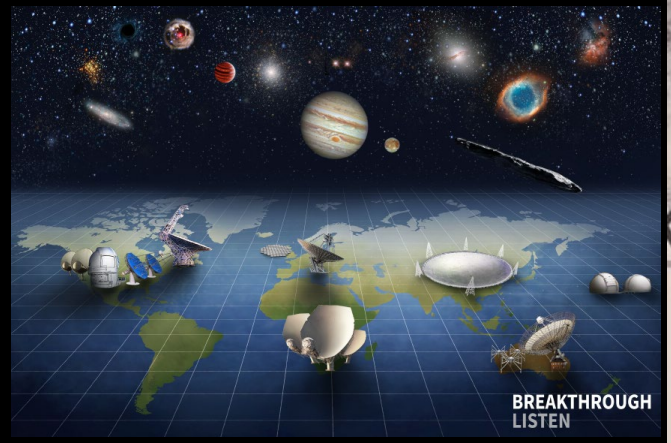
[1]*ASTRON, NL;* [2]*Radboud University, NL;* [3]*University of California, Berkeley, US;* [4]*Microwave Sciences, US;* [5]*NAOC, CN;* [6]*Oxford University, UK;* [7]*Cornell University, US;* [8]*MPIfR, DE;* [9]*NIKHEF, NL;* [10]*Leiden University, NL;* [11]*Jodrell Bank Observatory, UK;* [12]*JIVE, NL;* [13]*Delft University of Technology, NL* [14]*University of Leeds, UK;* [15]*Jet Propulsion Laboratory, California Inst. of Technology, US;* [16]*University of New South Wales, AU;* [17]*University of St. Andrews, UK;* [18]*SETI Inst., US*

E-mail: siemion at astron.nl

The vast collecting area of the Square Kilometre Array (SKA), harnessed by sensitive receivers, flexible digital electronics and increased computational capacity, could permit the most sensitive and exhaustive search for technologically-produced radio emission from advanced extraterrestrial intelligence (SETI) ever performed. For example, SKA1-MID will be capable of detecting a

2015年-突破创新计划

- 突破创新计划由**突破聆听**(Breakthrough Lisen)、**突破摄星**(Breakthrough Strashot)以及**突破信息**(Breakthrough Message)三个项目组成。
- 突破创新计划是俄罗斯富翁尤里·米尔纳于2015年创立的探索宇宙、搜寻地外智慧生命。
- 10年(15-25)内共计1亿美元的资金支持



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DEPARTMENT OF
PHYSICS

UNIVERSITY OF OXFORD

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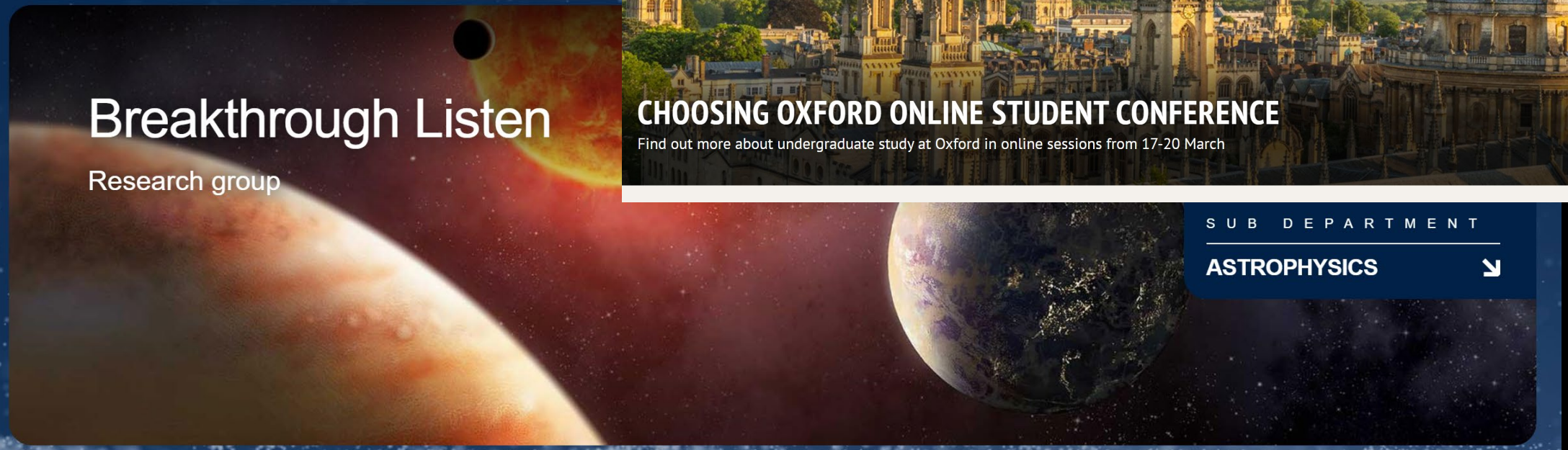
CHOOSING OXFORD ONLINE STUDENT CONFERENCE

Find out more about undergraduate study at Oxford in online sessions from 17-20 March



Breakthrough Listen

Research group

SUB DEPARTMENT

ASTROPHYSICS ↘

About

People

Breakthrough Listen represents humanity's most significant effort to date to quantify the distribution of advanced life in the Universe, using a global network of the world's largest and most advanced radio telescopes to search for signatures of technology. The project is undertaking a detailed census of hundreds of nearby stars, in addition to casting a wider net across millions more stars, the entire plane of our Milky Way Galaxy, and additional galaxies beyond.

突破聆听(Breakthrough Lisen)搜寻结果 2022年

therefore no technosignature signals of interest detected in this work.

The Astronomical Journal, 163:104 (10pp), 2022 March https://doi.org/10.3847/1538-3881/ac46c9

The Breakthrough Listen Search for Intelligent Life: Technosignature Search of Transiting TESS Targets of Interest

Noah Franz[1,2], Steve Croft[1,3], Andrew P. V. Siemion[1,3,4], Raffy Traas[1,5], Bryan Brzycki[1], Vishal Gajjar[1], Howard Isaacson[1,6], Matthew Lebofsky[1], David H. E. MacMahon[1], Danny C. Price[1,7], Sofia Z. Sheikh[1,3], Julia DeMarines[1], Jamie Drew[8], and S. Pete Worden[8]

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[3] SETI Institute, Mountain View, CA, USA
[4] University of Malta, Institute of Space Sciences and Astronomy, Malta
[5] Department of Physics, University of Wisconsin - La Crosse, 1725 State Street, La Crosse, WI 54601, USA
[6] University of Southern Queensland, Toowoomba, QLD 4350, Australia
[7] International Centre for Radio Astronomy Research, Curtin University, Bentley, WA 6102, Australia
[8] The Breakthrough Initiatives, NASA Research Park, Building 18, Moffett Field, CA, 94035, USA
Received 2021 November 4; revised 2021 December 20; accepted 2021 December 25; published 2022 February 1

Abstract

The Breakthrough Listen (BL) Initiative, as part of its larger mission, is performing the most thorough technosignature search of nearby stars. Additionally, BL is collaborating with scientists working on NASA's Transiting Exoplanet Survey Satellite (TESS) to examine TESS Targets of Interest (TOIs) for technosignatures. Here, we present a 1–11 GHz radio technosignature search of 61 TESS TOIs that were in transit during their BL observation at the Robert C. Byrd Green Bank Telescope. We performed a narrowband Doppler drift search with a minimum S/N threshold of 10 across a drift rate range of ± 4 Hz s^{-1} with a resolution of 3 Hz. We removed radio frequency interference by comparing signals across cadences of target sources. After interference removal, there are no remaining events in our survey and therefore no technosignature signals of interest detected in this work. This null result implies that at L, S, C, and X bands, fewer than 52%, 20%, 16%, and 15%, respectively, of TESS TOIs possess a transmitter with an equivalent isotropic radiated power greater than a few times 10^{14} W.

Unified Astronomy Thesaurus concepts: Technosignatures (2128); Search for extraterrestrial intelligence (2127); Astrobiology (74); Radio astronomy (1338); Exoplanets (498)

2022年 Breakthrough Lisen 观测结果

- 兴趣信号—最终确定是： an unusual but locally generated form of interference： 一种不寻常但局部产生的干扰形式

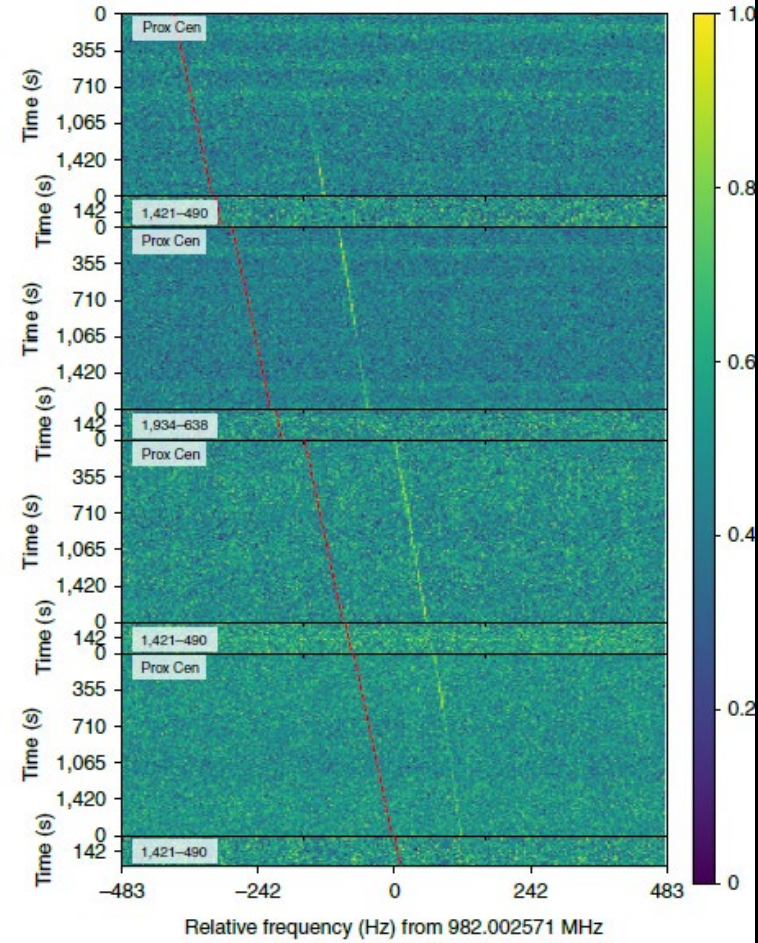

Fig. 4 | The signal of interest, BLC1, from our search of Prox Cen. Here,

零探测 ≠ 不探测

nature astronomy

ARTICLES

https://doi.org/10.1038/s41550-021-01479-w

Check for updates

OPEN

A radio technosignature search towards Proxima Centauri resulting in a signal of interest

Shane Smith[1,2], Danny C. Price[2,3]✉, Sofia Z. Sheikh[2], Daniel J. Czech[2], Steve Croft[2,4], David DeBoer[5], Vishal Gajjar[2], Howard Isaacson[2,6], Brian C. Lacki[2], Matt Lebofsky[2], David H. E. MacMahon[5], Cherry Ng[2,4,7], Karen I. Perez[8], Andrew P. V. Siemion[2,4,9], Claire Isabel Webb[2,10], Jamie Drew[11], S. Pete Worden[11] and Andrew Zic[12,13]

The detection of life beyond Earth is an ongoing scientific pursuit, with profound implications. One approach, known as the search for extraterrestrial intelligence (SETI), seeks to find engineered signals ('technosignatures') that indicate the existence of technologically capable life beyond Earth. Here, we report on the detection of a narrowband signal of interest at ~982 MHz, recorded during observations towards Proxima Centauri with the Parkes Murriyang radio telescope. This signal, BLC1, has characteristics broadly consistent with hypothesized technosignatures and is one of the most compelling candidates to date. Analysis of BLC1—which we ultimately attribute to being an unusual but locally generated form of interference—is provided in a companion paper. Nevertheless, our observations of Proxima Centauri are a particularly sensitive search for radio technosignatures towards a stellar target.

2023年 突破聆听(Breakthrough Lisen) AI-SETI

8个以前没有发现
的有希望的外星
智能信号。

nature astronomy

Article

https://doi.org/10.1038/s41550-022-01872-z

A deep-learning search for technosignatures from 820 nearby stars

Received: 10 December 2021

Accepted: 30 November 2022

Published online: 30 January 2023

Check for updates

Peter Xiangyuan Ma[1,2,3] ✉, Cherry Ng[3,4,5], Leandro Rizk[3], Steve Croft[4,5], Andrew P. V. Siemion[4,5,6,7], Bryan Brzycki[4], Daniel Czech[4], Jamie Drew[8], Vishal Gajjar[4], John Hoang[4], Howard Isaacson[4,9], Matt Lebofsky[4], David H. E. MacMahon[4], Imke de Pater[4,10], Danny C. Price[4,11], Sofia Z. Sheikh[4] & S. Pete Worden[8]

The goal of the search for extraterrestrial intelligence (SETI) is to quantify the prevalence of technological life beyond Earth via their 'technosignatures'. One theorized technosignature is narrowband Doppler drifting radio signals. The principal challenge in conducting SETI in the radio domain is developing a generalized technique to reject human radiofrequency interference. Here we present a comprehensive deep-learning-based technosignature search on 820 stellar targets from the Hipparcos catalogue, totalling over 480 h of on-sky data taken with the Robert C. Byrd Green Bank Telescope as part of the Breakthrough Listen initiative. We implement a novel β-convolutional variational autoencoder to identify technosignature candidates in a semi-unsupervised manner while keeping the false-positive rate manageably low, reducing the number of candidate signals by approximately two orders of magnitude compared with previous analyses on the same dataset. Our work also returned eight promising extraterrestrial intelligence signals of interest not previously identified. Re-observations on these targets have so far not resulted in re-detections of signals with similar morphology. This machine-learning approach presents itself as a leading solution in accelerating SETI and other transient research into the age of data-driven astronomy.

Correspondence and requests for materials should be addressed to Peter Xiangyuan Ma.

Peer review information *Nature Astronomy* thanks Devansh Agarwal, Tong-Jie Zhang and the other, anonymous, reviewer(s) for their contribution to the peer review of this work.

Nature子刊审稿

-----原始邮件-----
发件人:luca.maltagliati@nature.com
发送时间:2022-01-12 21:27:48 (星期三)
收件人: tjzhang@bnu.edu.cn
抄送:
主题: Nature Astronomy Review Request - manuscript NATASTR

Dear Professor Zhang

A manuscript has been submitted to Nature Astronomy, which we were hoping you would be interested in reviewing. The manuscript comes from Peter Ma, Cherry Ng, Leandro Rizk, Steve Croft, Andrew Siemion, Bryan Brzycki, Daniel Czech, Jamie Drew, Vishal Gajjar, John Hoang, Howard Isaacson, Matt Lebofsky, David MacMahon, Danny Price, Sofia Sheikh, and S. Worden and is entitled "The first deep-learning search for radio technosignatures from 820 nearby stars". Its first paragraph is pasted below.

nature astronomy

Article

https://doi.org/10.1038/s41550-022-01872-z

A deep-learning search for technosignatures from 820 nearby stars

Received: 10 December 2021

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Peer review information *Nature Astronomy* thanks Devansh Agarwal, Tong-Jie Zhang and the other, anonymous, reviewer(s) for their contribution to the peer review of this work.

国际研究动态: 美国地外文明2020年白皮书

- 美国宾夕法尼亚州立大学天文与天体物理学系与宜居行星中心，地外文明中心主任；126 科学家签名背书!

126 endorsers	Affiliation
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Tabetha Boyajian	Louisiana State University

Astro2020 APC White Paper

Searches for Technosignatures: The State of the Profession

Primary thematic area: Planetary Systems, especially exobiology and the search for life beyond the Solar System. **Secondary thematic areas**: •Star and planet formation •Resolved stellar populations and their environments • Galaxy evolution

Principal Author: Jason T. Wright
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525 Davey Laboratory
Department of Astronomy & Astrophysics & Center for Habitable Worlds
Penn State University, University Park, PA 16802

2022年美国JPL科学家和北师大教授再次考虑主动发送电磁波信息　银河系灯塔”(A Beacon in the Galaxy)

- the Arecibo Message, transmitted in 1974 as a beamed radio signal at wavelength 126 mm（微波） towards the M13 globular cluster some 25,000 lightyears distant.
- 光速极限 V<<c:　the electromagnetic waves conveying the Arecibo Message have traversed less than 0.2% of the distance to their intended target.
- Jet Propulsion Laboratory, California Institute of Technology

Galaxies 2022, *10*, 55. https://doi.org/10.3390/galaxies10020055

galaxies　MDPI

Article

A Beacon in the Galaxy: Updated Arecibo Message for Potential FAST and SETI Projects

Jonathan H. Jiang [1,*], Hanjie Li [2], Matthew Chong [3], Qitian Jin [4], Philip E. Rosen [5,†], Xiaoming Jiang [6], Kristen A. Fahy [1], Stuart F. Taylor [7], Zhihui Kong [8], Jamilah Hah [9] and Zong-Hong Zhu [8]

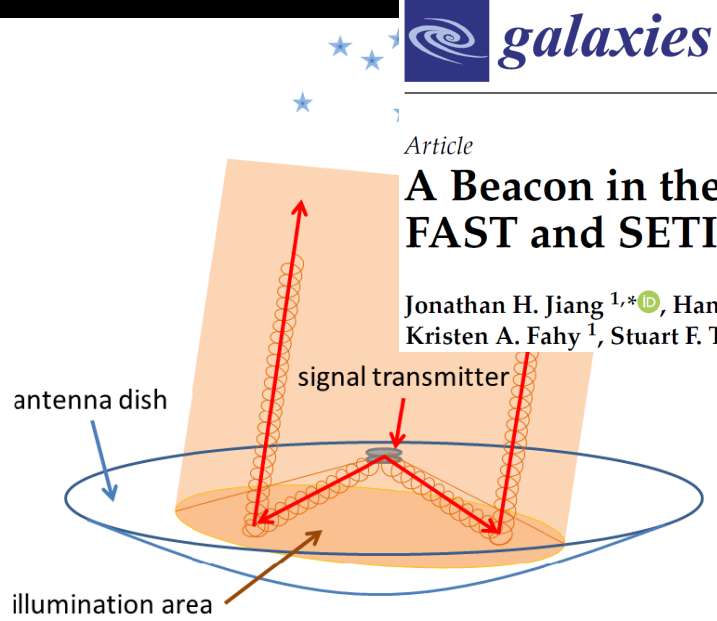
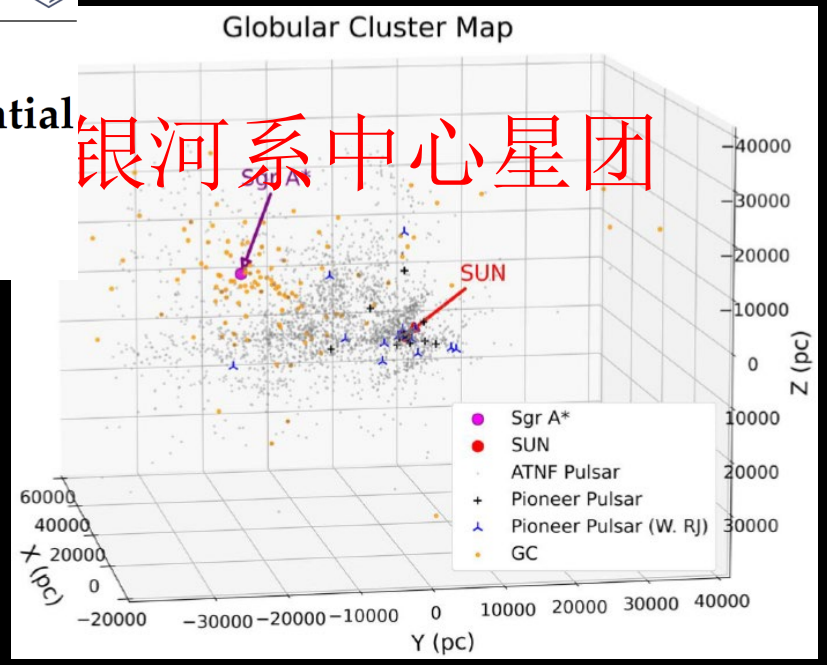


Figure 3. A diagram illustrating the FAST antenna dish and illumination area for receiving and transmitting signals.



地球凌日-2016年Nature文章

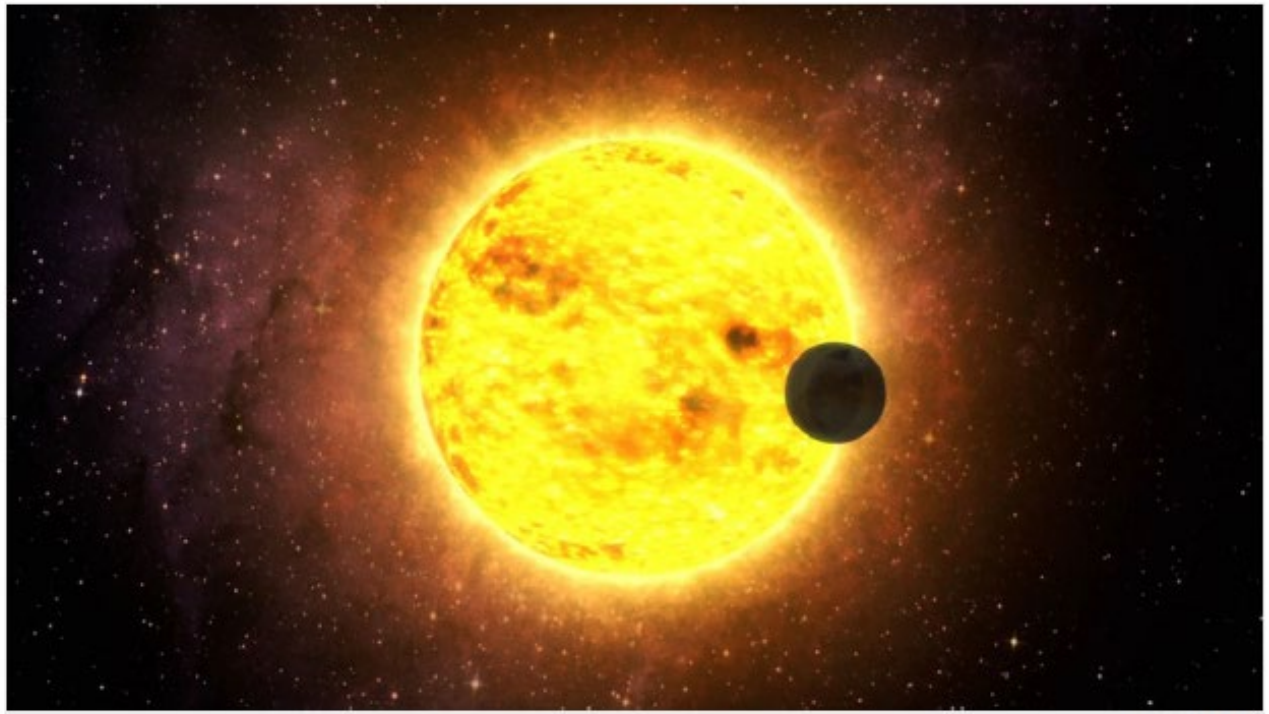
NATURE | NEWS

ET search: Look for the aliens looking for Earth

Astronomers propose hunting for civilizations on worlds that can see our planet cross the Sun.

Alexandra Witze

01 March 2016



ESA/Hubble

Alien astronomers could be watching for the 'blink' as Earth passes in front of the Sun, a technique researchers here use to spot alien worlds.

ET搜索：
寻找地球的外星人

外星人看我们

Monthly Notices
of the
ROYAL ASTRONOMICAL SOCIETY

MNRAS **499,** L111–L115 (2020) doi:10.1093/mnrasl/slaa161

Which stars can see Earth as a transiting exoplanet?

L. Kaltenegger [1,2]★ and J. Pepper[3]

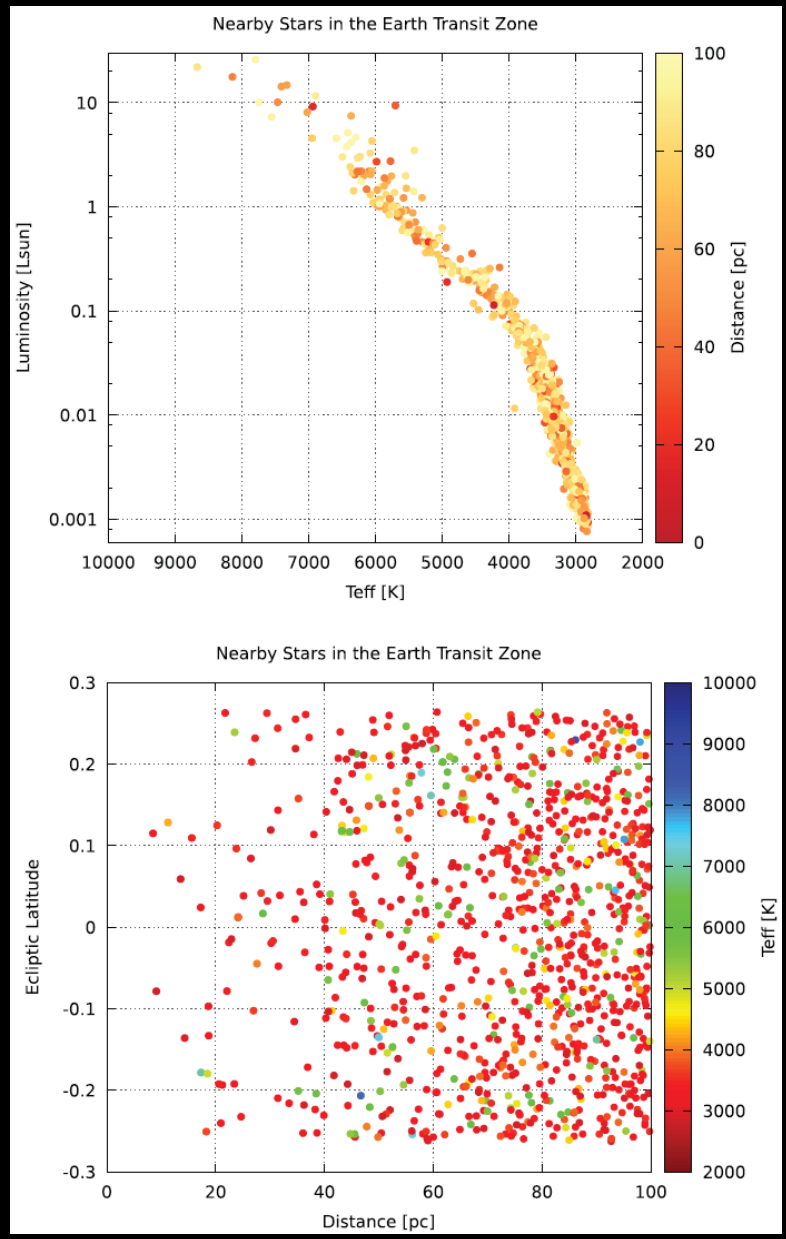
[1]*Carl Sagan Institute, Cornell University, Space Science Institute 302, Ithaca, NY 14850, USA*
[2]*Astronomy Department, Cornell University, Space Science Institute 302, Ithaca, NY 14850, USA*
[3]*Physics Department, Lehigh University, Bethlehem, PA 18015, USA*

Accepted 2020 September 9. Received 2020 September 9; in original form 2020 August 20

ABSTRACT

Transit observations have found the majority of exoplanets to date. Also spectroscopic observations of transits and eclipses are the most commonly used tool to characterize exoplanet atmospheres and will be used in the search for life. However, an exoplanet's orbit must be aligned with our line of sight to observe a transit. Here, we ask, from which stellar vantage points would a distant observer be able to search for life on Earth in the same way? We use the *TESS* Input Catalog and data from *Gaia* DR2 to identify the closest stars that could see Earth as a transiting exoplanet: We identify 1004 main-sequence stars within 100 parsecs, of which 508 guarantee a minimum 10-h long observation of Earth's transit. Our star list consists of about 77 percent M-type, 12 percent K-type, 6 percent G-type, 4 percent F-type stars, and 1 percent A-type stars close to the ecliptic. SETI searches like the Breakthrough Listen Initiative are already focusing on this part of the sky. Our catalogue now provides a target list for this search. As part of the extended mission, NASA's *TESS* will also search for transiting planets in the ecliptic to find planets that could already have found life on our transiting Earth .

Key words: astrobiology – catalogues – planets and satellites: terrestrial planets – planets and satellites: detection – methods: observational – extraterrestrial intelligence.



Our sample of 1004 main-sequence stars within 100 pc, which could see Earth as a transiting exoplanet: (top) luminosity versus effective temperature and (bottom) ecliptic latitude versus distance.

Nature文章-外星人可能正在看我们

nature

2000颗其外星人可以瞥见地球的恒星

NEWS | 23 June 2021

The 2,000 stars where aliens would catch a glimpse of Earth

Scientists searching for extraterrestrial life should narrow their hunt to stars
planetary systems that have an occasional view of the Earth as it passes in fro
the Sun.

可以将地球视为凌日系外行星的过去、现在和未来的恒星

Article

Past, present and future stars that can see Earth as a transiting exoplanet

https://doi.org/10.1038/s41586-021-03596-y

Received: 17 February 2021

Accepted: 29 April 2021

Published online: 23 June 2021

Check for updates

L. Kaltenegger[1,2]✉ & J. K. Faherty[3]

In the search for life in the cosmos, transiting exoplanets are currently our best targets. With thousands already detected, our search is entering a new era of discovery with upcoming large telescopes that will look for signs of 'life' in the atmospheres of transiting worlds. Previous work has explored the zone from which Earth would be visible while transiting the Sun[1–4]. However, these studies considered only the current position of stars, and did not include their changing vantage point over time. Here we report that 1,715 stars within 100 parsecs from the Sun are in the right position to have spotted life on a transiting Earth since early human civilization (about 5,000 years ago), with an additional 319 stars entering this special vantage point in the next 5,000 years. Among these stars are seven known exoplanet hosts, including Ross-128, which saw Earth transit the Sun in the past, and Teegarden's Star and Trappist-1, which will start to see it in 29 and 1,642 years, respectively. We found that human-made radio waves have already swept over 75 of the closest stars on our list.

Article

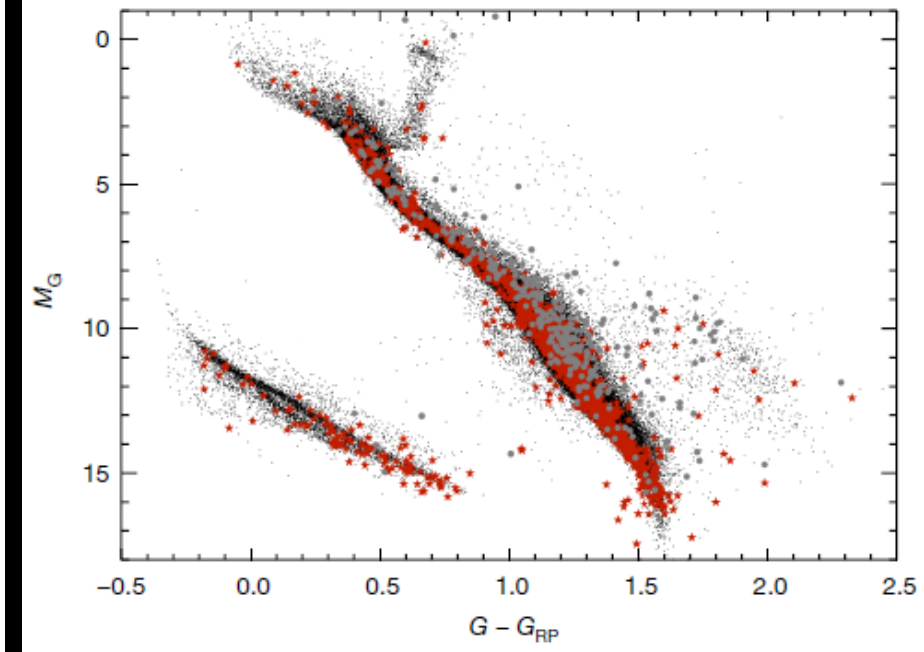


Fig. 1 | Stars that can see Earth transit since early human civilization. The colour–magnitude diagram of the GCNS (black), limited to sources with re-normalized unit weight error (RUWE) of <1.4, photometric signal-to-noise ratio >100 (in Gaia G and G_{RP} photometric passbands) and parallax uncertainties better than 5%. Overplotted are the 2,034 sources that cross the ETZ in the time interval of ±5,000 years (dark red star markers have RUWE < 1.4; grey filled circles have RUWE > 1.4). M_G is Gaia magnitude.

the NASA Roman Core Community Surveys White Paper Call
英国SKA科学家-2023年 Earth Transit Zone地球凌日带-SETI

Roman CCS White Paper
RoSETZ: Roman Survey of the Earth Transit Zone
SETI-optimized survey for habitable-zone exoplanet

Eamonn Kerins[1,*], Supachai Awiphan[2], Kathryn Edmondson[1], Michael Garrett[1], Jacob Haqq-Misra[3], Réne Heller[4], Macy Huston[5,6,7], David Kipping[8], Ravi Kopparap[9], Danny C. Price[10], Andrew Siemion[1,11,12], Siddhant Sharma[3,13], Evan L. Sneed[7,11,14], Hector Socas-Navarro[15,16], Robert F. Wilson[9], and Jason Wright[5,6,7]

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[3]Blue Marble Space Institute of Science, Seattle, 98104 WA, USA
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[6]Center for Exoplanets and Habitable Worlds, 525 Davey Laboratory, The Pennsylvania State University, University Park, PA, 16802, USA
[7]Penn State Extraterrestrial Intelligence Center, 525 Davey Laboratory, The Pennsylvania State University, University Park, PA, 16802, USA
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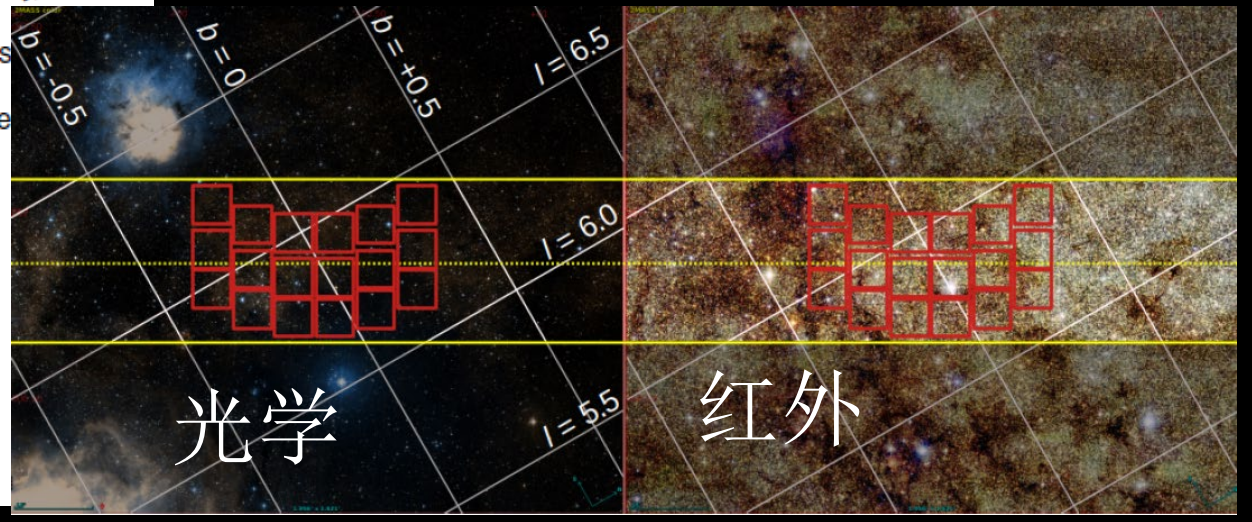
*Corresponding author: Eamonn.Kerins@manchester.ac.uk

arXiv: 2306.10202-Fri,16 Jun 2023

- Mike Garrett
- SETI Committee chair(SETI委员会主席)
- Bernard Lovell Chair in Astrophysics, Director of Jodrell Bank Centre for Astrophysics (JBCA)(Jodrell Bank天体物理中心主任).
- School of Physics and Astronomy, Jodrell Bank Observatory, The University of Manchester, M13 9PL, UK.

SKA总部位于英国曼彻斯特Jodrell Bank天文台

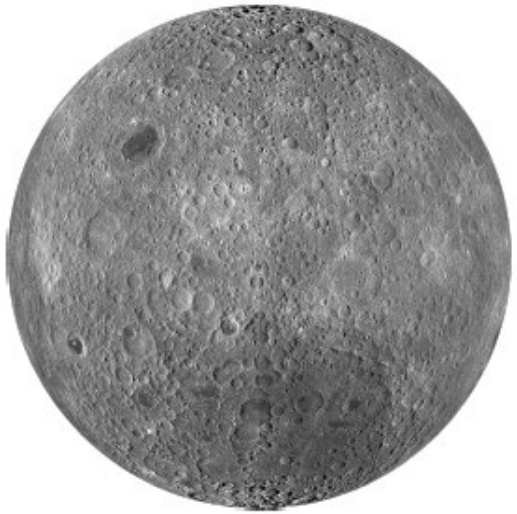


Breakthrough Listen：月球背面南极SETI白皮书

Lunar Opportunities for SETI

Eric J. Michaud*,[1], Andrew P. V. Siemion[1,2,3], Jamie Drew[4], S. Pete Worden[4]

[1] *University of California Berkeley, Berkeley, CA 94720*
[2] *SETI Institute, Mountain View, CA 94043*
[3] *University of Malta, Institute of Space Sciences and Astronomy*
[4] *The Breakthrough Initiatives, NASA Research Park, Bld. 18, Moffett Field, CA, 94035*



A white paper
National Academy of Sciences
Planetary Science and Astrobiology Decadal Survey 2023-2032

美国国家科学院行星科学和天体生物学十年调查白皮书2023-2032

Sat, 26 Sep 2020

SETI from the Lunar South Pole

Eric J. Michaud*[1], Andrew P. V. Siemion[1], Jamie Drew[2], S. Pete Worden[2]

[1] *University of California, Berkeley, Berkeley, CA 94720*
[2] *The Breakthrough Initiatives, NASA Research Park, Bld. 18, Moffett Field, CA, 94035*

1 SETI and its Challenges

The Search for Extraterrestrial Intelligence (SETI) refers to astronomical observation campaigns which look for *technosignatures* - electromagnetic radiation produced by technology, and not by natural sources. If technosignatures were discovered whose origin was non-human, such a detection would provide strong evidence for life having also emerged elsewhere in the Universe. Technosignature searches, when conducted with telescopes located on the Earth's surface, face a number of challenges including (1) the Earth's ionosphere blocks low frequency radio waves, limiting the range of frequencies that can be searched and (2) when terrestrial radio frequency interference (RFI) is detected in high volume in SETI observations, it becomes challenging to attribute any particular signal to extraterrestrial intelligence. Despite being constructed in remote, radio-quiet regions, terrestrial radio telescopes are still exposed to RFI from artificial satellites around the Earth, the number of which is expected to increase massively in the next decades. While SETI astronomers have developed observing strategies and specialized software for approaching this challenge, a more radical solution could be to avoid of the problem entirely by conducting observations from a region of space with minimal exposure to terrestrial RFI.

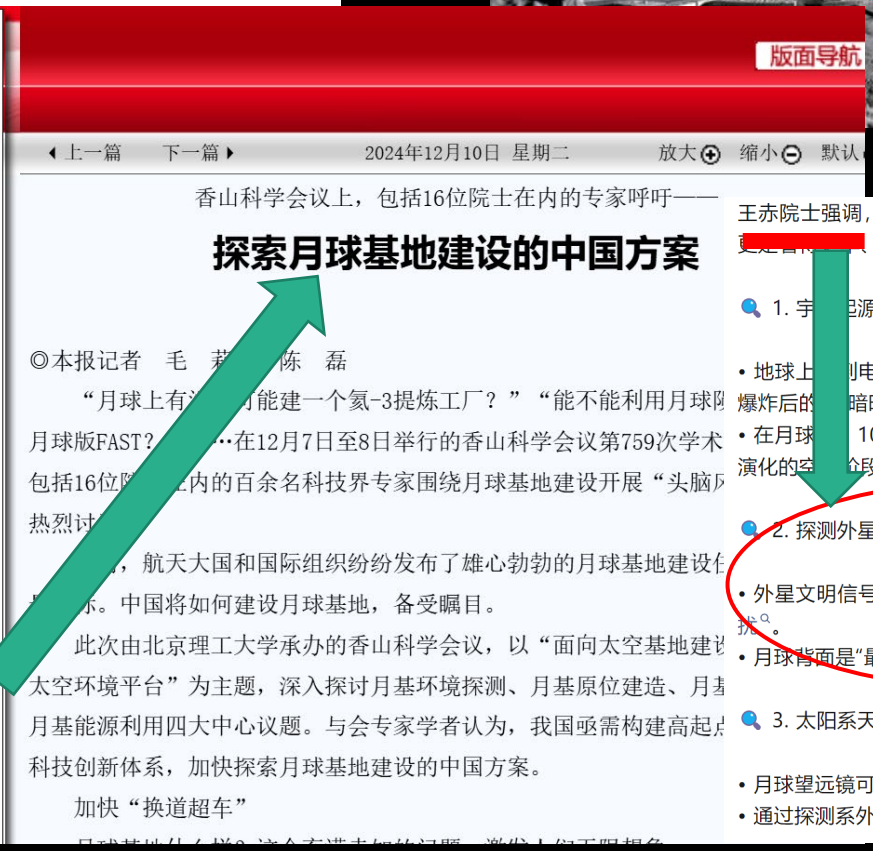
2023年1月我们提交的月球南极背面SETI方案，到了体现！

题目（中文）：月球南极背面地外文明技术印迹射电搜寻

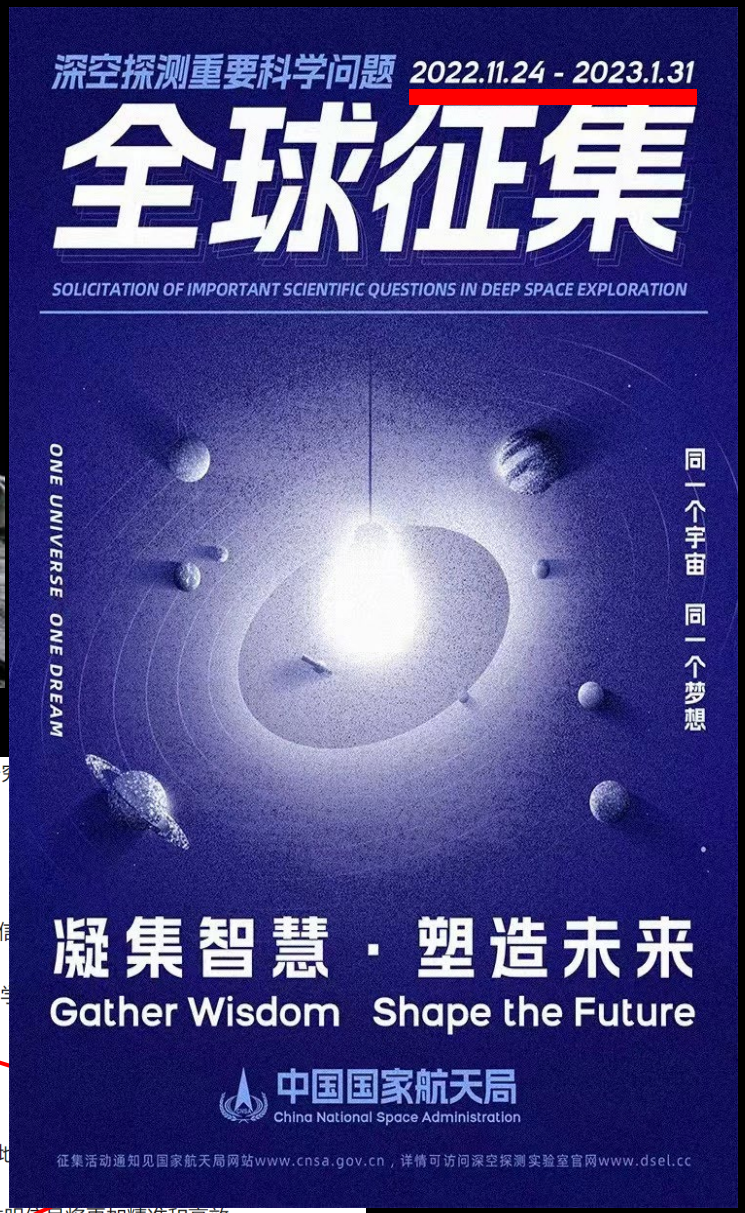
题目（英文）：Radio Search for Extraterrestrial Intelligence technosignatures from the Farside of the Moon and South Pole of the Moon

主建议人(Proposer)：张同杰（北师大）


科技日报
SCIENCE AND TECHNOLOGY DAILY
中共中央政治局召开会议 研究部署党风廉政建设和反腐败工作 分析研究二〇二五年经济工作 中共中央总书记习近平主持会议
中央宣传部授予单杏花同志"时代楷模"称号
开拓"精致化"发展新路径
征求对经济工作的意见和建议
中共中央召开党外人士座谈会
习近平主持并发表重要讲话
挺立中国式现代化的精神脊梁
——写在《习近平文化思想学习纲要》出版发行之际
探索月球基地建设的中国方案


版面导航
上一篇 下一篇 2024年12月10日 星期二 放大 缩小 默认
香山科学会议上，包括16位院士在内的专家呼吁——
探索月球基地建设的中国方案
◎本报记者 毛 [redacted] 陈 磊
"月球上有[redacted]能建一个氦-3提炼工厂？""能不能利用月球陨坑建一个月球版FAST？"……在12月7日至8日举行的香山科学会议第759次学术讨论会上，包括16位院士在内的百余名科技界专家围绕月球基地建设开展"头脑风暴"，热烈讨[redacted]，航天大国和国际组织纷纷发布了雄心勃勃的月球基地建设[redacted]。中国将如何建设月球基地，备受瞩目。
此次由北京理工大学承办的香山科学会议，以"面向太空基地建设的[redacted]太空环境平台"为主题，深入探讨月基环境探测、月基原位建造、月基[redacted]月基能源利用四大中心议题。与会专家学者认为，我国亟需构建高起点[redacted]科技创新体系，加快探索月球基地建设的中国方案。
加快"换道超车"

王赤院士强调，月球望远镜的建设将带来科学研究[redacted]看得更深。
1. 宇[redacted]起源和早期星系演化
• 地球上[redacted]电离层的限制，无法探测低频射电信[redacted]爆炸后的[redacted]暗时代"**的演化过程。
• 在月球[redacted]10~30MHz的射电信号有望帮助科学[redacted]演化的空[redacted]阶段。
2. 探测外星文明（SETI计划）
• 外星文明信号的搜寻需要极高的电磁洁净度，地[redacted]扰。
• 月球背面是"最安静的地方"，在这里搜寻外星文明信号将更加精准和高效。
3. 太阳系天体和外星系研究
• 月球望远镜可探测太阳系内的行星和小行星的低频射电信号。
• 通过探测系外行星的大气射电辐射，或许能间接推测这些行星是否具有生命可能性。



2024年国际宇航学会第一届月球背面保护国际大会

月背重要性-Torino, Italy(意大利都灵)on March 21-22, 2024

THE IMPORTANCE OF THE MOON FARSIDE

The Moon has the unique property of naturally shielding radio waves generated by human activities on Earth and around it. This results in a wide radio silence zone on and above its Farside, called *Shielded Zone on the Moon* (SZM).

Therefore, the Farside becomes a region of utmost scientific interest, as it provides an environment free from the electromagnetic pollution typical on Earth. In particular, some of the branches of science that would greatly benefit from operating from the Farside are: Cosmology, Astrobiology, Planetary Defense, and SETI/Technosignatures.

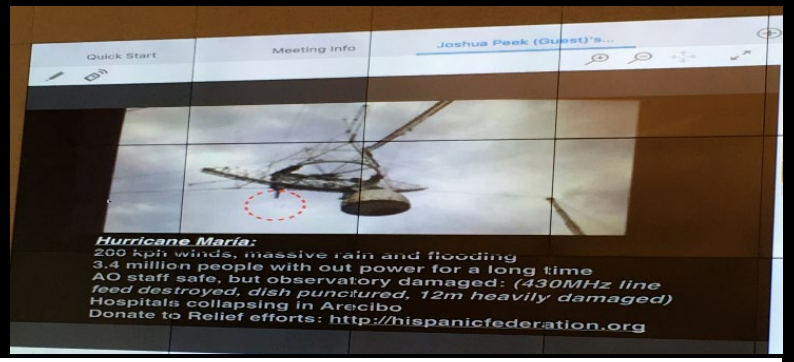
1. COSMOLOGY – To detect the extremely feeble radiation of the hydrogen line at 1420 MHz, down-shifted to much lower frequencies, Mhz or kHz, due to the 14 billion years of universe expansion. The radio silence of the Farside would ensure a significant leap forward in research.
2. ASTROBIOLOGY – To study pre-biological interstellar molecules through their rotational spectra, a fine search for weak spectral lines that can be supported by advanced radio telescopes in combination with the radio silence given by Farside.
3. PLANETARY DEFENSE – From the Moon Farside, radar and optical telescopes can be used for accurate measurements, without interference of the usual bodies orbiting near Earth, thus to increase the lead time.
4. SETI/TECHNOSIGNATURES – To search, with very low noise, for "signatures" of Alien Civilizations that would reach us extremely faint due to the vast distances between stars in the Milky Way, if not from other galaxies.

SETI/TECHNOSIGNATURES — To search, with very low noise, for "signatures" of Alien Civilizations that would reach us extremely faint due to the vast distances between stars in the Milky Way, if not from other galaxies.

	SCIENCE ON THE FARSIDE		
14.20-14.30	**Introduction**	*Claudio Maccone*	IAA Technical Director
14.30-15.00	**Radio telescopes on the far side**	*Joseph Silk (Cosmology)*	The Johns Hopkins University and Institut
15.00-15.30	**Astrobiology**	*Rocco Mancinelli*	BAER Institute
15.30-16.00	**Planetary Defense**	*Ian Carnelli*	HERA Project Manager at ESA
16.00-16.30	*COFFEE BREAK*		
16.30-17.00			
17.00-17.30	**SETI/Technosignatures**	*Mike Garrett*	Director of Jodrell Bank Centre for Astroph Manchester
17.30-18.00	**Landing on the farside: Chang'e 4 mission**	*Ji Wu*	General Director of National Space Science Academy of Sciences
18.00-18.30	**Observing the Early Universe from the Moon's Far Side at Low Radio Frequencies**	*Jack Burns*	Director, NASA/SSERVI Network for Explora

美国300米阿雷西博望远镜(Arecibo Telescope)

- 2020年12月1日崩塌, **悲壮的一幕**，结束使命!
- 下一代望远镜：搜寻宇宙中高等生命



THE FUTURE OF THE ARECIBO OBSERVATORY:

THE NEXT GENERATION ARECIBO TELESCOPE

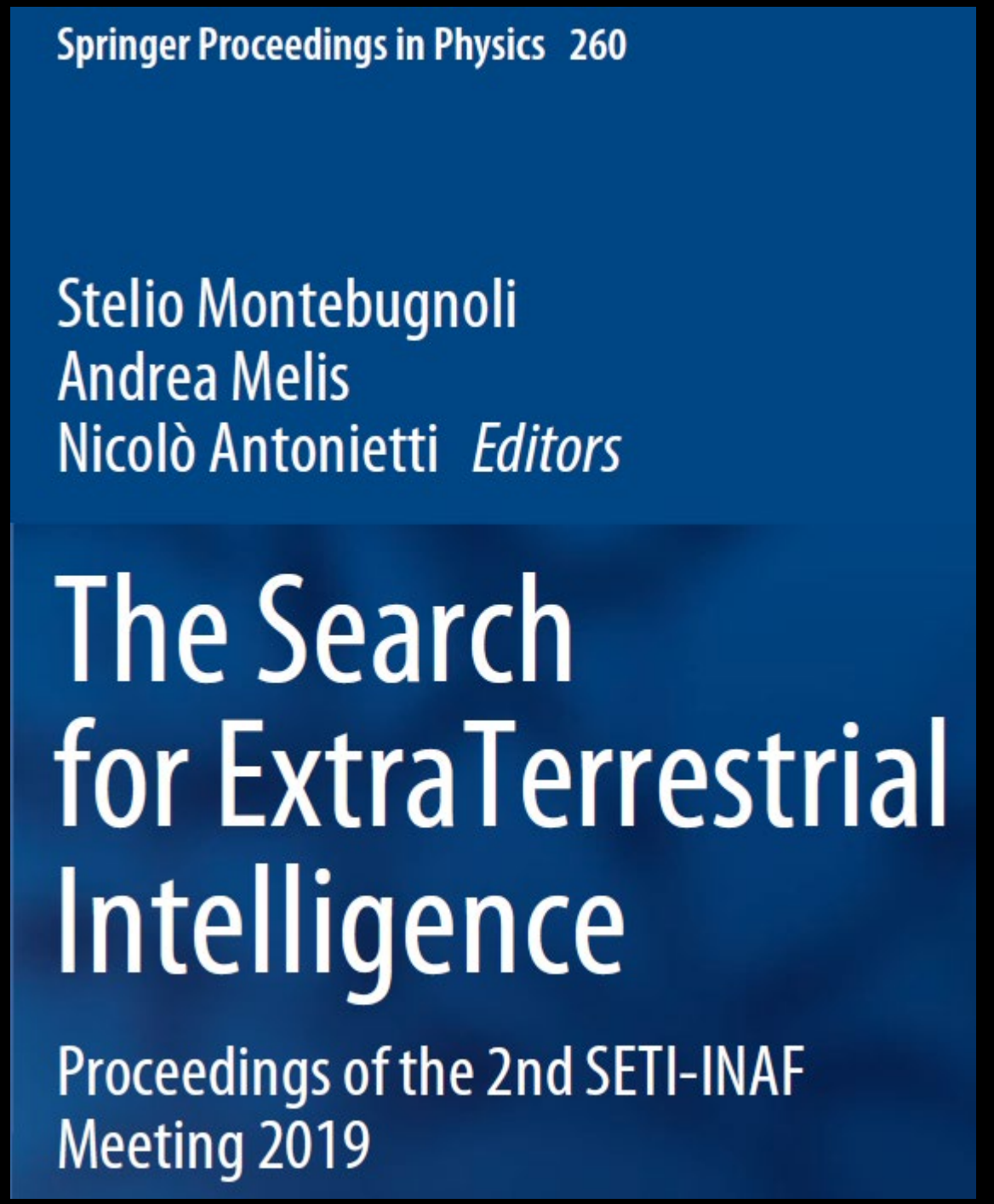
White Paper, ver 2.0, 02-01-2021

Contact Author: D. Anish Roshi[1], aroshi@naic.edu

Authors: N. Aponte[1], E. Araya[2], H. Arce[3], L. A. Baker[7], W. Baan[35], T. M. Becker[4], J. K. Breakall[34], R. G. Brown[5], C. G. M. Brum[1], M. Busch[6], D. B. Campbell[7], T. Cohen[24], F. Cordova[1], J. S. Deneva[8], M. Devogèle[1], T. Dolch[30], F. O. Fernandez-Rodriguez[1], T. Ghosh[9], P. F. Goldsmith[10], L. Gurvits[27], M. Haynes[7], C. Heiles[11], D. Hickson[1], B. Isham[12], R. B. Kerr[13], J. Kelly[28], J. J. Kiriazes[5], S. Kumar[14], J. Lautenbach[1], M. Lebron[15], N. Lewandowska[16], L. Magnani[17], P. K. Manoharan[1], S. E. Marshall[1], A. K. McGilvray[1], A. Mendez[36], R. Minchin[18], V. Negron[1], M. C. Nolan[19], L. Olmi[26], F. Paganelli[9], N. T. Palliyaguru[20], C. A. Pantoja[15], Z. Paragi[27], S. C. Parshley[7], J. E. G. Peek[6,21], B. B. P. Perera[1], P. Perillat[1], N. Pinilla-Alonso[22,1], L. Quintero[1], H. Radovan[37], S. Raizada[1], T. Robishaw[23], M. Route[31], C. J. Salter[9,1], A. Santoni[1], P. Santos[1], S. Sau[1], D. Selvaraj[1], A. J. Smith[1], M. Sulzer[1], S. Vaddi[1], F. Vargas[33], F. C. F. Venditti[1], A. Venkataraman[1], A. K. Virkki[1], A. Vishwas[7], S. Weinreb[32], D. Werthimer[11], A. Wolszczan[29] and L. F. Zambrano-Marin[1].

Affiliations are listed after the acknowledgements, immediately before the appendices.

SETI会议文集
2019年



IAA SETI Post-Detection Protocol 国际宇航科学院搜寻地外文明计划后探测协议

国际宇航科学院

-搜寻地外文明计划后期探测协议

关于探测地外文明后活动原则声明

Adopted by the International Academy of Astronautics, 1989

1. 凡个人、公众或私人研究机构，或认为已探测到来自地外文明的信号及其证
者)，在发布任何公告之前，应设法核实对于地外文明的
理的解释，而非其它自然现象或人为现象。如证据不能被
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发件人： "Michael Garrett" <michael.garrett@manchester.ac.uk> (由 members+bncbcxnjap5wypbbqhpylaamgqe7z3idzi@iaaseti.org 代发)

收件人： "members@iaaseti.org" <members@iaaseti.org>

抄 送： "iaa.pdp.2025@gmail.com" <iaa.pdp.2025@gmail.com>

附 件： 1 个 (DRAFT REVISED Declaration of Principles October ...) 查看附件

Dear Colleagues,

As many of you are aware, the IAA SETI Committee (SC) is in the process of updating the *Declaration of Principles Concerning the Conduct of the Search for Extraterrestrial Intelligence (SETI)*, otherwise known as the "IAA SETI Post-Detection Protocol".

A draft revised text (October 2024, v1.0), prepared by the IAA SC Task Group, was presented at the IAC 2024 and IAA SETI Committee meetings in Milan (Tennen et al. 2024). This document is attached to this em

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在其他站点的独立观测来确认发
象。在确定该情报是否为地外文
公开宣布该消息。发现者应通报

果的情报，通知给联合国秘书长、公众和国际科学界。"(第 11 条)，我们认识
到任何初始探测都可能不完整或是模棱两可，因此要求仔细地检查并核实，对

发现似乎是地外文明的可靠证据后，并在通报本声明的其
国际天文学联合会附属中央天文电报局通知世界
各国在探索与利用包括月球和其他天体在内的外
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发现通报下
息：

Version 1.0 - October 2024 Draft

October 2024 DRAFT REVISED Declaration of Principles Concerning the Conduct of the Search for ExtraTerrestrial Intelligence (SETI)

The parties to this Declaration are individuals and institutions participating in the scientific Search for Extraterrest
Intelligence (SETI), that is, the astronomy-based search for 'technosignatures'[1] or evidence of past or pres
intelligent life and technology beyond Earth.

2021年NASA美国国家航空航天局总部首席科学家办公室呼吁建立报告地球外生命证据的框架

Perspective

Call for a framework for reporting evidence for life beyond Earth

事实上，我们这一代人可能会发现地球以外存在生命

https://doi.org/10.1038/s41586-021-03804-9

Received: 8 February 2021

Accepted: 6 July 2021

Published online: 27 October 2021

Check for updates

James Green[1], Tori Hoehler[2], Marc Neveu[3,4], Shawn Domagal-Goldm… Daniella Scalice[6] & Mary Voytek[7]

Our generation could realistically be the one to discover evidence of life beyond Earth. With this privileged potential comes responsibility. The magnitude of the question of whether we are alone in the Universe, and the public interest therein, opens the possibility that results may be taken to imply more than the observations support, or than the observers intend. As life-detection objectives become increasingly prominent in space sciences, it is essential to open a community dialogue about how to convey information in a subject matter that is diverse, complicated and has a high potential to be sensationalized. Establishing best practices for communicating about life detection can serve to set reasonable expectations on the early stages of a hugely challenging endeavour, attach value to incremental steps along the path, and build

首席科学家办公室，美国国家航空航天局总部，华盛顿特区.

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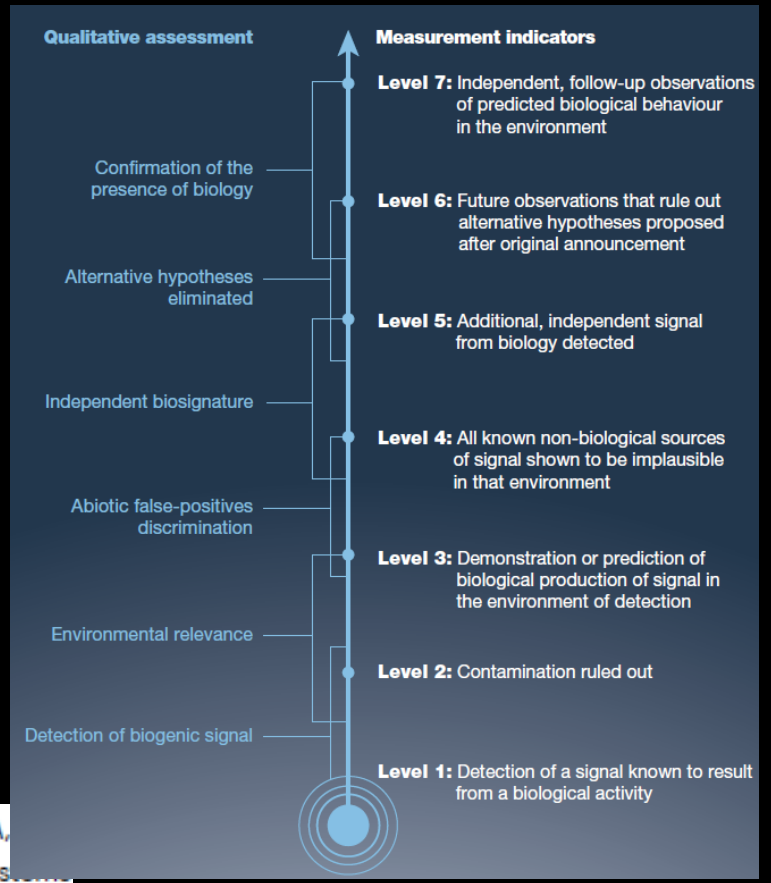
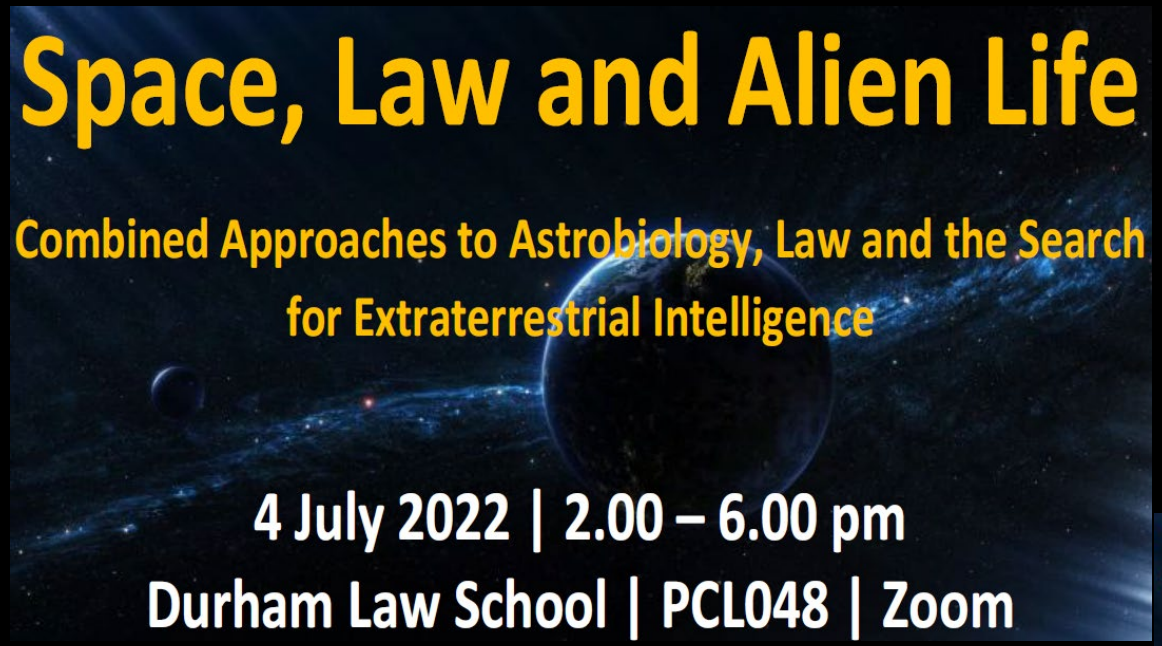
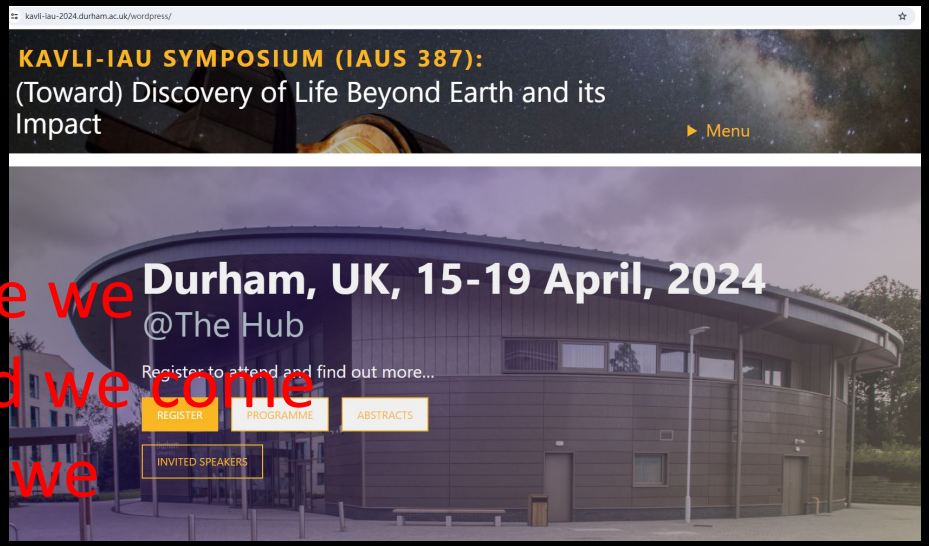
7等级量表 即
“生命检测的信心”（CoLD）量表





空间、法律和外星生命
2022年

Kavli-IAU Symposium (IAUS 387) “(Toward) Discovery of Life Beyond Earth and its Impact（走向）发现地球以外的生命及其影响” April 15-19, 2024 in Durham, UK



- Who are we? What are we doing here? Where did we come from? And, where are we going?

We should plan early, setting out impact assessments, protocols, procedures and treaties that allow us to act responsibly as individuals and communities and as a species

（我们应该尽早制定计划，制定影响评估、议定书、程序和条约，使我们能够作为个人、社区和物种负责任地行事）.

发件人： “Kavli-IAU Symposium (IAUS 387) Organising Committee” <no-reply@eso.org>

发送时间： 2024-02-23 17:23:02 (星期五)

收件人： tjzhang@bnu.edu.cn

主题： Announcement: Kavli-IAU Symposium (IAUS 387) “(Toward) Discovery of Life Beyond Earth and its Impact” April 15-19, 2024 in Durham, UK

Kavli-IAU Symposium (IAUS 387) “(Toward) Discovery of Life Beyond Earth and its Impact” April 15-19, 2024 in Durham, UK

Rationale

From our origins, humans have been inspired by pinpoints of light in the night sky. They cause us to wonder about our existence. Who are we? What are we doing here? Where did we come from? And, where are we going? Despite impressive investment and activity in space exploration over the years, the question remains unanswered. This decade sees a once-in-a-lifetime investment into the ‘Search for Life Beyond Earth.’ Research communities, governments and philanthropists alike are set to explore. NASA’s Apollo program showed that sufficient commitment of resources can lead to breakthroughs. Their progress, culminating in the Moon landing, inspired many to become astronomers. Both NASA and ESA have active and planned missions focused on the detection and characterisation of exoplanets. Most large observatories have invested in planetary astronomy and “Big Data” approaches, including the upcoming Legacy Survey of Space and Time (LSST) at the Vera C. Rubin observatory and the radio Square Kilometer Array (SKA). Meanwhile, new Machine Learning (ML) algorithms will make the search for technosignatures feasible at scale.

We still do not know if there is life beyond Earth or how probable it may be. But if it exists, we might find it (or it us) as early as tomorrow. And, there or not, found or not, the search itself has a profound impact on humanity. Beyond science, the ‘Search for Life Beyond Earth’ raises complex questions of policy, law, philosophy, and theology. It challenges us to think critically about life as a category and as a thing of value. But we are not prepared for a discovery. This multi-disciplinary symposium will bring together diverse expertise to investigate and plan how we will assess evidence and communicate what we know (and don’t know) with the public. We should plan early, setting out impact assessments, protocols, procedures and treaties that allow us to act responsibly as individuals and communities and as a species. Any outcome will have to be presented to ‘Planet Earth.’

英国SETI后探测中心

University of St Andrews | FOUNDED 1413

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Researchers

John Elliott

Coordinator of SETI Post-Detection Hub

Dr John Elliott has been a leading contributor for SETI post-detection research and development, since the late 1990s: initially in the fields of signal categorisation, analytics and message decipherment, which subsequently expanded to include post-detection metapolicy, protocols, societal impact and dissemination strategies. More recently, this has extended to post detection strategies for designing a global framework for integrating comprising multidisciplinary research. In 2012, together with Lord Martin Rees (Astronomer Royal) as patron, he co-founded the UK SETI Research Network, of which he is currently the Chair.

三. 国内SETI合作团队FAST观测研究进展

中国天眼FAST的科学目标之一(2011年)

- “时代楷模”南仁东先生 被尊为“中国天眼之父”。
  500米口径球面射电望远镜（FAST）工程的发起者和奠基人。

1022 *R. Nan et al.*

4.6. *SETI*

The only practical way to contact distant civilizations may also be through radio waves. Most SETI searches concentrate on microwaves at 1–60 GHz, using “free space” in the microwave window, especially the narrow band between the hydroxyl

International Journal of Modern Physics D
Vol. 20, No. 6 (2011) 989–1024
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DOI: 10.1142/S0218271811019335

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500米口径球面射电望远镜工程(FAST工程)

Five-hundred-meter Aperture Spherical radio Telescope project

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历史沿革
系统构成
密云模型
台址概况
>> 工程管理
组织机构
管理规章
人力资源
人才培养

5. 搜索星际通讯信号——寻找地外文明

寻找地外文明（Search for Extra－Terrestrial Intelligence，SETI)的学科风险是不言而喻的，但它一旦成功，将使人类所有的科学成就黯然失色。所以科学界的探索、发达国家政府与民间对SETI的投入也从未停止。

我们与地外文明通讯的唯一可行方法是寻找来自地外的“人工”无线电信号。非热银河背景噪声、量子噪声及宇宙微波背景噪声是我们银河系中无处不在的3个噪声源，地外文明社会的工程师面临同样的电噪谱，他们可能会和我们想到相同的频率窗口。

SETI专家认为人类应该将搜索集中在1—3GHz的频率范围，尤其是21厘米的中性氢线HI与18厘米羟基线OH之间。H与OH结合成水H2O，因而这一狭窄频带又称为“水洞”。水对地球生命是最基本的，地外的“水族”可能也会自然地通过水洞寻找同类。

THE FIVE-HUNDRED-METER APERTURE SPHERICAL RADIO TELESCOPE (FAST) PROJECT

RENDONG NAN*,†,§, DI LI*,‡,¶, CHENGJIN JIN*, QIMING WANG*, LICHUN ZHU*, WENBAI ZHU*, HAIYAN ZHANG*,†, YOULING YUE* and LEI QIAN*

*National Astronomical Observatories, Chinese Academy of Sciences, A20 Datun Road, Chaoyang District, Beijing 100012, China

†Key Laboratory for Radio Astronomy, Chinese Academy of Sciences, Nanjing 210008, China

‡Jet Propulsion Laboratory, California Institute of Technology, Pasadena, CA 91109, USA

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¶dili@jpl.nasa.gov

2016年我和其他科学家接受纽约时报采访

The New York TimesThe New York Times | http://nyti.ms/2daQdG0

ASIA PACIFIC

China Hunts for Scientific Glory, and Aliens, With New Telescope

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By CHRIS BUCKLEY and ADAM WU SEPT. 25, 2016

PINGTANG COUNTY, China — When hundreds of engineers and builders b
clambering up a jagged hill in southwestern China to assemble a giant telesc
a deep, bowl-shaped basin, poor villagers sometimes crept over the sheer sl
glimpse the country's latest technological wonder

But alien life is not a focus for now. Initially, the scientists running the telescope will scan the skies to test and calibrate their equipment, and researchers involved in the international effort to explore for intelligent life on distant planets will "piggyback" to sift for signals, Dan Werthimer, the chief scientist of the SETI Research Center at the University of California, Berkeley, which engages in the search for extraterrestrial intelligence, said in a telephone interview.

"They're very keen to collaborate," he said. "We can use the telescope at the same time that they're doing more traditional astronomy to look for E.T."

"Previous research could only tell us that the universe is expanding," Zhang Tongjie, a professor of cosmology at Beijing Normal University who plans to use the telescope, said in an interview.

If the telescope can be used to survey electromagnetic radiation from neutral hydrogen, he said, Chinese scientists would be well positioned to gain a much more accurate grasp of how fast the universe is expanding. "That would be very significant," he said.

2016年10月美国绿岸天文台 做报告：SETI in China

NRAO - Green Bank
P.O. Box 2
Green Bank, WV 24944-0002
304.456.2011 Fax 304.456.2229
www.nrao.edu

Green Bank, WV USA, September 9, 2016

Tong-Jie Zhang
affiliation: Beijing Normal University
address: No. 19, XinJieKouWai St, Beijing 100875 CHINA
email: tjzhang@bnu.edu.cn

Dear Dr. Zhang,

On behalf of the Scientific Organizing Committee, we hereby invite you to participate in and present a talk regarding "SETI in China" the GBO hosted workshop "*Breakthrough Listen North American Community Workshop,*" to take place at the Green Bank Observatory, Green Bank, WV USA. The event dates are October 5-6, 2016. In addition, you are invited to the dedication of the Green Bank Observatory, October 7-9, 2016. We look forward to seeing you there.

Please let us know if you have any further questions.

Best,

Karen Ransom (Meeting Planner, on behalf of the SOC)

中美地外文明合作计划

2016年10月12日中国科学院国家天文台与美国“突破计划”签署合作意向，
共同探寻地外智慧生命！

- https://nao.cas.cn/news/ky/201611/t20161118_6407826.html

合作签署仪式合影

合作协议签署仪式后，Pete Worden教授作报告介绍“突破计划”并回答听众提问

2019 年首次尝试SETI分形宇宙理论研究

Results in Physics 15 (2019) 102548

Contents lists available at ScienceDirect

Results in Physics

journal homepage: www.elsevier.com/locate/rinp

Search for Extraterrestrial Intelligence (SETI) by fractal universe

Sheena Chen, Tong-Jie Zhang

Department of Astronomy, Beijing Normal University, Beijing 100875, China

ARTICLE INFO

Keywords:
SETI
Fractal universe

ABSTRACT

We propose the hypothesis that the universes we live are provided with fractal properties, from macro to micro scale, which have self-similarity and space filling. In this paper, we try to describe the different structures of the mechanical motion between universes and microscopic spaces, and aim to provide a different view of the detection of extraterrestrial signals.

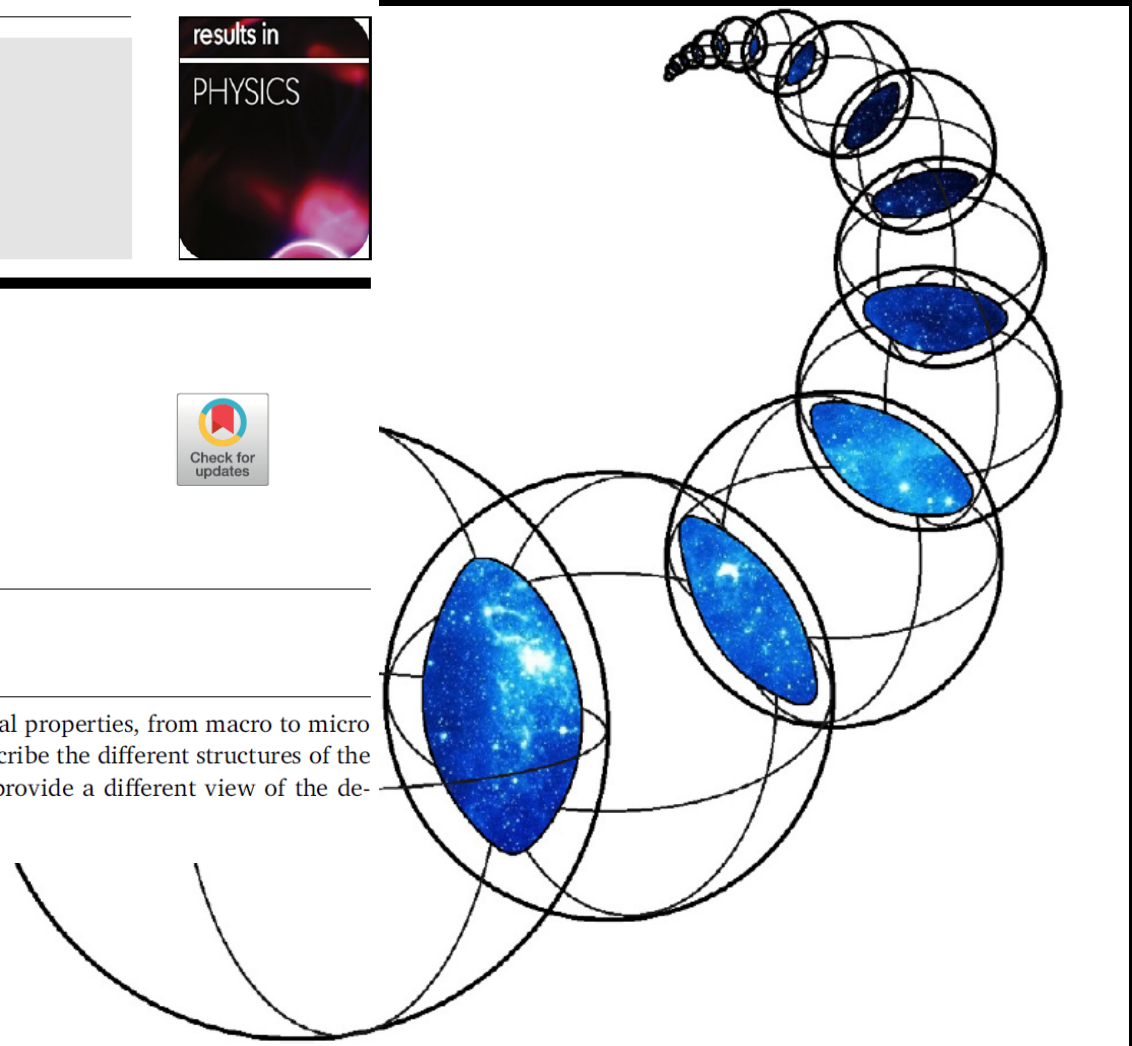
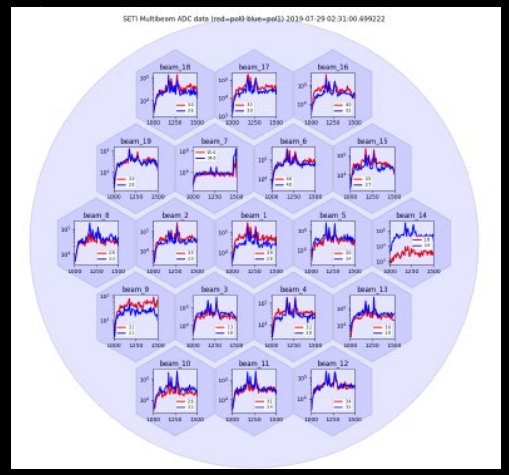
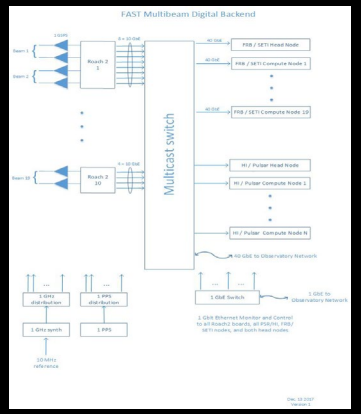


Fig. 4. A locally observable fractal universe. Each interface may exists the particular brane dynamics itself of the possible residence.

2018-2019年SETI 巡天

- 2018年9月在FAST上成功安装了SETI后端数据处理系统。 2019年7月开始后端系统已经进行了ETI信号的共时巡天观测。



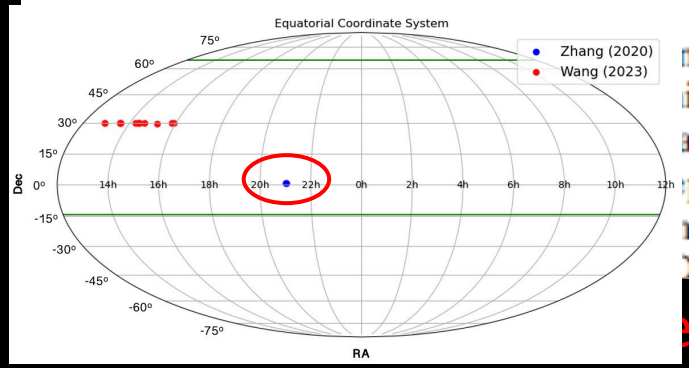


2020 年国内第一个SETI观测结果

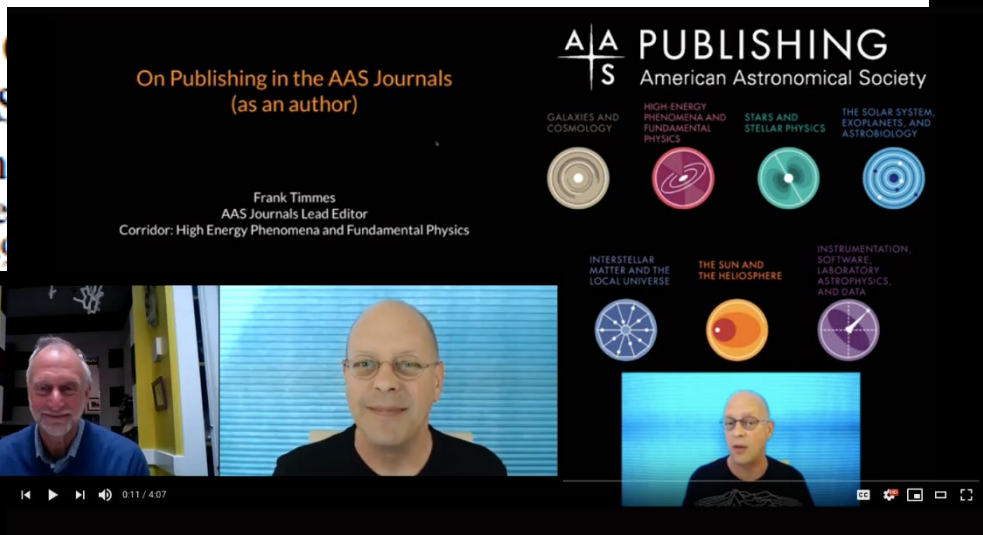
THE ASTROPHYSICAL JOURNAL, 891:174 (16pp), 2020 March 10

First SETI Observations with China's Five-hundred-meter Aperture Spherical Rad Telescope (FAST)

Zhi-Song Zhang[1,2,3,4], Dan Werthimer[3,4], Tong-Jie Zhang[5], Jeff
Vishal Gajjar[3,4], Ryan Lee[4,6,7], Shi-Yu Li[5], Xin Pei[2,8], Xin-Xin Zhang[1],
Hai-Yan Zhang[1], Cheng Jin Jin[1], Li-Chun Zh
nomical Observatories, Chinese Acad y of Sciences, Be
iversity of Chinese Academy of Sciences, Beijing 10004
ace Sciences Laboratory, University of Californ
partment of Astronomy, University of California
ent of Astronomy, Beijing Normal University, B
Department of Physics, University of California



eries video of Dan discussing



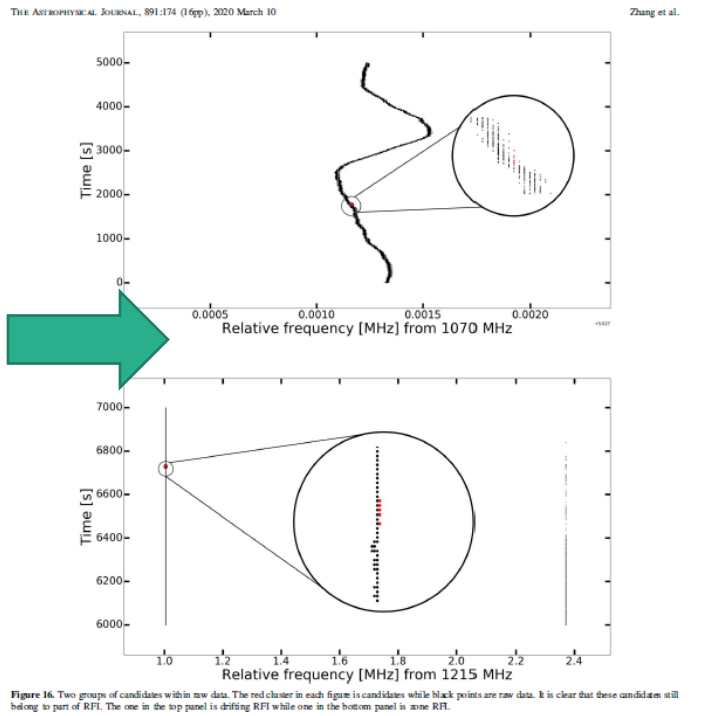


Figure 16. Two groups of candidates within raw data. The red cluster in each figure is candidates while black points are raw data. It is clear that these candidates still belong to part of RFI. The one in the top panel is drifting RFI while one in the bottom panel is zone RFI.

2021年：SETI 观测策略

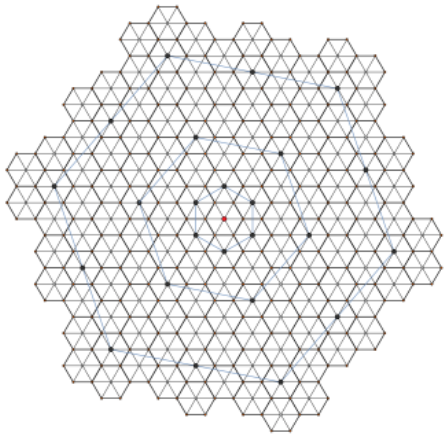


Fig. 2 The *blue-marked edges* in Fig. 2 represent the partial deformation from star tracking. The whole area of FAST is composed of 10 728 identical triangular shaped reflectors. Each actuator node can be represented in Cartesian coordinates. Considering the mechanical support, we claim the local spatial coordinates for every cable element of FAST $\mathscr{Q}_{\rm FAST} = [\mathbf{X},\mathbf{Y},\mathbf{Z}]^{\rm T}$, where these matrices **X**, **Y** and **Z** are sets of actuator node positions.

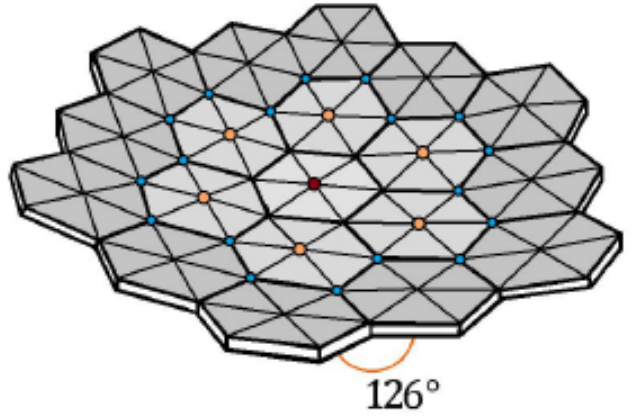


Fig. 1 A part of the local fractalized main reflector. This displays iteration $n = 2$. The center of the aperture is the 19 multibeam feed located at the coordinate (498956.8651, 2838440.713, 838.32178).

time by dynamically
et al. 2019). Intere
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RAA 2021 Vol. 21 No. 7, 178(7pp) doi: 10.1088/1674-4527/21/7/178

http://www.raa-journal.org *http://iopscience.iop.org/raa*

Research in Astronomy and Astrophysics

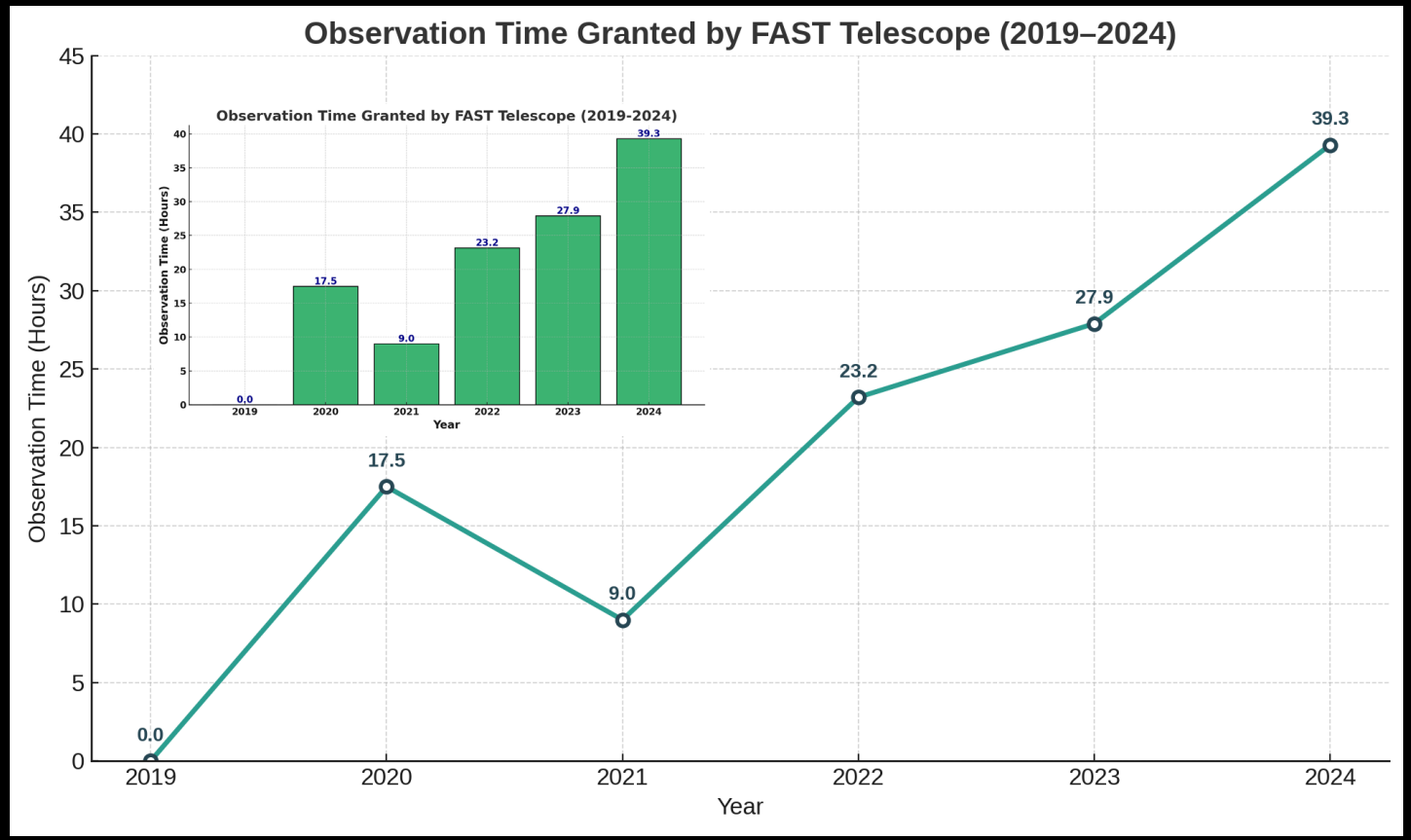
SETI strategy with FAST fractality

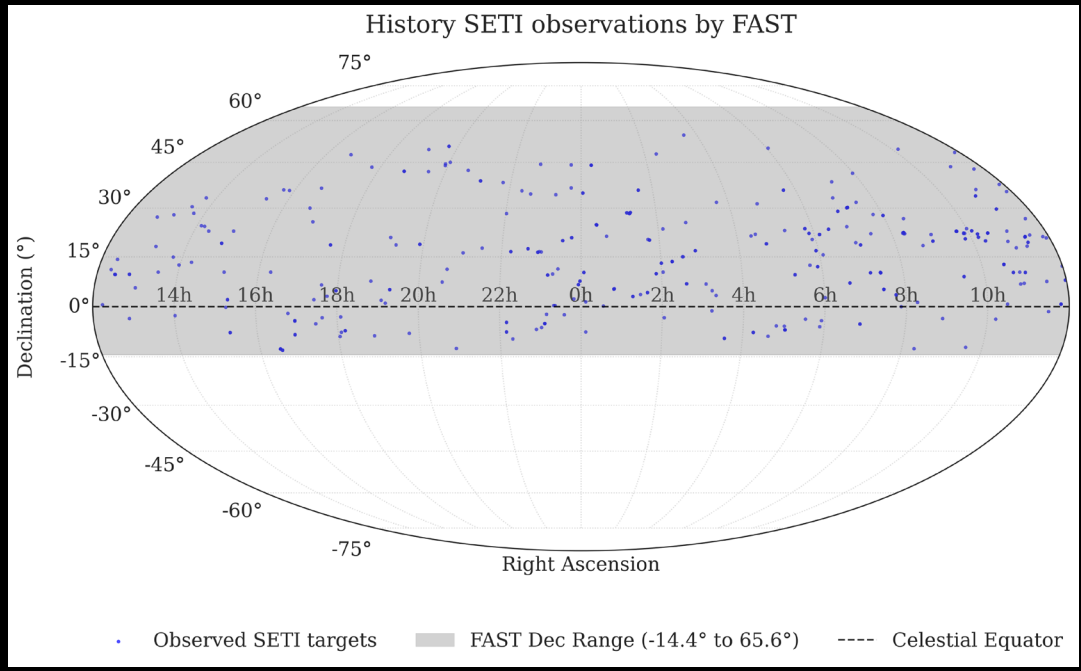
Yi-Xuan Chen[1], Wen-Fei Liu[2], Zhi-Song Zhang[3] and Tong-Jie Zhang[1,2]

[1] Department of Astronomy, Beijing Normal University, Beijing 100875, China; *tjzhang@bnu.edu.cn*
[2] College of Physics and Electronic Engineering, Qilu Normal University, Jinan 250200, China
[3] National Astronomical Observatories, Chinese Academy of Sciences, Beijing 100101, China

Received 2021 February 17; Accepted 2021 April 12

2.目标观测：五年(2020-2025)获批观测时间





SETI系外行星FAST观测时间：五次共计116.9个小时
国际评审人的评语　第三次(2022年)

- 发件人:fast-proposal-support@bao.ac.cn
  发送时间:2022-07-31 14:01:53 (星期日)
  收件人: tjzhang@bnu.edu.cn
  主题: The results of the FAST proposal review in 2022

  Dear Tong-Jie Zhang,

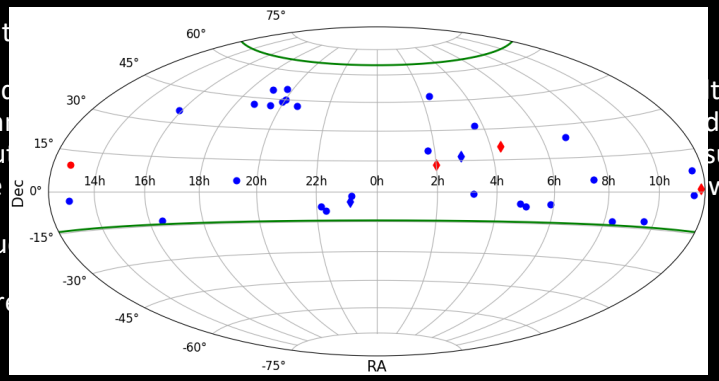
- Thank you for submit

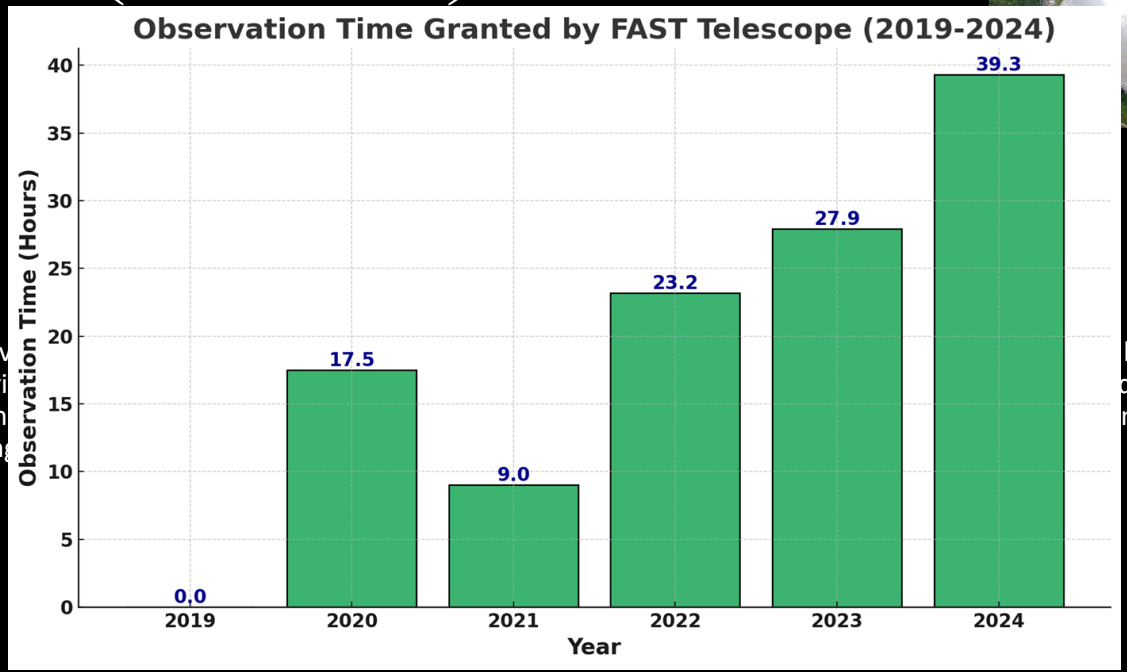
- This year we received ting an av by the FAST Time Allocation Com d wi riori d observing time would be execu subs tion ng 7.8, we also specify the time win nking

- B （23.2 hours, inclu

- Please find below a r

- Strengths:





- This is a recurring proposal from a previously approved program, and it propo s to conduct targeted SETI study, which is one of the five key science goals of the FAST. They updated their SETI strategy based on observations in the last two years. They propose search for periodical signals, which is a new approach. While this project could fall under the broad description of "fishing expedition", it is worthwhile trying it, as detecting a p ble artificial signal would be a breakthrough discovery.

- ***这是FAST的五个关键科学目标之一。他们根据过去两年的观测结果更新了SETI策略。他们建议寻找周期性信号，这是一种新的方法。虽然这个项目可以被广泛地描述为“捕鱼探险（或者大海捞针）”，但它值得一试，因为探测到可能的人工信号将是一个突破性的发现。

国际评审人评语
第五次 2024年

- 发件人: fast-proposal-support@bao.ac.cn
  发送时间: 2024-08-10 19:03:12 (星期六)
  收件人: tjzhang@bnu.edu.cn
  主题: The results of the FAST proposal review in 2024

- Dear Tong-Jie Zhang,
-
  Thank you for submitting your FAST proposal coded SQB-2024-0200.

- This year we received a total of 310 proposals requesting over 9992.11 hours, resulting in an average oversubscription rate of 4.9. All the proposals were peer-reviewed, and then discussed by the FAST Time Allocation Committee. Observing time allocation was ranked in A (accepted with priority), B (accepted), or C (no time allocated). While we expect that a significant portion of B-rated observing time would be executed, these observations are not guaranteed. Since the oversubscription rate for the Right Ascension (RA) range of 18 to 22 hr is much higher than the average, reaching 7.6, we also specify the time allocated to this RA range. Your proposal received the following ranking:

- B（16.0 hours, including 0.0 hours for RA=18—22hr）

- Please find below a report on your proposal:
- Strengths:
- SETI search is an important part of FAST science. This is a continuation of previous proposals, with improvements led by the same team. Clearly, the project will detect an abundance of techno-signatures, with almost all attributable to terrestrial sources rather than the extra-terrestrial origins sought. As Cocconi and Morrison wisely put it: "The probability of success is difficult to estimate; but if we never search, the chance of success is zero." Regardless, the improved understanding of the various ways that RFI can manifest itself are of potential benefit to all other users.
-

***成功的可能性很难估计，但如果我们从不去寻找，成功的可能性是零”。。

信号层级：相当于 1-5σ

- Levels in signal（1-5）

1. hit – signal that exceeds S/N threshold with RA/dec, time, freq (and freq res) , beam, types

2. event – single or brunch of hit(s) (recognized as to be)from the same source (ET, smart phone, satellite, …)

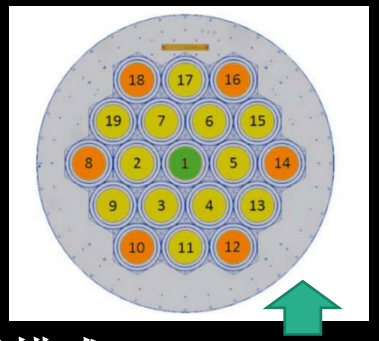
3. candidate – event that passes the RFI algorithm

4. Signal of interest – candidate that can’t be excluded by astro/phys/math criteria (freq drift, polarization, intensity variation, repeat rate,…)

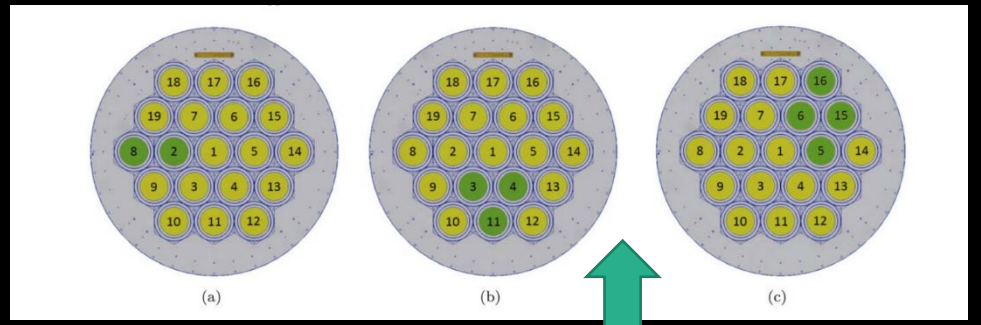
5. ETI signal

1. hit → 2. event

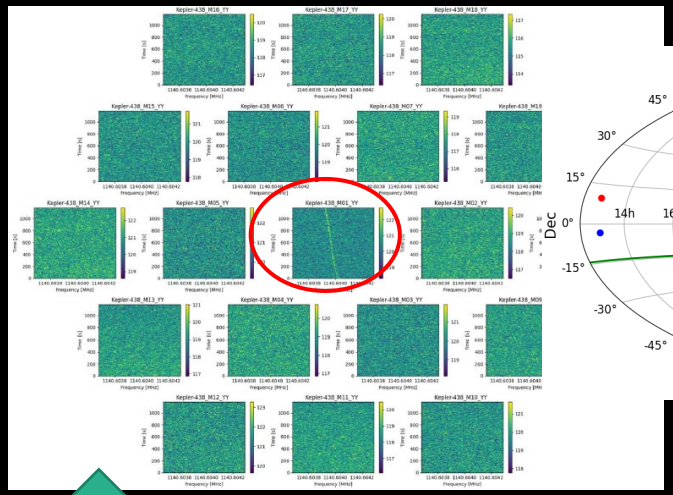
针对FAST-19波束，首次提出SETI“多波束联合匹配策略-the multibeam coincidence matching strategy（MBCM）”

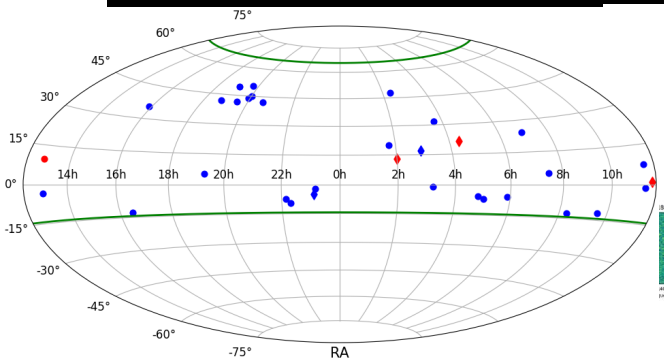


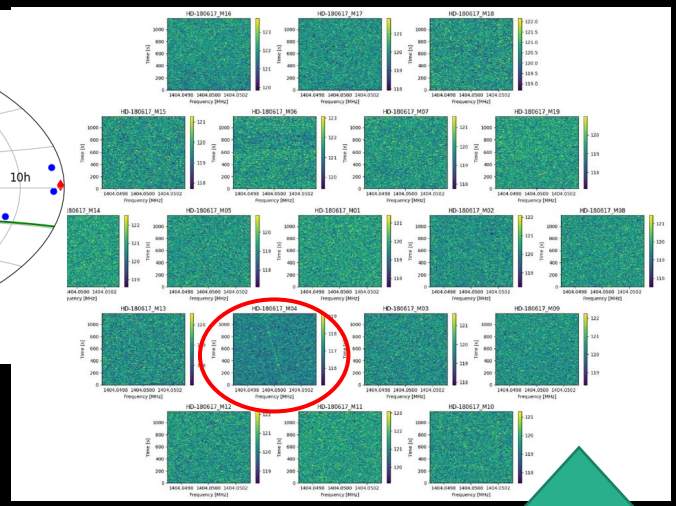
目标搜寻模式-targeted search mode



盲搜模式-blind search mode







(1). Zhen-Zhao Tao(陶振钊), Hai-Chen Zhao, **Tong-Jie Zhang** *et al* 2022 *AJ* **164** 160.

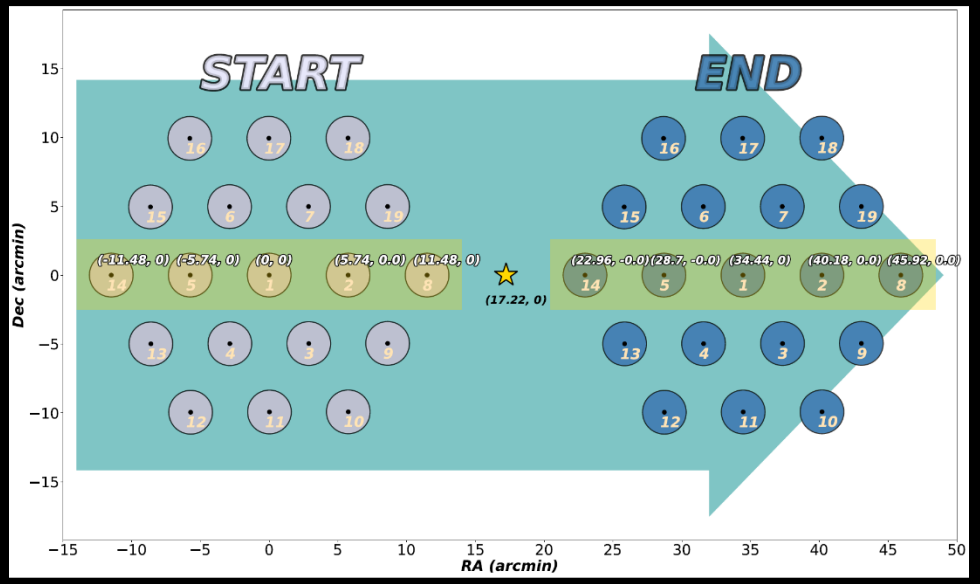
(2). Xiao-Hang Luan(栾晓航), Zhen-Zhao Tao, Hai-Chen Zhao, **Tong-Jie Zhang** *et al* 2023 *AJ* **165** 132.

FSAT多波束点源扫描策略-- 1. hit → 3. candidate

- 针对FAST后端和目标协同观测，首次提出了 MultiBeam Point-source Scanning 观测策略，从而建立了可在单次观测中交叉验证的ETI信号确认和RFI排除之标准与流程。

●Bo-Lun Huang (黄博伦）

The Astronomical Journal(**AJ**), Volume 166, Issue 6, id.245, 8 pp.(2023)



THE ASTRONOMICAL JOURNAL, 166:245 (8pp), 2023 December
https://doi.org/10.3847/1538-3881/ad06b1

A Solution to Continuous RFI in Narrowband Radio SETI with FAST: The MultiBeam Point-source Scanning Strategy

Bo-Lun Huang[1,2], Zhen-Zhao Tao[1,2,3], and Tong-Jie Zhang[1,2]
[1] Institute for Frontiers in Astronomy and Astrophysics, Beijing Normal University, Beijing 102206, People's Republic of China; tjzhang@bnu.edu.cn
[2] Department of Astronomy, Beijing Normal University, Beijing 100875, People's Republic of China
[3] Institute for Astronomical Science, Dezhou University, Dezhou 253023, People's Republic of China
Received 2023 July 4; revised 2023 October 19; accepted 2023 October 23; published 2023 November 15

AI在SETI中的首次应用 射电干扰去除

2. Event → 3. candidate

The Astrophysical Journal, 891:174 (16pp), 2020 March 10 https://doi.org/10.3847/1538-4357/ab7376

CrossMark

First SETI Observations with China's Five-hundred-meter Aperture Spherical Radio Telescope (FAST)

Zhi-Song Zhang[1,2,3,4], Dan Werthimer[3,4], Tong-Jie Zhang[5], Jeff Cobb[3,4], Eric Korpela[3], David Anderson[3], Vishal Gajjar[3,4], Ryan Lee[4,6,7], Shi-Yu Li[5], Xin Pei[2,8], Xin-Xin Zhang[1], Shi-Jie Huang[1], Pei Wang[1], Yan Zhu[1], Ran Duan[1], Hai-Yan Zhang[1], Cheng-jin Jin[1], Li-Chun Zhu[1], and Di Li[1,2,9]

[1] National Astronomical Observatories, Chinese Academy of Sciences, Beijing 100012, People's Republic of China
[2] University of Chinese Academy of Sciences, Beijing 100049, People's Republic of China
[3] Space Sciences Laboratory, University of California Berkeley, Berkeley, CA 94720, USA
[4] Department of Astronomy, University of California Berkeley, Berkeley, CA 94720, USA
[5] Department of Astronomy, Beijing Normal University, Beijing 100875, People's Republic of China
[6] Department of Physics, University of California Berkeley, Berkeley, CA 94720, USA
[7] Department of Computer Science, University of California Berkeley, Berkeley, CA 94720, USA
[8] Xinjiang Astronomical Obse CAS, 150, Science 1-Street, Urumqi, Xinjiang 830011, People's Republic of China
[9] CAS Key Laboratory of FAST, National nical Observatories, Chinese Academy of Sciences, Beijing 100101, People's Republic o
Received 2019 Septembe ised 2020 January 17; accepted 2020 February 5; published 2020 March 17

5. Machine Learning for RFI Removal and Candidate Selection

It should be noted that we employ the traditional assumption that advanced life wishing to be detected at interstellar distances will use narrowband microwave emissions, as narrowband

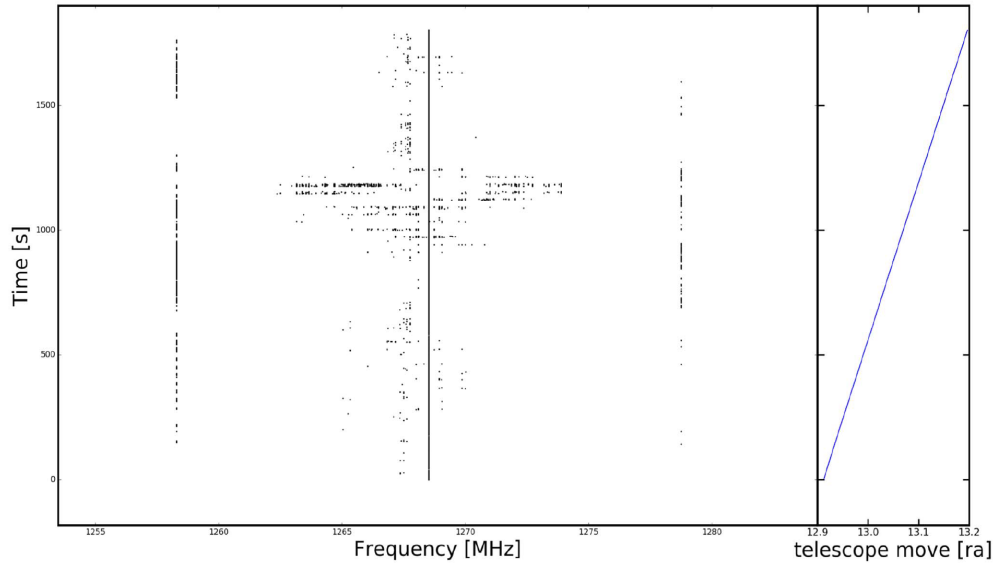
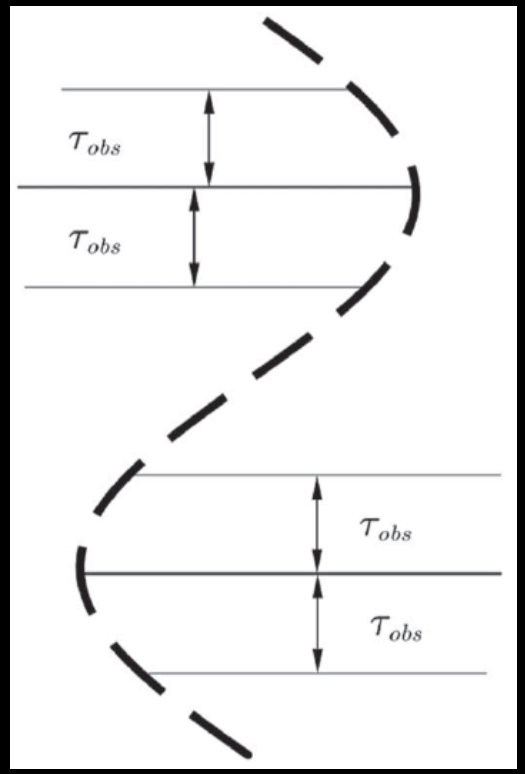
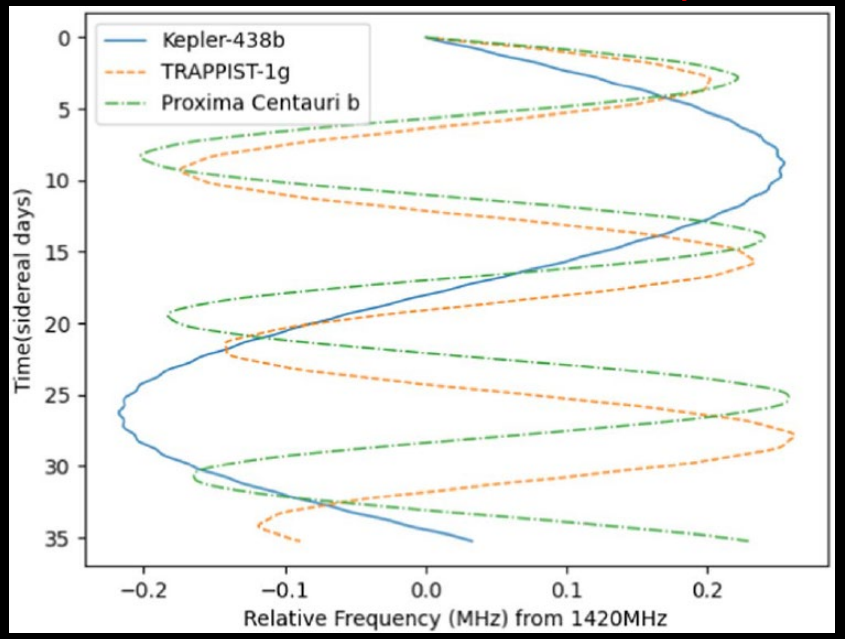


Figure 3. Waterfall plot showing time vs. frequency for a zone RFI and the R.A. of FAST in equatorial coordinates. There is a typical zone RFI around 1268 MHz. Because they often contaminate the entire frequency channel, we call them zone RFI. In this figure, and other waterfall figures in this paper, the R.A. coordinates are not exact (see the position error discussion in Section 4.3). The decl. is constant during these drift-scan observations; for this particular observation, the decl. was 0:42:55.5.

3. candidate→ 4. Signal of interest 终审裁决1-ETI信号频率漂移

- 提出了最后甄别的ETI信号频率漂移判据
- Reviewer: *** I think it will be a great resource to the SETI community and I recommend the work for publication with a few minor edits.





The Astrophysical Journal, 938:1 (12pp), 2022 October 10 https://doi.org/10.3847/1538-4357/ac90bd

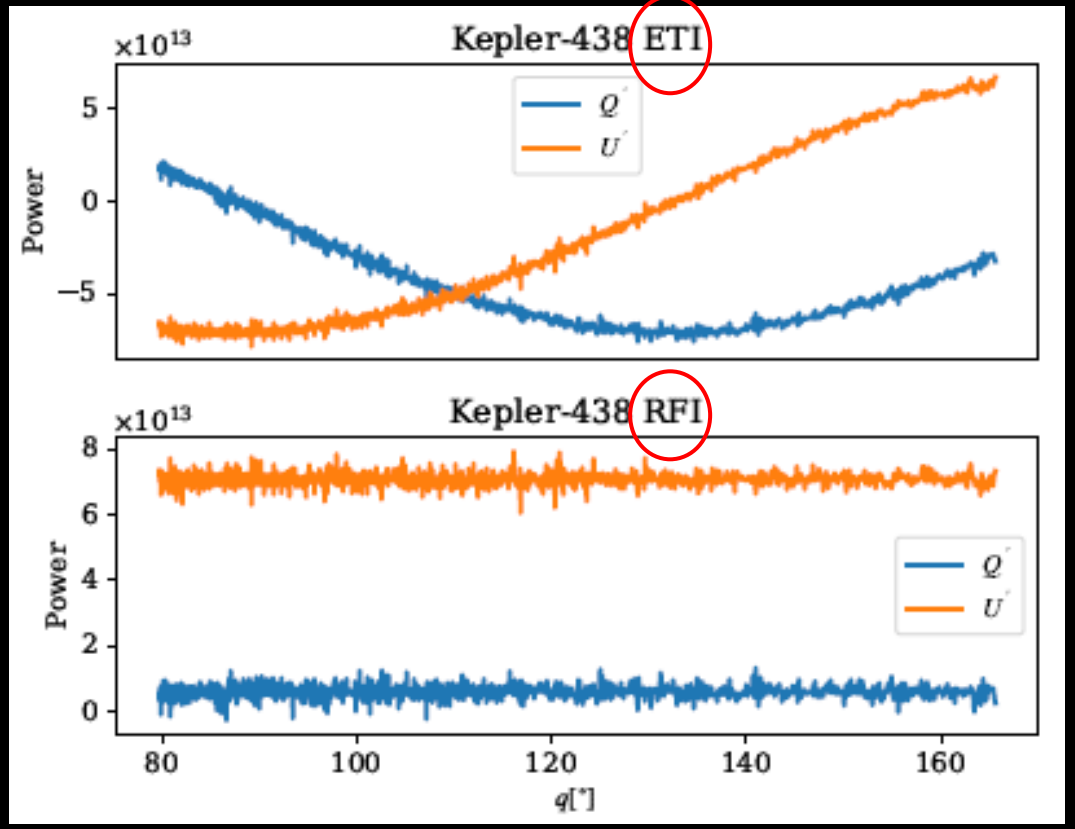
Drift Rates of Narrowband Signals in Long-term SETI Observations for Exoplanets

Jian-Kang Li[1,2,3], Hai-Chen Zhao[3,4], Zhen-Zhao Tao[3,4], Tong-Jie Zhang[3,4], and Sun Xiao-Hui[1,2]
[1] Department of Astronomy, Yunnan University, Kunming 650500, People's Republic of China; tjzhang@bnu.edu.cn
[2] Department of Astronomy, Key Laboratory of Astroparticle Physics of Yunnan Province, Yunnan University, Kunming 650091, People's Republic of China
[3] Department of Astronomy, Beijing Normal University, Beijing 100875, People's Republic of China
[4] Institute for Frontiers in Astronomy and Astrophysics, Beijing Normal University, Beijing 102206, People's Republic of China
Received 2022 June 11; revised 2022 September 7; accepted 2022 September 7; published 2022 October 7

Jian-Kang Li (李健康), Hai-Chen Zhao, Zhen-Zhao Tao, **Tong-Jie Zhang**, and Sun Xiao-Hui. 2022 *ApJ* **938** 1.

终审裁决2-ETI信号偏振判据

- 基于FAST偏振观测的高灵敏度，首次提出了ETI信号的偏振判据。



Jian-Kang Li(李健康), Yu Chen, Zhen-Zhao Tao, Xiao-Hang Luan, **Tong-Jie Zhang**, Bo-Lun Huang, Xiao-Hui Sun, Vishal Gajjar
arXiv: 2305.15715

The Astronomical Journal(**AJ**), Volume 167, Issue 1, id.8, 5 pp.(2024)

The Astronomical Journal, 167:8 (5pp), 2024 January https://doi.org/10.3847/1538-3881/ad0be8

Polarization Criterion in Targeted SETI Observation

Jian-Kang Li[1,2,3], Yu Chen[1,2], Bo-Lun Huang[1,2], Zhen-Zhao Tao[1,2], Xiao-Hang Luan[1,2], Xiao-Hui Sun[3], Tong-Jie Zhang (张同杰)[1,2], and Vishal Gajjar[4,5]
[1] Institute for Frontiers in Astronomy and Astrophysics, Beijing Normal University, Beijing 102206, People's Republic of China; mailto:tjzhang@bnu.edu.cn
[2] Department of Astronomy, Beijing Normal University, Beijing 100875, People's Republic of China
[3] Department of Astronomy, Yunnan University, Kunming 650500, People's Republic of China
[4] Breakthrough Listen, University of California Berkeley, Berkeley, CA 94720, USA
[5] SETI Institute, 339 N Bernardo Avenue Suite 200, Mountain View, CA 94043, USA
Received 2023 July 23; revised 2023 November 8; accepted 2023 November 9; published 2023 December 6

最后一步 5. ETI signal 终极证认： IAA SETI Post-Detection Protocol 国际宇航科学院搜寻地外文明计划后探测协议

国际宇航科学院

-搜寻地外文明计划后期探测协议

关于探测地外文明后活动原则声明

Adopted by the International Academy of Astronautics, 1989

1. 凡个人、公众或私人研究机构，或认为已探测到来自地外文明的信号及其证
者)，在发布任何公告之前，应设法核实对于地外文明的
理的解释，而非其它自然现象或人为现象。如证据不能被
存在，发现者对于任何未知现象的发现得酌情传播信息。

发件人： "Michael Garrett" <michael.garrett@manchester.ac.uk> (由 members+bncbcxnjap5wypbbqhpylaamgqe7z3idzi@iaaseti.org 代发)

收件人： "members@iaaseti.org" <members@iaaseti.org>

抄 送： "iaa.pdp.2025@gmail.com" <iaa.pdp.2025@gmail.com>

附 件： 1 个 (DRAFT REVISED Declaration of Principles October ...) 查看附件

Dear Colleagues,

As many of you are aware, the IAA SETI Committee (SC) is in the process of updating the *Declaration of Principles Concerning the Conduct of the Search for Extraterrestrial Intelligence (SETI)*, otherwise known as the "IAA SETI Post-Detection Protocol".

A draft revised text (October 2024, v1.0), prepared by the IAA SC Task Group, was presented at the IAC 2024 and IAA SETI Committee meetings in Milan (Tennen et al. 2024). This document is attached to this em

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在其他站点的独立观测来确认发
象。在确定该情报是否为地外文
公开宣布该消息。发现者应通报

果的情报，通知给联合国秘书长、公众和国际科学界。"(第 11 条)，我们认识
到任何初始探测都可能不完整或是模棱两可，因此要求仔细地检查并核实，对

发现似乎是地外文明的可靠证据后，并在通报本声明的其
国际天文学联合会附属中央天文电报局通知世界
"各国在探索与利用包括月球和其他天体在内的外
于地外文
发现通报下
息：

Version 1.0 - October 2024 Draft

October 2024 DRAFT REVISED Declaration of Principles
Concerning the Conduct of the Search for ExtraTerrestrial Intelligence (SETI)

The parties to this Declaration are individuals and institutions participating in the scientific Search for Extraterrest
Intelligence (SETI), that is, the astronomy-based search for 'technosignatures'[1] or evidence of past or pres
intelligent life and technology beyond Earth.

SETI进展综述2022年

科学通报
进 展
《中国科学》杂志社
SCIENCE CHINA PRESS

地外文明技术印迹射电搜寻进展

张同杰[1,2,3*], 陶振钊[1,2,3], 刘文斐[4], 李时雨[2,5], 赵海辰[1,2], 张志嵩[6], 李健康[1,2,7], 陈沂瑄[1,2], 栾晓航[1,2], 王洪丰[8], 张建臣[2,8]

1. 北京师范大学天文与天体物理前沿科学研究所, 北京 102206;
2. 北京师范大学天文系, 北京 100875;
3. 德州学院天文科学研究院, 德州 253023;
4. 齐鲁师范学院物理与电子工程系, 济南 250200;
5. 北京天文馆, 北京 100044;
6. 中国科学院国家天文台, 北京 100012;
7. 云南大学天文系, 昆明 650500;
8. 德州学院计算机与信息工程学院, 德州 253023

* 联系人, E-mail: tjzhang@bnu.edu.cn

2022-10-17 收稿, 2022-11-22 修回, 2022-11-25 接受, 2022-11-28 网络版发表
科技部中国SKA生命摇篮计划、国家重点基础研究发展计划(2017YFA0402600

摘要 基于哥白尼原理、德雷克公式以及大量系外行星的发现
高级智慧生命(或文明). 射电技术由于其优势而成为地外文明搜
的单天线射电望远镜, 地外文明搜寻(search for extraterrestrial i
射电L波段上极高的灵敏度对SETI有着重要意义. 基于FAST
间, 我们开展了SETI后端共时巡天观测和系外行星目标观测.
(SETI@home)和突破聆听(Breakthrough Listen)团队合作, 我们
明(extraterrestrial intelligence, ETI)信号鉴别过程更加科学完备的
ETI候选目标. 本文主要介绍国际上的SETI观测历史, 尤其是FA

关键词 地外智慧生命搜寻, 技术印迹, 射频干扰, 共时巡天观测, 系外行星

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Chinese Science Bulletin, (2022) Free Content

地外文明技术印迹射电搜寻进展 CrossMark

Tongjie Zhang [1], Zhenzhao Tao [2], Wenfei Liu [3], Shiyu Li [4], Haichen Zhao [2], Zhisong Zhang [5], Jiankang Li [6], Yixuan Chen [2], Xiaohang Luan [2], Hongfeng Wang [7], Jianchen Zhang [7]

4.国内国际影响力

2020年9月23-24日国家自然科学基金委“行星宜居性及演化双清论坛”

- 受邀参加论坛，做“SETI在中国”的报告，推动和呼吁在国内深度开展SETI！

主 题：行星宜居性及演化双清论坛邀请

尊敬的张同杰教授：

您好！

行星宜居性及演化是地球科学、天文学、生命科学等共同关注的前沿重大科学问题，也是我国深空探测的重要研究领域。我国已启动探测火星、小行星、木星及其卫星计划，7月23日“天问一号”探测器已奔向火星，这为从全新视野认识包括地球在内的行星宜居性及演化提供了契机，研讨相关的重大科学问题必要而迫切。

拟于2020年9月23-24日在京举办国家自然科学基金委“行星宜居性及演化双清论坛”，会期1天半（24日中午闭会）。论坛讨论主题包括行星宜居环境要素、火星探测、系外行星等。鉴于您深厚的学术造诣，我们诚挚地邀请您出席论坛，参与讨论，提出未来研究建议。希您能及早回复是否出席。

祝好，

国家空间科学中长期发展规划（2024—2050年）

国家空间科学中心 2024年10月15日 11:31 北京

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国家空间科学中长期发展规划（2024—2050年）

中国科学院 国家航天局 中国载人航天工程办公室
联合发布

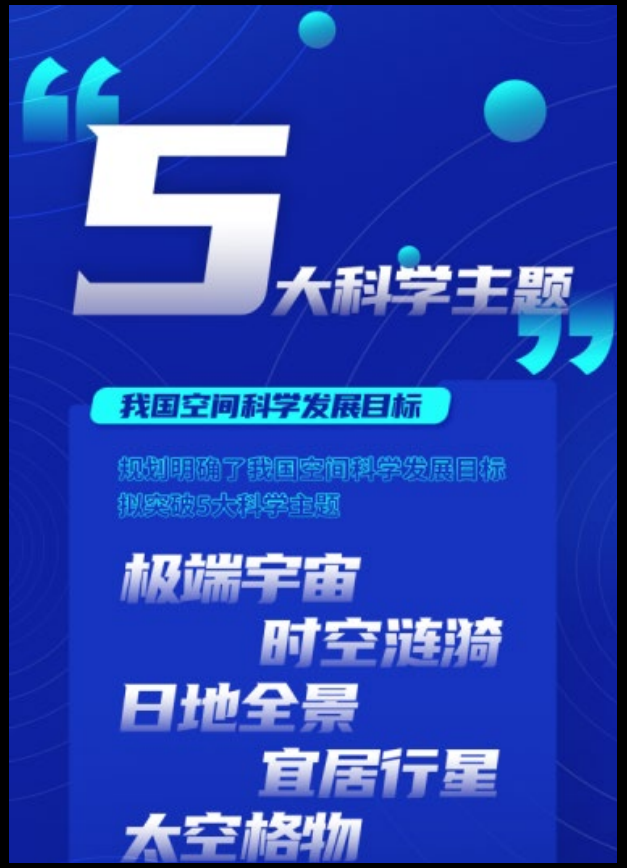
2024年10月

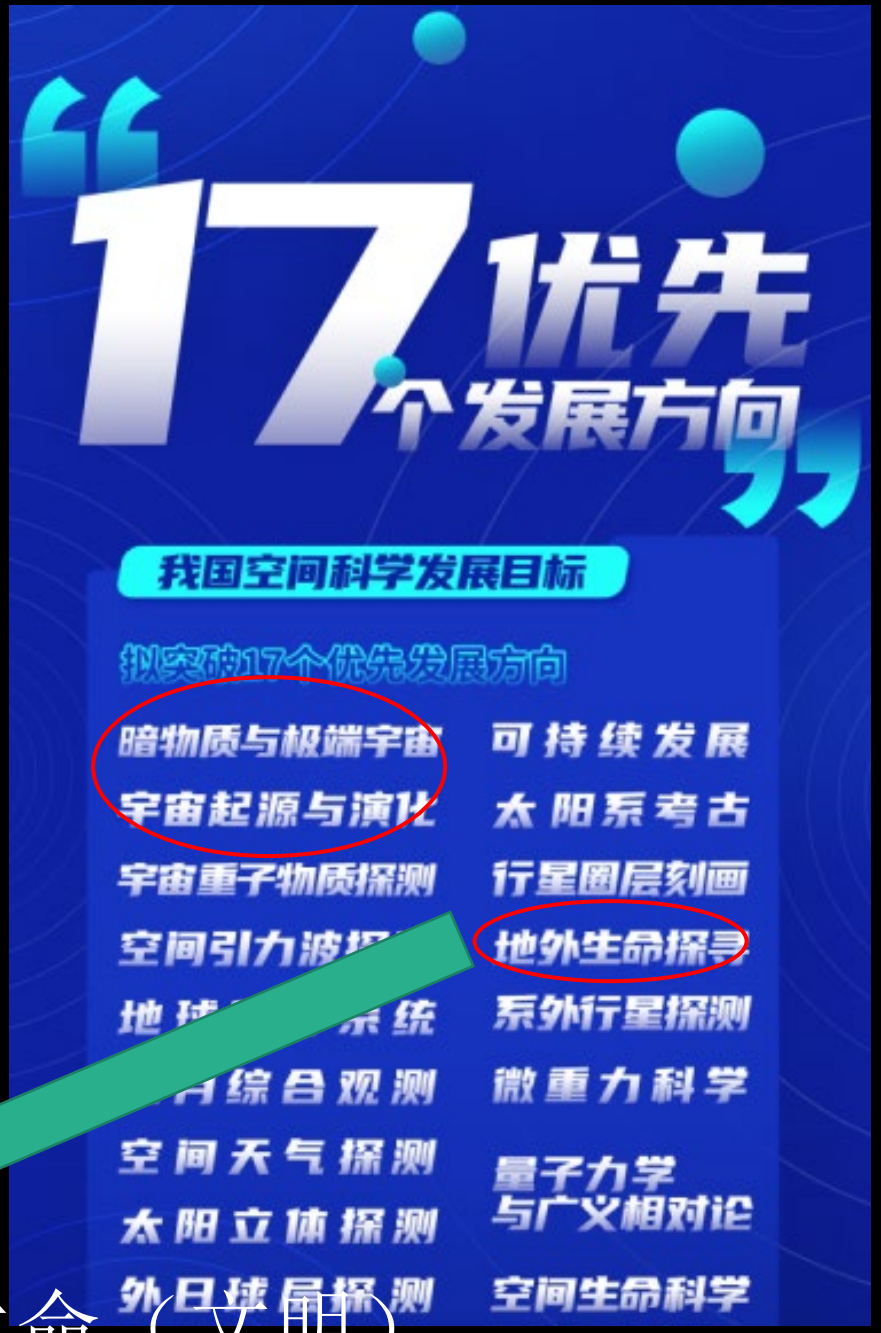
为贯彻落实党的二十大和二十届二中、三中全会精神，推动空间科学、空间技术、空间应用全面发展，制定本规划，作为当前和今后一个时期指导我国空间科学任务部署、开展空间科学研究的依据。

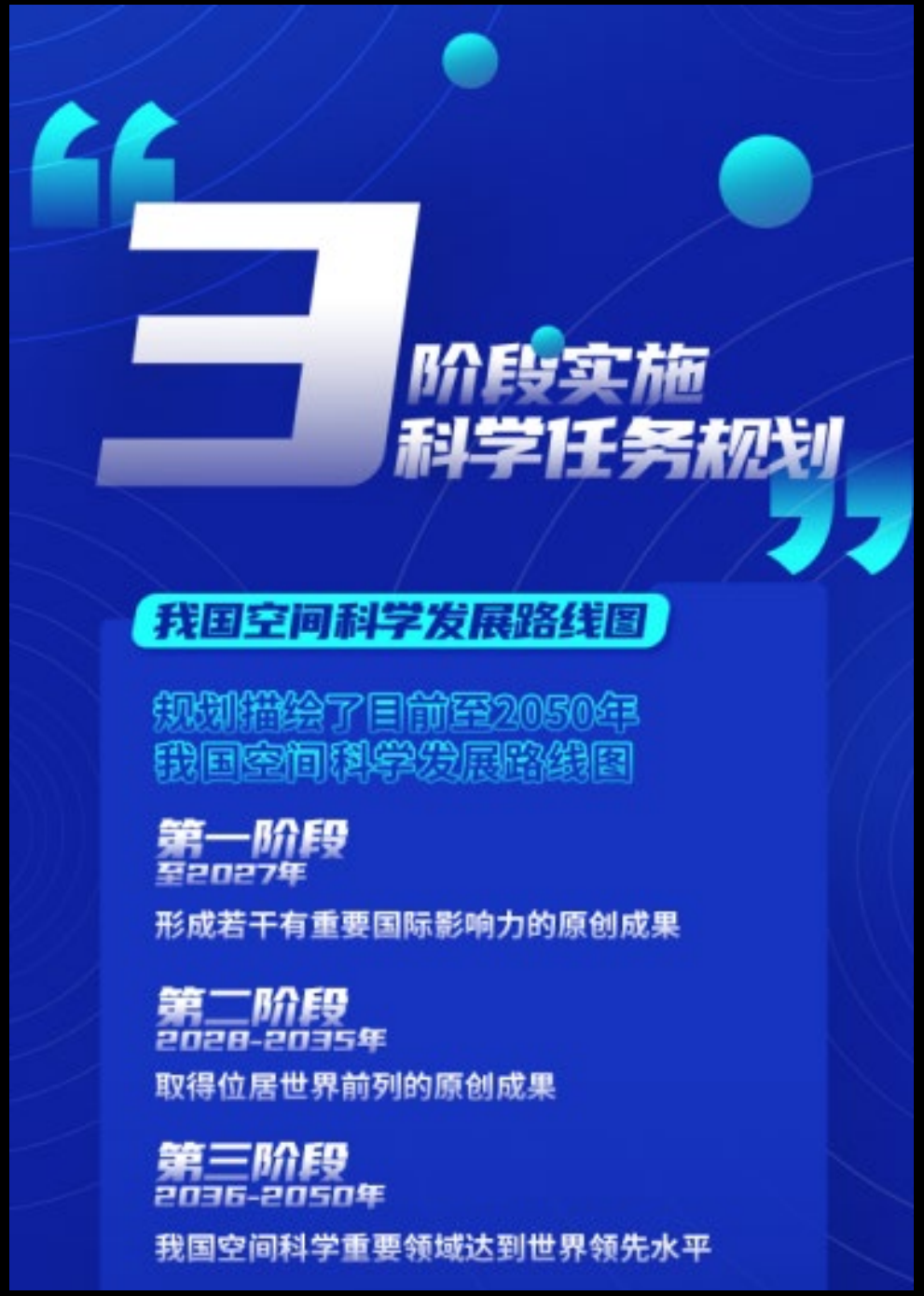
一、发展目标

（一）总目标

梯次布局和论证实施国家空间科学任务，统筹和强化任务驱动的基础研究，打造空间科学高水平人才队伍，不断取得具有重大国际影响力的标志性原创成果，实现空间科学高质量发







地外生命：
有机分子->
氨基酸->
低级生命->
高级（智慧）生命（文明）

2021年牛津大学邀请报告
“穿越百年SETI”在线报告

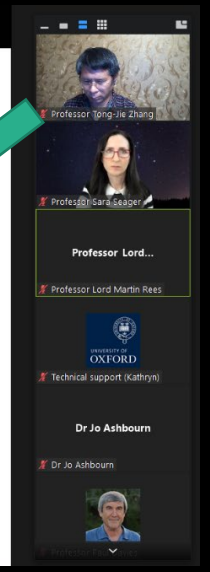
ST CROSS COLLEGE
UNIVERSITY OF OXFORD
Centre for the History & Philosophy of Physics

STX HAPP

HAPP Discussion Panel on “Searching for Extraterrestrial Intelligen… Across a Century”

5-7 pm GMT on …ay 26th November 2021

THIS E… T WILL START SHORTLY.



Friday 26 November 2021

Time: 17:00 - 19:00 (GMT)

RSVP: FREE to attend but registration required. Book your place here.

英国皇家天文学家：Martin Rees

Zoom details …the event will be sent to registered attendees af… he registration deadline has closed at 12:00 (GMT) on Th… ay 25 November 2021.

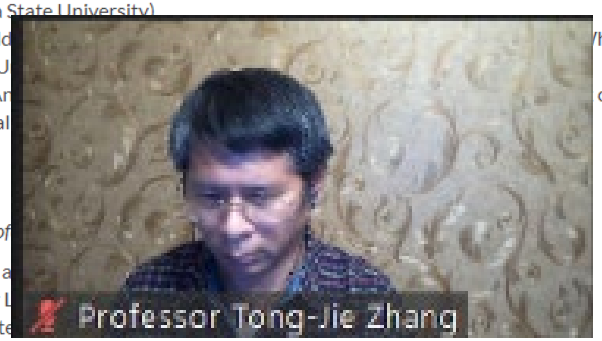
Please contact happ-centre@stx.ox.ac.uk with any queries.

The confirmed panellists are:

Professor Lord Martin Rees OM FRS (UK Astronomer Roy…
Dr Jill Tarter (Co-founder and Emeritus Director, SETI Inst…
Dr Andrew Siemion (Director of Breakthrough Listen, Uni…
Professor Tong-Jie Zhang (Beijing Normal University)

The confirmed discussants are:

Professor Paul Davies (Director of the Beyond Centre for … Science, Arizona State University)
Professor Donald… Why Complex Life is U…
Professor G.C. An… of the Astronomical…

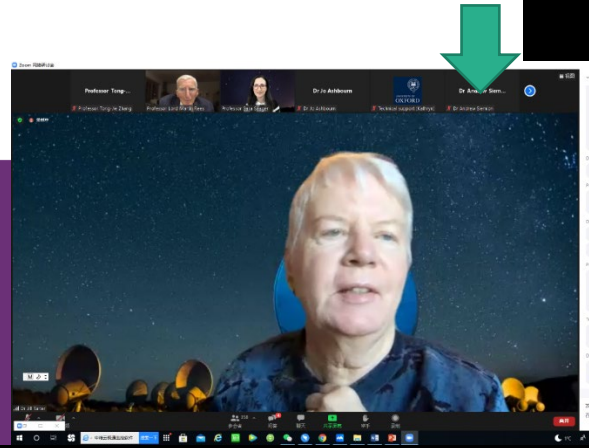


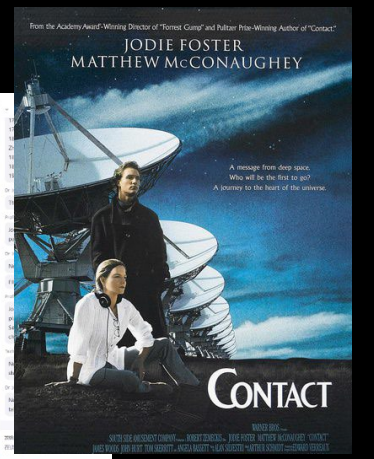
Programme:

Session Chair: Prof…

17:00 Welcome a…
17:05 Professor L…
17:25 Dr Jill Tarte…
17:45 Dr Andrew Siemion
18:05 Professor Tong-Jie Zhang
18:25 Panel Discussion
18:45 Q&A
19:00 Close

SETI 研究所所长：Jill Tarter





UNIVERSITY OF OXFORD

ST CROSS COLLEGE

SETI常设委员会会员闭门会议：5分钟邀请发言

北京師範大學

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-----原始邮件-----
发件人: "Michael Garrett" <michael.garrett@manchester.ac.uk>
发送时间: 2024-10-14 14:39:18 (星期一)
收件人: "Bill Diamond" <bdiamond@seti.org>, "Jamie Drew" <drew@breakthroughprize.org>, "Jason Wright" <astrowright@gmail.com>, PaoloMusso <musso.pl@libero.it>, "Charles.Takalani@dst.gov.za" <Charles.Takalani@dst.gov.za>, "Charles Takalani" <charles.takalana@afasociety.org>, "andrea.melis@inaf.it" <andrea.melis@inaf.it>, "tjzhang@bnu.edu.cn" <tjzhang@bnu.edu.cn>, "rjb@pastafrica.co.za" <rjb@pastafrica.co.za>
抄送: "Lori Walton" <lawalton@telus.net> [redacted]
主题: Your SHORT 5 minute presentations at IAA SETI Committee meeting

Gentlemen!

Just a reminder that your **verbal (no slides!) reports** at the upcoming IAA SETI Committee meeting should be short - **maximum 5 minutes.**

Please keep within the allotted time - 5 minutes.

The time, location, draft agenda etc are included below.

Looking forward to seeing you soon,

Mike.

SETI常设委员会主席邀请

- **发件人:** "Michael Garrett" <michael.garrett@manchester.ac.uk>
  发送时间: 2024-11-10 02:36:17（星期日）
  收件人: tjzhang <tjzhang@bnu.edu.cn>
  主题: Re: Your SHORT 5 minute presentations at IAA SETI Committee meeting

- Hi Tong-Jie, I just sent you the "chairs notes" from the IAA SC meeting – this includes a photo of the participants. As soon as we get the new IAA Committee ToR, we need to get you elected as a member of the committee. Let's keep in touch.
-
- Best regards,
-
- Mike.

- Mike Garrett
- SETI Committee chair(SETI委员会主席)
- Bernard Lovell Chair in Astrophysics, Director of Jodrell Bank Centre for Astrophysics (JBCA)(Jodrell Bank天体物理中心主任).
- School of Physics and Astronomy, Jodrell Bank Observatory, The University of Manchester, M13 9PL, UK.

International Academy of Astronautics

Dr Tong-Jie Zhang

Beijing Normal University
No.19, Xinjiekouwai St,
100875 Beijing Haidian District
China

G20/056

Friday, October 09, 2020

Re: IAA Committee on SETI (Membership term October 2019-October 2021)

Dear Dr Tong-Jie Zhang,

Upon recommendation of Prof Anatoly Perminov, Vice-President for Scientific Activities, and in accordance with the Bylaws of the Academy, it gives me great pleasure to inform you that you have been appointed as Member of the **IAA Committee on SETI**.
This membership is contingent on your active participation through attendance of Committee meetings and regular correspondence with fellow members. The SETI Committee webpage is available at: https://iaaspace.org/about/permanent-committees/#SA-PERMCseti
Your name will be listed on the Committee membership list when we receive your acceptance form by email to office@iaamail.org (or an email message with your membership confirmation).
However, if you do not have the ability to honour this membership, please let us know by return of mail / email.

Sincerely yours,

Jean Michel Contant
Secretary General

Copy P. Jankowitsch
Encl.

2025 Penn State SETI Symposium
SETI研讨会-SETI方向博士生李健康参加会议

- Plenary talk
- 大会报告

PennState

Department of Astronomy & Astrophysics

Wednesday, June 18, 2025

Dr. Jason T Wright

OFFICE
Dept. of Astronomy and Astrophysics
Penn State
525 Davey Laboratory

Dear Mr. Jian-Kang Li

As Chair of the SOC, it is my pleasure to invite you to participate in the 2025 PENN STATE SETI SYMPOSIUM, which will be held from August 18-21, 2025, in Pennsylvania, USA.

You have been accepted to present your work titled "Process and future of Multifaceted SETI at FAST" as a poster. The poster will be presented throughout all 4 days of the conference.

In addition, the SOC is considering whether your work should be presented as a plenary talk. We do not know on which day this would be but regardless it is appropriate for you to be present for the entire symposium.

Call for Abstracts – 2025 Penn State SETI Symposium (Aug 18–21)

2025-04-14 20:00

Jason Wright 发送给 community@iaaseti.org

Call for Abstracts – 2025 Penn State SETI Symposium (Aug 18–21)

Dear SETI colleagues and friends,

We're thrilled to invite you to the 2025 Penn State SETI Symposium, hosted by the Penn State Extraterrestrial Intelligence (PSETI) Center, taking place August 18–21, 2025 at the Penn Stater Hotel and Conference Center i

国际天文联合会专题研讨会第 404 次研讨会(2026年): 推进技术特征信号的搜寻 (IAUS 404: Advancing the Search for Technosignatures) 邀请报告- SETI方向博士生栾晓航

北京師範大學

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[SPAM] Speaking Invitation for an IAU Symposium on Technosignatures

Dear Dr. Xiao-Hang Luan,

I am writing to ask if you would be willing and interested in being one of our invited speakers for IAUS 404: Advancing the Search for Technosignatures, which will take place entirely online from 2-6 March 2026.

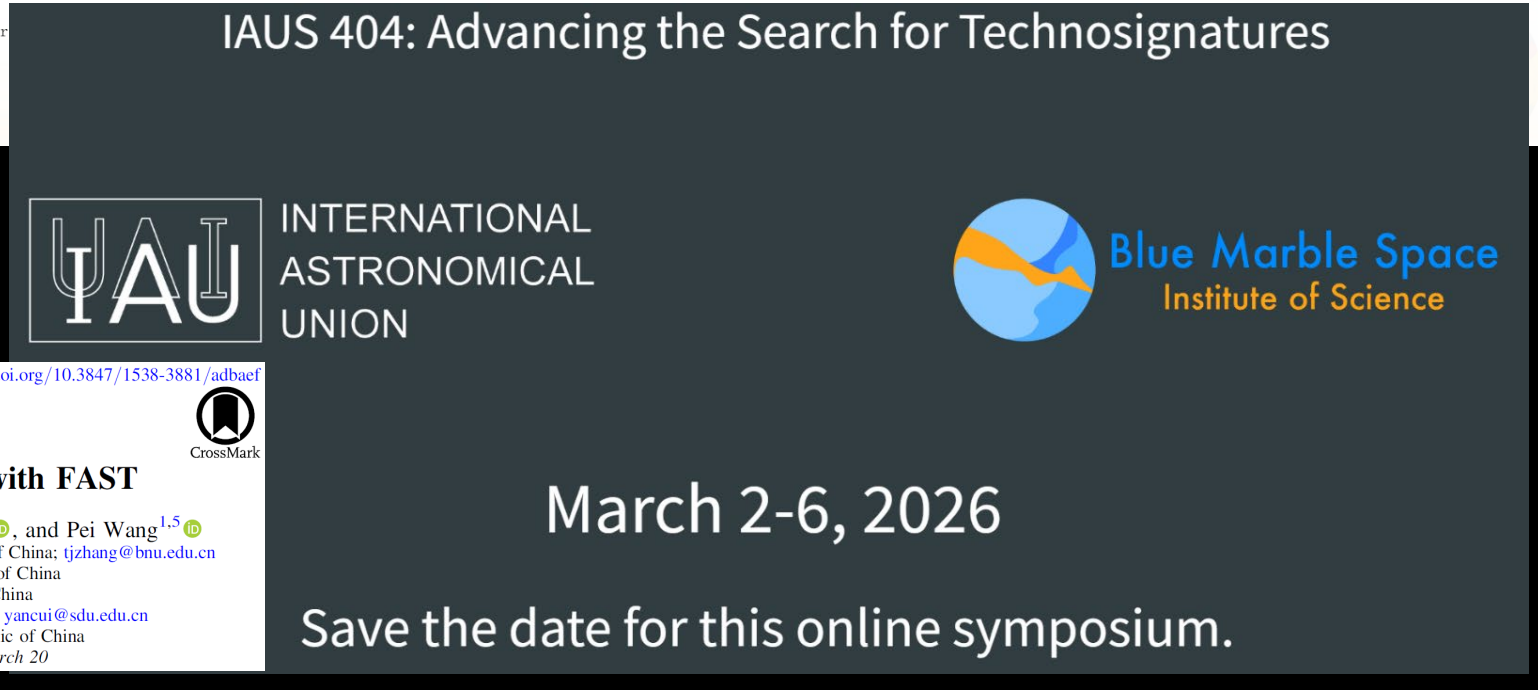
The goal of this symposium is to foster discussion on ways to advance the search for technosignatures by leveraging existing missions and data archives. We would specifically be interested in your work on radio SETI with FAST. However, you are welcome to discuss any aspect of technosignature science that you like, including your ongoing work and any ideas you have for advancing the search.

As an invited speaker, your registration fee for the symposium would be covered, which includes a copy of the symposium proceedings published by Cambridge. We will hold the synchronous meetings for the symposium each day over Zoom from 14:00 – 18:00 UTC each day. Invited talks will be 30 minutes.

We hope that you will consider joining us as an invited speaker. Please let me know either

Sincerely,

Jacob Haqq-Misra
SOC Chair, IAUS 404



The Astronomical Journal, 169:217 (10pp), 2025 April https://doi.org/10.3847/1538-3881/adbaef

Multibeam SETI Observations Toward Nearby M Dwarfs with FAST

Xiao-Hang Luan[1,2], Bo-Lun Huang[1,2], Zhen-Zhao Tao[3], Yan Cui[4], Tong-Jie Zhang[1,2,3], and Pei Wang[1,5]
[1] Institute for Frontiers in Astronomy and Astrophysics, Beijing Normal University, Beijing 102206, People's Republic of China; tjzhang@bnu.edu.cn
[2] School of Physics and Astronomy, Beijing Normal University, Beijing 100875, People's Republic of China
[3] Institute for Astronomical Science, Dezhou University, Dezhou 253023, People's Republic of China
[4] School of Law, Gansu University of Political Science and Law, Lanzhou 730070, People's Republic of China; yancui@sdu.edu.cn
[5] National Astronomical Observatories, Chinese Academy of Sciences, Beijing 100101, People's Republic of China
Received 2024 July 31; revised 2025 January 27; accepted 2025 February 25; published 2025 March 20

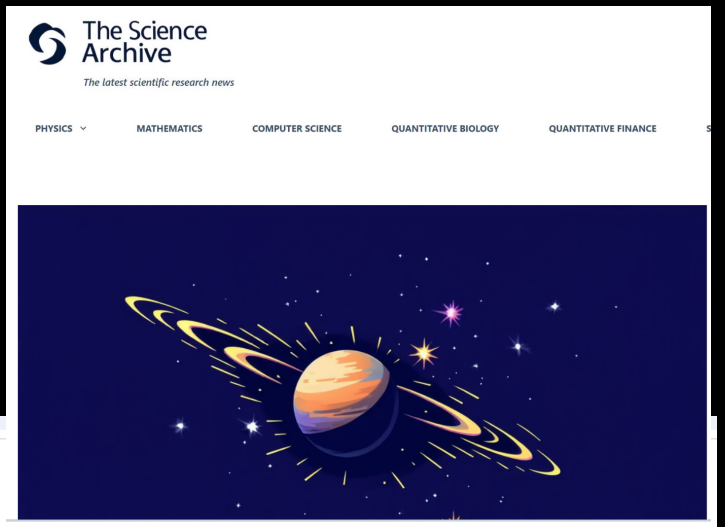
John Peacock：英国皇家学会会员

邵逸夫奖获得者

> 发件人: "John Peacock" <jap@roe.a
> 发送时间:2024-05-08 15:41:43 (星
> 收件人: tjzhang <tjzhang@bnu.edu.
> 主题: Contact
>
> Dear Tong-Jie,
>
> Thanks for your email, and sorry for
the year.
> It's good to hear from you, as it remi
that you were so kind in organising. I h
my mind as a unique and special event.
>
> Life has been busy and ***. Looking at ADS, you seem to have been very active since I saw you, and I noted you've recently started working on SETI - what a revolution that would be if there were a detection.
(看看ADS，自从我见到你以来，你似乎一直很活跃。我注意到你最近开始研究SETI—如果有探测，那将是一场多么大的革命).
>
> Best wishes,
>
> John

国外报道

- https://thesciencearchive.org/2502-20419v1/



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Listening for Life: Scientists Scan Nearby Stars for Signs of Intelligent Activity

Monday 31 March 2025

Save Article ☆

In a quest to search for signs of extraterrestrial life, scientists have been scouring the skies for faint signals that could indicate intelligent activity elsewhere in the universe. A recent study has taken this approach to new heights by targeting nearby M-dwarf stars, which are thought to be more likely to host planets capable of supporting life.

The researchers used China's Five-hundred-meter Aperture Spherical radio Telescope (FAST), one of the world's most powerful radio telescopes, to scan three nearby M-dwarf stars for narrowband drifting signals. These signals are thought to be indicative of intelligent activity, as they would require a civilization to intentionally emit them.

The team analyzed data from FAST's 19-beam receiver, which was tuned to frequencies between 1.05 and 1.45 GHz. They searched for signals with drift rates within ±4 Hz/s and signal-to-noise ratios above 10 in two orthogonal linear polarizati directions.

While the majority of detected events were likely radio frequency interference (RFI), one particular event caught their atte Dubbed NBS 230624, it exhibited a periodic pattern that was initially intriguing but ultimately ruled out as an extraterrest origin due to its characteristics.

The researchers noted that the signal's frequency and polarization did not match those expected from known astrophysic

findings demonstrate the value of targeting nearby stars in the search for extraterrestrial intelligence (SETI).

The use of M-dwarf stars as targets is particularly intriguing, as they are thought to be more likely to host planets with conditions suitable for life. These small, cool stars are also abundant in the universe, making them a prime target for SETI searches.

As scientists continue to explore the vast expanse of space, the search for extraterrestrial intelligence remains an alluring and challenging pursuit. While this study's results may not have yielded definitive proof of alien life, it has taken us one step closer to understanding the possibilities and pitfalls of detecting signs of intelligent activity elsewhere in the universe.

The Astronomical Journal, 169:217 (10pp), 2025 April https://doi.org/10.3847/1538-3881/adbaef

Multibeam SETI Observations Toward Nearby M Dwarfs with FAST

Xiao-Hang Luan[1,2], Bo-Lun Huang[1,2], Zhen-Zhao Tao[3], Yan Cui[4], Tong-Jie Zhang[1,2,3], and Pei Wang[1,5]
[1] Institute for Frontiers in Astronomy and Astrophysics, Beijing Normal University, Beijing 102206, People's Republic of China; tjzhang@bnu.edu.cn
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[5] National Astronomical Observatories, Chinese Academy of Sciences, Beijing 100101, People's Republic of China
Received 2024 July 31; revised 2025 January 27; accepted 2025 February 25; published 2025 March 20

2023年SETI会议

Republic of San Marino

International Symposium on

Big History & SETI 2023

Past, Present and Future of Humankind

Sala Polivalente Murata, Republic of San Marino (Italy),

Via del Serrone, 67A, 47890 San Marino. Republic of San Marino (RSM)

July 10th - 11th, 2023, in English

July 12th, 2023, in Italian

Figure 1 Most Serene Republic of San Marino

Big History seeks to understand the integrated history of the Cosmos, Earth, Life, and Humanity, using the best available empirical evidence and scholarly methods. The International Big History Association (IBHA) seeks to promote the unified and interdisciplinary study and teaching of the history of Cosmos, Earth, Life, and Humanity.

SETI, the Search for Extra-Terrestrial Intelligence, is the scientific search for radio signals or other signs of life reaching the Earth from other Civilizations supposed to exist in the Milky Way or elsewhere. SETI started in 1960 with Project Ozma conducted by Frank D. Drake at the USA National Radio Astronomy Observatory (NRAO) and continued with interruptions up to now in the USA and in an increasing number of technologically advanced countries like Russia, the UK, France, Italy, Argentina, South Africa, Australia and, most recently, China.

中国科学报报道

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新浪微博 http://weibo.com/kexuebao　科学网 www.sciencenet.cn

搜寻地外智慧生命的中国人

本报记者 倪思洁

最近，参加完国际宇航大会的张同杰，从意大利米兰回到北京不久就收到了一封邮件，发件人是国际宇航联合会地外文明搜寻（SETI）委员会主席迈克尔·加勒特。信里，加勒特邀请张同杰担任新一届 SETI 委员会委员。

张同杰是北京师范大学物理与天文学院教授，研究方向是宇宙学和射电 SETI 研究。SETI 委员会是国际宇航联合会的下属分会，以美国、英国、意大利、法国等国的科学家为主要参与者，目标是搜寻地外智慧生命。

对于被邀请加入委员会，张同杰倒真兴但并不觉得意外。“中国的研究工作，已经得到了国际 SETI 同行的重视。其实，2020 年我就曾被 SETI 同行、美国伯克利 SETI 研究中心首席技术专家丹·沃库斯推荐加入过 SETI 委员会。”他说。

从误解中争取认可

在地外智慧生命搜寻研究上，张同杰遇到过不少困难和误解。

尽管国际 SETI 研究已经开展了 60 多年，并且都是一些知名天体物理学家在开展研究，但张同杰只要对国内的一些专业人士提起自己在做 SETI 研究，很多听者的第一反应是瞪大眼睛，再意味深长地笑笑。因为对于很多人来说，那就像找不明飞行物（UFO）一样纯属幻想。

“国际上，尤其是美国，早已经过了这个尴尬阶段，而我国起步晚，对 SETI 的认知还处于初级阶段。”张同杰说。

过去很多年里，张同杰申请不到与 SETI 研究相关的经费支持。虽然他多次主持宇宙学相关的国家级科研项目，但是关于 SETI 研究的申请书仍然常在预审请阶段就无法通过审核。无奈之下，张同杰只能等他的宇宙学相关项目结题后，用结余的少量经费开展 SETI 研究。

张同杰还遭遇过同行的误解。2017 年，以研究宇宙学为主业的张同杰加入了撰写《中国平方公里阵列天文台（SKA）白皮书》的专家组。当时，他建议用 SKA 开展 SETI 研究，很快就有人公开反对，觉得这项研究“不切实际”。张同杰耐心地向对方解释之后，终于获得了理解和支持。

张同杰认为正是因为“地外文明搜寻”这样的说法具有科幻色彩，所以应该克严谨地将“SETI”翻译为“地外智慧生命搜寻”。在一些科普活动、媒体采访中，他不断告诉大家，SETI 不是“科幻”，而是“严肃的科学研究”，“一些天体物理学家、计算机专家和射电通信专家等都是在用科学的方法做观测、理论分析、数据处理”。

受访者供图

幸运的是，置身诸多误解之中的张同杰从一群志同道合的海内外朋友中获得了前进的动力。“这是一个很小众的领域，论文成果没那么多，谁有进展了，大家几乎都能第一时间知道，并相互祝贺。”张同杰说。

从祝贺声中，张同杰感到，这些年，中国的 SETI 研究成果慢慢受到国际关注。每年，美国奥夕法尼亚州立大学天文学与天体物理学教授杰森·赖特都会收集和总结全球科学家发表的 SETI 科学论文。张同杰团队的几乎所有 SETI 论文都会被收录进去。

张同杰认为，我国 SETI 研究逐渐受重视，大约始于 2011 年天文学家南仁东等人发表在《国际现代物理学杂志 D》上的一篇文章。文中，南仁东全面介绍了“中国天眼”的工程设计、科学目标等，并提到“‘500 米口径球面射电望远镜’可能会给我们带来一个很好的机会”。之后，“参与 SETI”成为“中国天眼”的五大科学目标之一。

2016 年 10 月，中国科学院国家天文台与俄罗斯企业家尤里·米尔纳创立的“突破计划”签署合作意向，“中国天眼”计划加入国际地外智慧生命寻找计划——“突破聆听”项目，与位于美国的绿岸望远镜及位于澳大利亚的帕克斯天文台合作，寻找地外智慧生命的线索。

2019 年 7 月，张同杰与中国科学院国家天文台“中国天眼”团队以及沃西默合作，利用“中国天眼”首次开展了 SETI 研究，并于 2020 年 4 月在《天体物理学杂志》发表了“中国天眼”的首篇 SETI 论文。

截至目前，他们已经在《天体物理学杂志》和《天文学杂志》上发表了 7 篇基于“中国天眼”的 SETI 研究文章，获得了国际同行的关注和认可。

从证伪中寻找希望

尽管得到了同行认可，张同杰有时还是很无奈。

2020 年，当基于“中国天眼”的首篇 SETI 论文发表时，消息上了“热搜”，人们惊呼“‘中国天眼’要开始找外星人了”；2022 年，他们用“中国天眼”发现了疑似地外智慧生命信号时，消息又上了“热搜”，人们惊呼“‘中国天眼’发现外星人了”。

他需要不停地跟大家解释，“不能这么绝对”“还有很长的路要走”……

很多人不知道，这个研究圈子里有一种与大多数科研领域不同的科研文化。

他们最常用的是“排除法”——排除射电干扰。当其他研究领域的科学家为证实某项结果欢呼时，他们的大部分成果是在证伪，很多论文都在“排除某信号是由地外智慧生命传输的可能”。即便他们发现了无法被排除的新信号，也会在信号前面加上“疑似”“候选”等字样。

在这个研究领域，99% 的结果令人“失望”，但获得研究结果的过程对于国际同行来说很重要。地外生命搜寻乃至地外智慧生命搜寻研究领域都曾闹过“乌龙”。例如，2020 年，科学家将两台望远镜观测到的数据进行处理后，发现金星云层中存在含量相对较高的磷化氢，而磷化氢的存在很可能与生命活动有关，论文发表于《自然－天文学》。但没过多久，人们发现，研究团队在数据处理上可能存在问题。

“我们最重要的工作就是提升探测能力和数据处理能力，识别干扰信号并排除，包括来自地球的人类活动干扰和天体信号干扰等。”张同杰说。

（下转第 2 版）

四. 未来的研究计划和公众科学设想

北师大SETI研究团队：未来的研究计划

- FAST目标观测+后端盲寻
- SETI理论和预研究
- 与国际上先进的SETI研究组合作（加州大学伯克利分校: Breakthrough Lisen (突破聆听计划)，SETI@HOME项目组）
- 未来SKA观测
- SETI宇宙（空间）法和伦理（SETI Space Law and Ethics）：与大学空间法专家合作!
- AI+SETI（未来重要研究方向）
-

中国未来可能的SETI计划

时间跨度：10年(2026-2036年) 预算：亿级(与突破聆听相当)

- 建造新技术时变天体(科学目标：SETI和FRB等)望远镜(100米球面+PAF，台址可以在广东和湖南)
- 建造SETI专用阵列-遍布全国，西部沙漠!

计划在下面已经有或者在建的望远镜上开展SETI

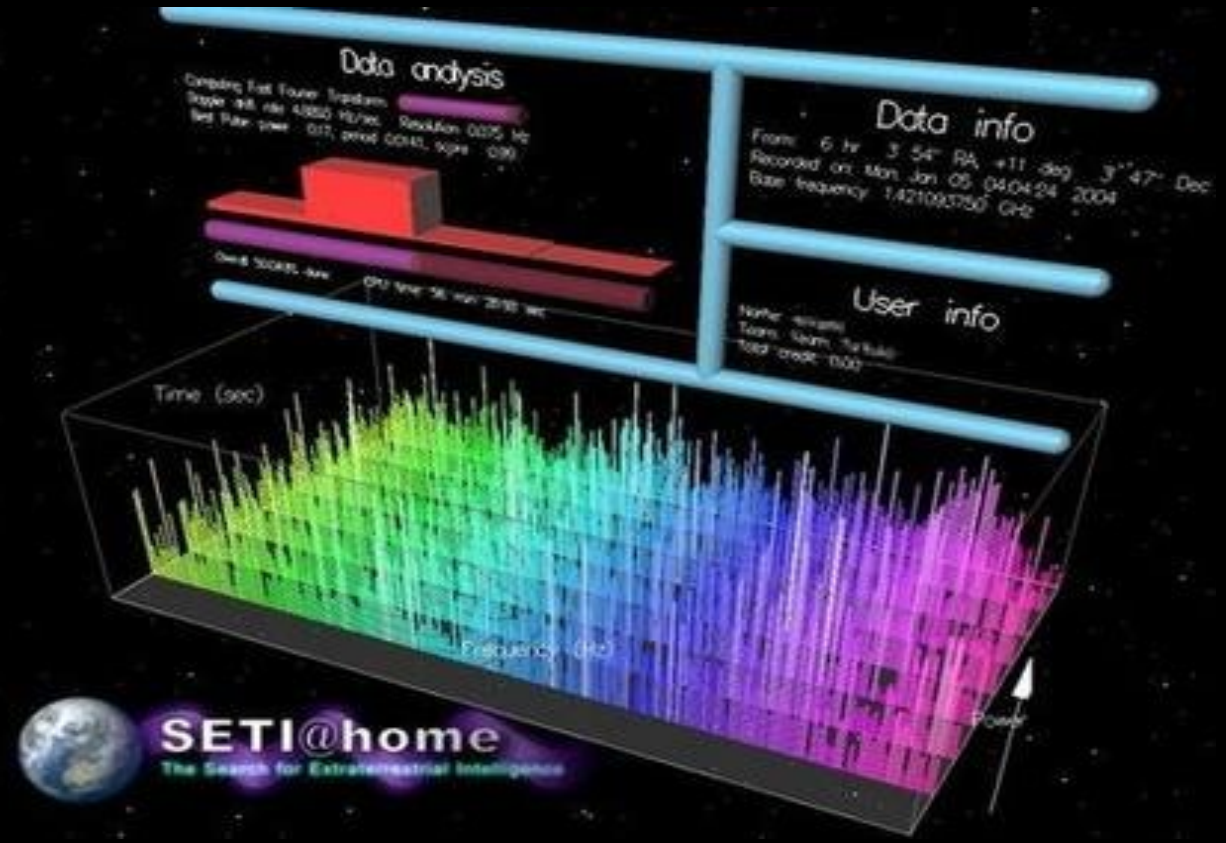
- FAST(阵列) + FASTA
- 新疆110米射电望远镜；云南和东北100米级射电望远镜
- 空间站和司天望远镜(光学SETI).

公众科学：SETI @ 虚拟天文台

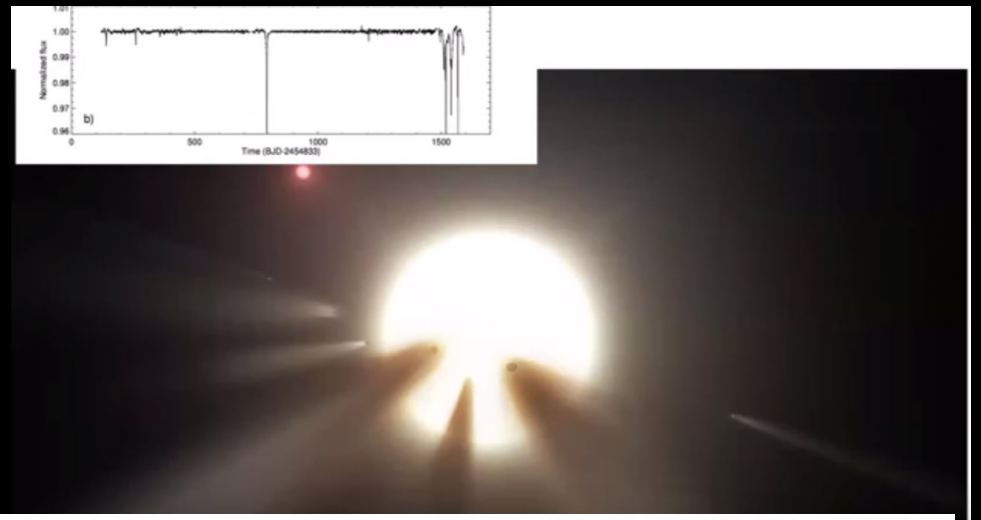
- SETI@home at 虚拟天文台
- AI + SETI at 虚拟天文台：探讨AI应用
- SETI 数据处理：RFI去除比赛 at 虚拟天文台
- SETI 科普讲座 at 虚拟天文台
- 公众科学+科幻

公众参与--数据处理：

- 在虚拟天文台搭建网站，类似于**电脑屏保-SETI@home**



公众参与-戴森球-搜索



THE Ĝ SEARCH FOR EXTRATERRESTRIAL CIVILIZATIONS WITH LARGE ENERGY SUPPLIES.
IV. THE SIGNATURES AND INFORMATION CONTENT OF TRANSITING MEGASTRUCTURES

JASON T. WRIGHT[1], KIMBERLY M. S. CARTIER, MING ZHAO[1], DANIEL JONTOF-HUTTER, ERIC B. FORD[1]
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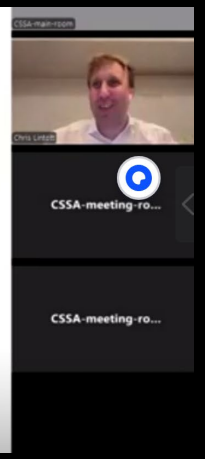
Accepted to ApJ

ABSTRACT

Arnold, Forgan, and Korpela et al. noted that planet-sized artificial structures could be discovered with *Kepler* as they transit their host star. We present a general discussion of transiting megastructures, and enumerate ten potential ways their anomalous silhouettes, orbits, and transmission properties would distinguish them from exoplanets. We also enumerate the *natural* sources of such signatures.

Several anomalous objects, such as KIC 12557548 and CoRoT-29, have variability in depth consistent with Arnold's prediction and/or an asymmetric shape consistent with Forgan's model. Since well motivated physical models have so far provided natural explanations for these signals, the ETI hypothesis is not warranted for these objects, but they still serve as useful examples of how non-standard transit signatures might be identified and interpreted in a SETI context. Boyajian et al. 2015 recently announced KIC 8462852, an object with a bizarre light curve consistent with a "swarm" of megastructures. We suggest this is an outstanding SETI target.



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戴森去世，他提出的“戴森球”究竟存在吗？

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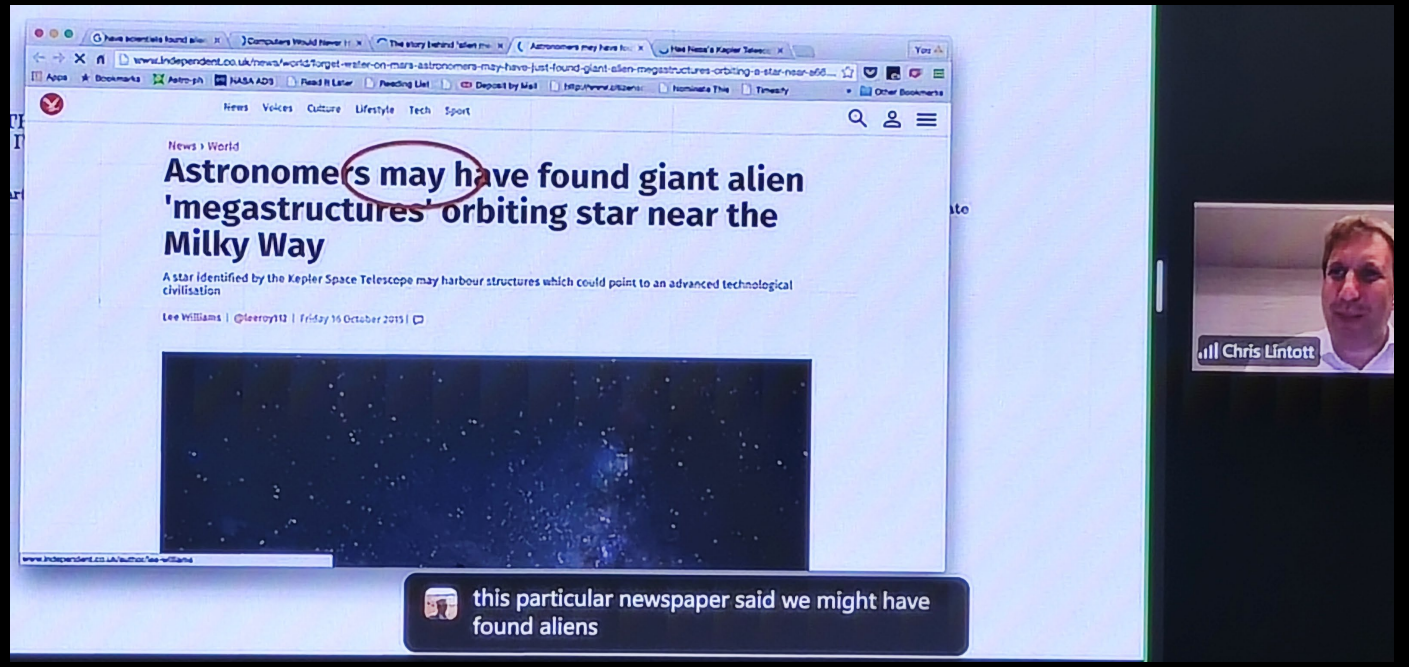
Freeman J. Dyson (1923–2020),
Scientist and Writer, Who Dreamt



Nature, vol. 184, no. 4690, pp. 844-846, 1959.

结束语

SEARCHING FOR INTERSTELLAR COMMUNICATIONS

By GIUSEPPE COCCONI* and PHILIP MORRISON†
Cornell University, Ithaca, New York

NO theories yet exist which enable a reliable estimate of the probabilities of (1) planet formation ; (2) origin of life ; (3) evolution of societies possessing advanced scientific capabilities. In the absence of such theories, our environment suggests that stars of the main sequence with a lifetime of many billions of years can possess planets, that of a small set of such planets two (Earth and very probably Mars) support life, that life on one such planet includes a society recently capable of considerable scientific investigation. The lifetime of such societies is not known ; but it seems unwarranted to deny that among such societies some might maintain themselves for times very long compared to the time of human history, perhaps for times comparable with geological time. It follows, then, that near some star rather like the Sun there are civilizations with scientific interests and with technical possibilities much greater than those now available to us.

* Now on leave at CERN, Geneva.
† Now on leave at the Imperial College of Science and Technology, London, S.W.7.

To the beings of such a society, our Sun must appear as a likely site for the evolution of a new society. It is highly probable that for a long time they will have been expecting the development of science near the Sun. We shall assume that long ago they established a channel of communication that would one day become known to us, and that they look forward patiently to the answering signals from the Sun which would make known to them that a new society has entered the community of intelligence. What sort of a channel would it be ?

The Optimum Channel

Interstellar communication across the galactic plasma without dispersion in direction and flight-time is practical, so far as we know, only with electromagnetic waves.

Since the object of those who operate the source is to find a newly evolved society, we may presume that the channel used will be one that places a minimum burden of frequency and angular discrimi-

settings should cover the frequency range F using an integration time of minutes or hours.

Nature of the Signal and Possible Sources

No guesswork here is as good as finding the signal. We expect that the signal will be pulse-modulated with a speed not very fast or very slow compared to a second, on grounds of band-width and of rotations. A message is likely to continue for a time measured in years, since no answer can return in any event for some ten years. It will then repeat, from the beginning. Possibly it will contain different types of signals alternating throughout the years. For indisputable identification as an artificial signal, one signal might contain, for example, a sequence of small prime numbers of pulses, or simple arithmetical sums.

The first effort should be devoted to examining the closest likely stars. Among the stars within 15 light years, seven have luminosity and lifetime similar to those of our Sun. Four of these lie in the directions of low background. They are τ Ceti, 0_2 Eridani, ε Eridani, and ε Indi. All these happen to have southern declinations. Three others, α Centauri, 70 Ophiucus and 61 Cygni, lie near the galactic plane and therefore stand against higher backgrounds. There are about a hundred stars of the appropriate luminosity among the stars of known spectral type within some fifty light years. All main-sequence dwarfs between perhaps $G0$ and $K2$ with visual magnitudes less than about $+6$ are candidates.

The reader may seek to consign these speculations wholly to the domain of science-fiction. We submit, rather, that the foregoing line of argument demonstrates that the presence of interstellar signals is entirely consistent with all we now know, and that if signals are present the means of detecting them is now at hand. Few will deny the profound importance, practical and philosophical, which the detection of interstellar communications would have. We therefore feel that a discriminating search for signals deserves a considerable effort. The probability of success is difficult to estimate ; but if we never search, the chance of success is zero.

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美国康奈尔大学天文学家
G.Cocconi and P.Morrison 在Nature文章结尾说：
成功的可能性很难估计，但如果我们从不去寻找，成功的可能性是零”。

谢谢!

- 期待着我们共同参与SETI研究!
- 呼吁民间资助（百度，搜狐，腾讯，阿里巴巴等），效仿国际突破聆听计划(Breakthrough Lisen)。