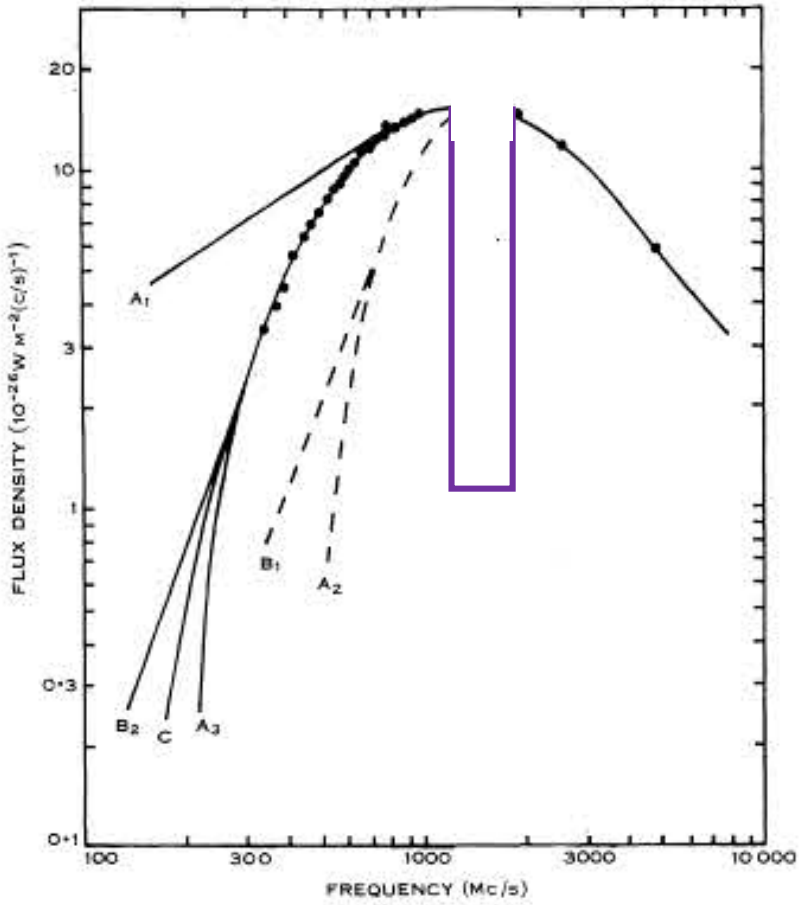
Nicolai Kardashev and The Search for Extraterrestrial Civilizations: A Scientific, Technical, Political, Social, and Cultural Adventure

Ken Kellermann

NRAO

Kardashev Papers

- Radio Recombination Lines
- Cooling of Synchrotron Radiation
- Search for Extraterrestrial Civilizations



1934-63

SPACE MYSTERY FOR AUST.

LOW NOTE'S HIGH SALE

OCEAN RACE

Favourable conditions are forecast for the "Herald" marathon surfboat race today.

Scene of the State's top crews will race over a tough 22-mile course from Palm Beach to Manly.

The race will start from the Palm Beach surfing area at 11 a.m. and is expected to finish at Manly Ocean Beach about 2.30 p.m.

The draw and identification numbers in the carried will be broadcast by Station 2GB just before the start.

Crowds waiting at Manly will be entertained by local surf riders in open competition.

NATO TALKS

PARIS, Sat. (A.A.P.-Reuter).—Defence Ministers of the North Atlantic Treaty Organisation will meet in Paris from May 31 to June 2, a French Defence Ministry spokesman said today.

Scientists pick up signals

DR. KELLERMANN . . . to Moscow to compare notes.

DR. TOVMASSIAN . . . sun's energy harnessed.

By BOB JOHNSON

Australian scientists have had mysterious radio signals from an unidentified body, billions of miles away in southern skies, under observation since 1962.

This was revealed in Sydney this week following claims by Russian scientists.

The Russians claimed that radio signals picked up from a stellar body code-named CTA102 could be evidence of a super - civilisation in

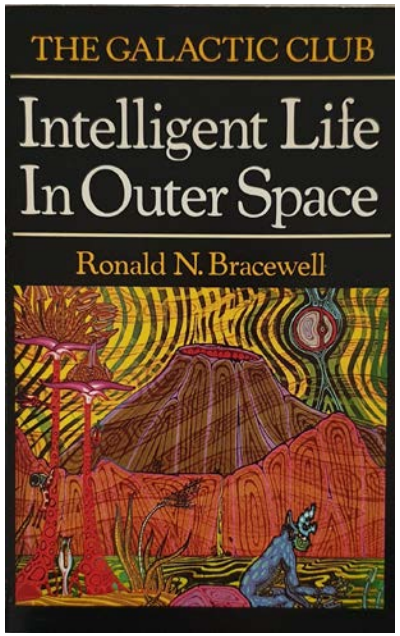
Low notes are making high sales at the Royal Easter Show.

No other area of human inquiry where we know so little about

- How to look for ETs?
- Where to look?
- What we are looking for?
- Is there anything there to look for?

What is the right technique/frequency?

- Neutral hydrogen: 21 cm (C&M)
  - ET would recognize this as intergalactic calling frequency
  - Low galactic noise
  - One frequency band on Earth not used for telecommunications
  - ETs would probably reserve 21 cm for radio astronomy
- Water hole (Barney Oliver)
  - OH masers discovered - 18 cm
  - H (21 cm) + OH (18 cm) = H_2O!
- Infrared/lasers (Charlie Townes)
- Optical SETI (Paul Horowitz)
- Dyson Spheres – engineering artifacts
- USSR (Troitsky) Broad band pulses
- Gamma rays
- Neutrinos
- Extreme astrophysics
- Gravity Waves?
- Solar System Artifacts (Ron Bracewell) The Galactic Club




FALSE
ALARM

The WOW Signal

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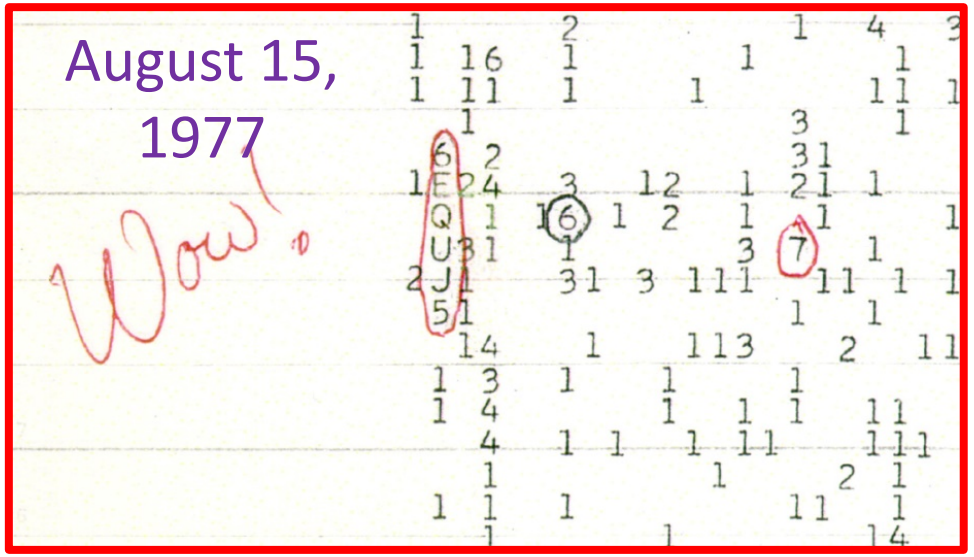
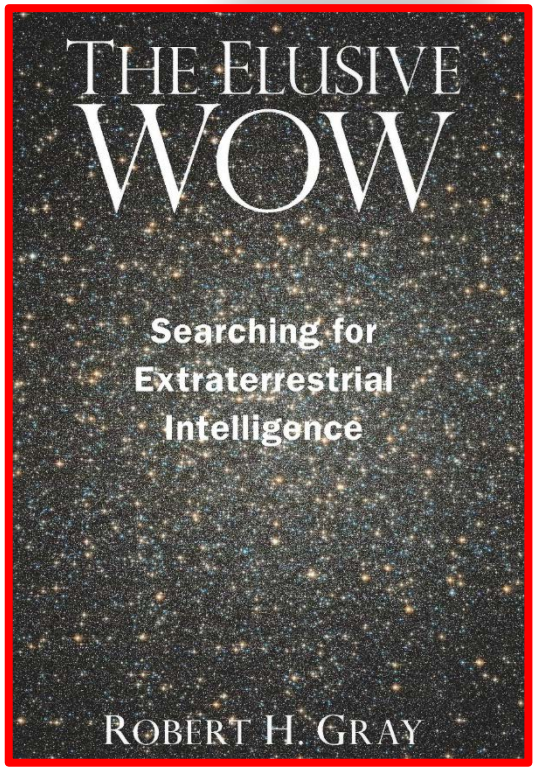
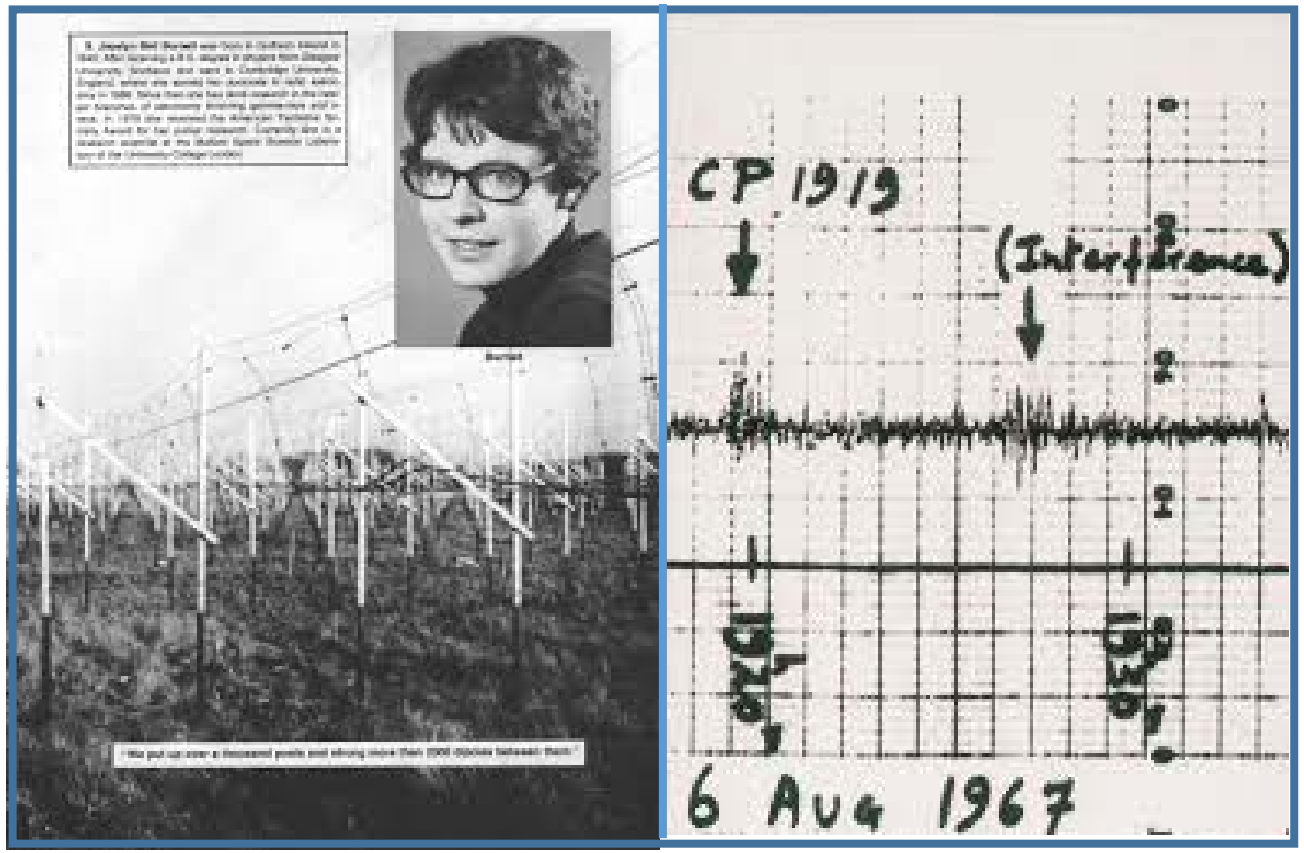


frequency

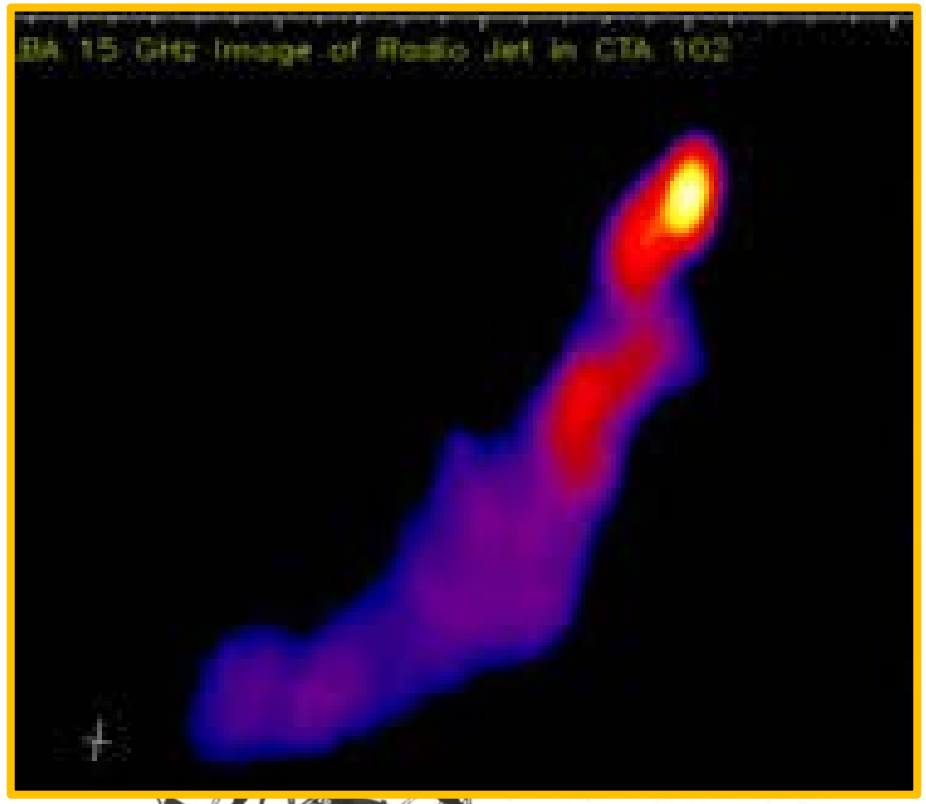


Pulsars aka LGM



Cambridge, UK

CTA 102



Новое в радиоастрономии

ИНТЕРВЬЮ «ПРАВДЫ»

Недавно молодой радиоастроном Московского университета Г. Б. Шоломицкий совместно со своими товарищами по работе обнаружил переменность потока радиоизлучения от космического источника, известного под обозначением СТА-102.

В беседе с корреспондентом «Правды» заведующий отделом радиоастрономии Государственного астрономического института имени Штернберга при Московском университете профессор Н. С. Шиловский сообщил:

— Эти наблюдения проводились группой радиоастрономов нашего института под руководством Г. Б. Шоломицкого начиная с августа 1964 года. Успеху наблюдений способствовала специально разработанная приемная аппаратура с квантовым парамагнитным усилителем и антенна с большой эффективной площадью.

Источники космического радиоизлучения СТА-102 и СТА-21 были открыты пять лет назад американскими радиоастрономами. Эти источники обладают рядом необычных свойств, резко отличающихся от других источников (необычный радиоспектр, ничтожно малые угловые размеры).

Интерес к этим объектам стимулировался также опубликованной в прошлом году в советской научной печати очень смелой гипотезой московского радиоастронома Н. С. Кардашева, который на основе анализа экспериментальных и теоретических данных предположил, что излучения от СТА-102 и СТА-21 могут иметь искусственное происхождение. Согласно гипотезе Кардашева эти источники могут быть радиосигналами весьма удаленных от нас космических цивилизаций.

Наблюдения московских радиоастрономов привели к крупному научному открытию. Было обнаружено, что поток излучения от источника СТА-102 регулярно меняется со временем по периодическому закону, причем период изменений потока близок к 100 дням (см. рисунок).

Что можно сказать по поводу этих в высшей степени интересных наблюдений? Этот источник радиоизлучения может быть либо представителем совершенно нового класса объектов, либо отражать совершенно новые свойства уже известных космических источников радиоизлучения (например, остатков взрывов так называемых «сверхновых» звезд). Конечно, нельзя исключить и волнующую гипотезу о том, что наблюдается искусственный сигнал от внеземной цивилизации. Необходимы, однако, новые специальные наблюдения, чтобы гипотеза стала научным фактом.

Прежде всего надо подтвердить наличие переменности потока СТА-102 независимыми наблюдениями на других частотах. Очень важно проводить и другие радиоастрономические наблюдения этого источника, например, исследовать его поляризацию.

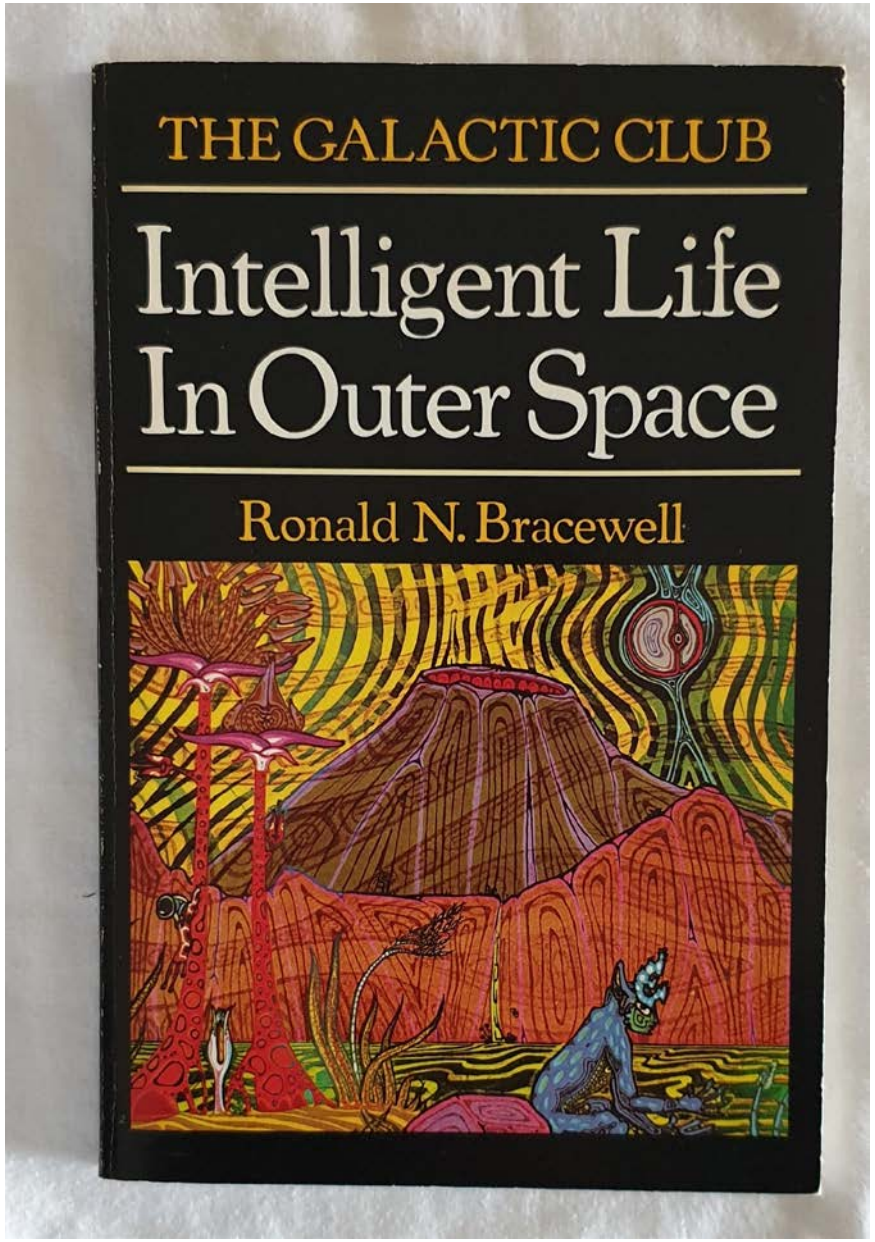
На месте источника СТА-102 недавно американскими астрономами была обнаружена слабая звездочка 17-й величины. Было бы очень хорошо получить спектр этой звезды. Это позволило бы уточнить расстояние до СТА-102, что очень важно. Кроме того, очень важно исследовать возможную переменность этой звездочки.

Если переменность периодического характера у источника СТА-102 подтвердится, это будет одним из крупнейших открытий в радиоастрономии.

На рисунке приведена зависимость от времени отношения источников СТА-21 и СТА-102 к потоку от радиоисточника ЗС-48, принимаемого за эталон. По горизонтальной оси указаны даты наблюдений. По вертикальной оси — отношения потоков СТА-21 и СТА-102 к потоку от источника ЗС-48. Кружки относятся к источнику СТА-21, черные точки — к источнику СТА-102. Видно, что поток радиоизлучения от источника СТА-21 практически остается постоянным, в то время как радиоизлучение СТА-102 периодически меняется.

Questions to Think About

- International Collaboration? Why only US/USSR?
- What is the best technique to detect ETI? Technosignatures?
- Where to look (Type I, II, or III Civilizations)?
- Scope of effort (Major national/international) or PI (grant) driven?
- Private vs Government funding? NASA or NSF?
- Likelihood of serendipitous discovery from conventional astronomy observations?
- How to report a successful SETI detection? Receipt of information?
- Should we transmit?
- What are the implications of continued failure? Are we alone?


THE GALACTIC CLUB
Intelligent Life In Outer Space
Ronald N. Bracewell


CONTACT

Will the terrestrial computer share the information with us (or our decedents) --

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.

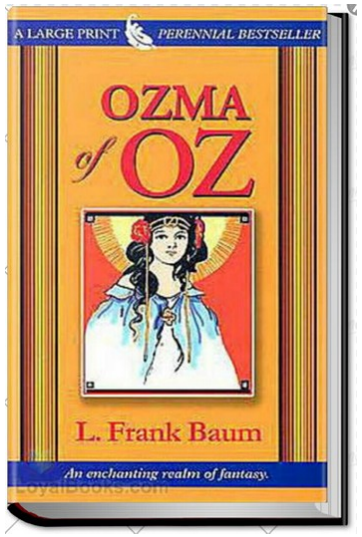
Since the object of those who operate the source is to find a newly evolved society, we may presume that the channel used will be one that places a minimum burden of frequency and angular discrimi-

Hydrogen is the most abundant element in the Universe

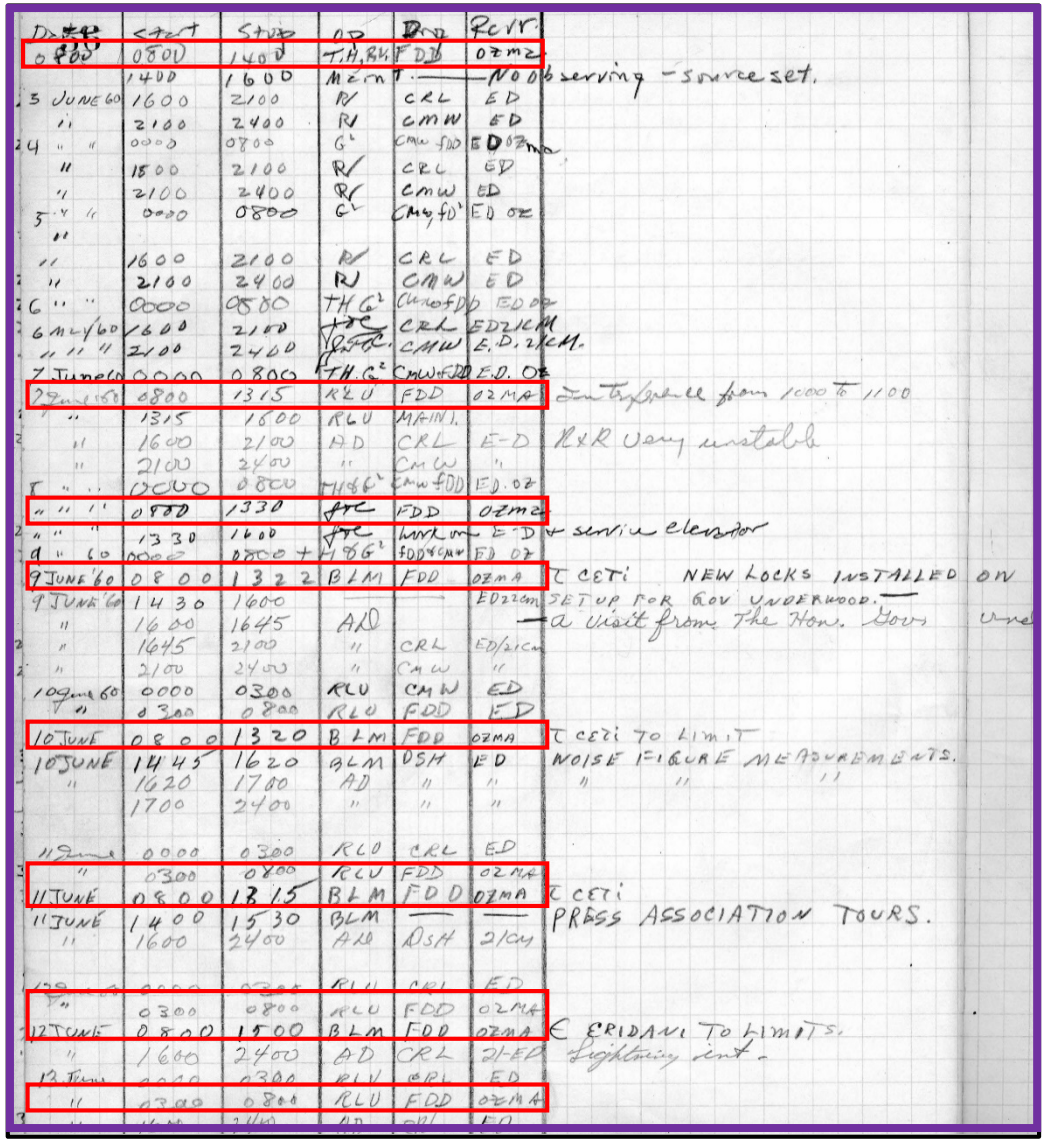
Simplest and most natural frequency to search

The probability of success is difficult to estimate; but if we never search the chance of success is zero.

Project Ozma

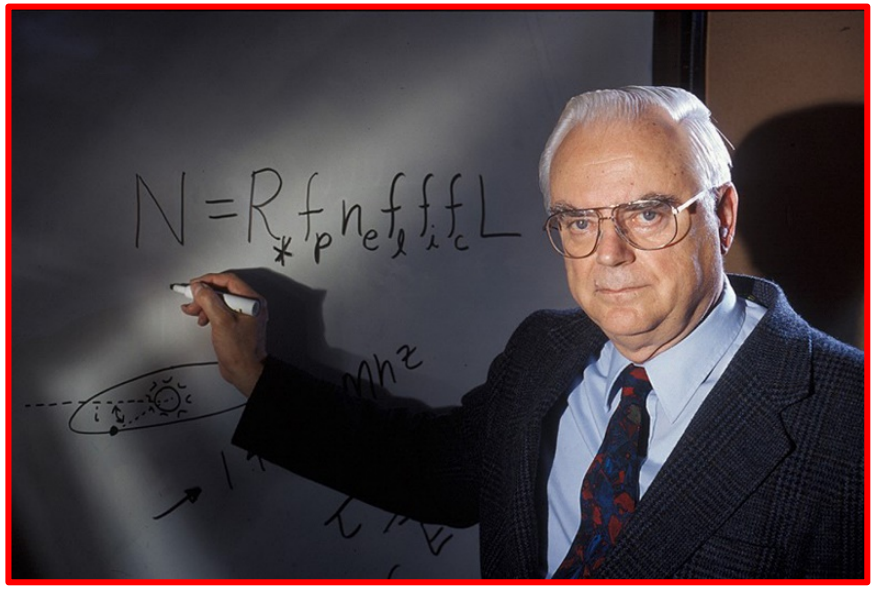


April, 1960
Tau Ceti & Epsilon Eridani
150 hours
100 Hz resolution
Negative results



85 foot log

Green Bank Conference on Extraterrestrial Intelligent Life November, 1961



Otto Struve, Chair

- Frank Drake
- Phil Morrison
- Giuseppi Cocconi
- Su-Shu Huang
- John Lilly (Man and the Dolphin)
- Melvin Calvin (chemist)
- Carl Sagan
- Barney Oliver

Green Bank Conference on Extraterrestrial Intelligent Life

- What are the conditions that intelligent transmitters are likely to be observable?
- Is it worthwhile to observe with existing equipment? Or, are prospects for success too small to be of interest?
- What observations are needed to make negative results interesting?

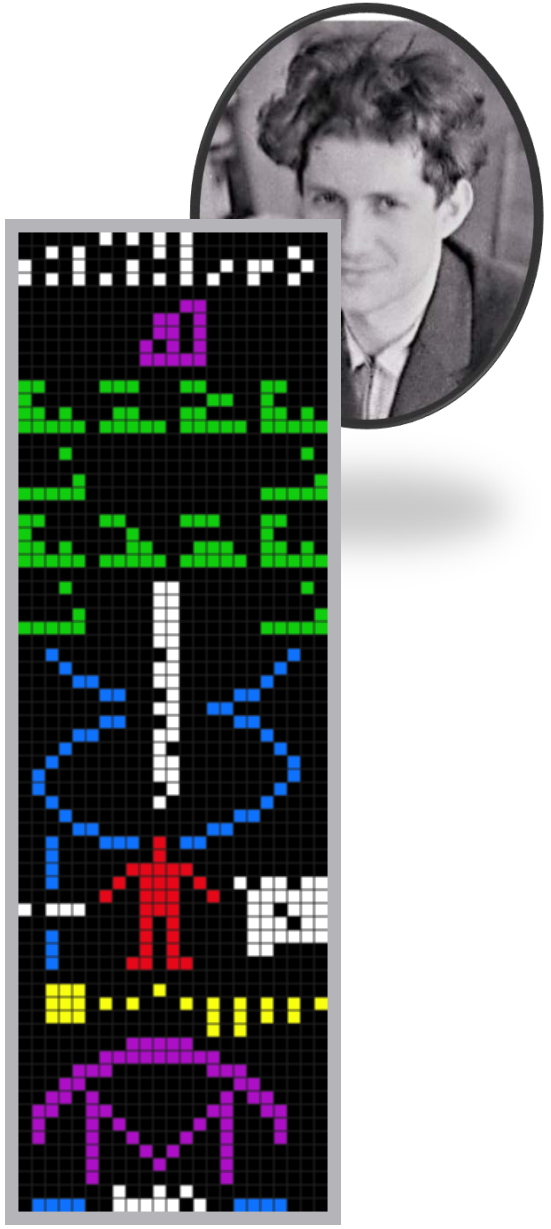
Drake Equation

$$N = R_* f_p n_e f_l f_i f_c L$$

- R_* = mean rate of star formation over galactic history
- f_p = fraction of stars with planetary systems
- n_e = number of planets per planetary system with conditions ecologically suitable for the origin and evolution of life
- f_l = fraction of suitable planets on which life originates and evolves to more complex forms
- f_i = fraction of life-bearing planets with intelligence possessed of manipulative capabilities
- f_c = fraction of planets with intelligence that develops a technological phase during which there is the capability for and interest in interstellar communication
- L = mean lifetime of a technological civilization

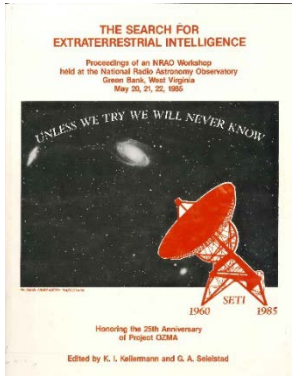
SETI after Ozma

- Sholomitsky (1964-1965) CTA 102
- Kellermann (1965) PKS 1934-63
- Troitsky (1968-1983) Broad band pulses – wide field
- Verschuur– 21 cm – 10 stars
  —Green Bank 140 /300 foot telescope-
- Palmer and Zuckerman - Ozma II - 674 stars (500 hours)
  —Green Bank 300 ft---
- Tarter et al. – 18 cm 201 Solar type stars
  —Green Bank 300 foot
- Kardashev – Galactic Center
- Drake – Arecibo message to M 13 (1974)



SETI Conferences

- 1961 Green Bank
- 1964 Armenia: Problems of Communication with Extraterrestrial Civilizations (CETI)
- 1971 US-USSR Armenia: (CETI) becomes SETI)
- 1979 IAU GA (Montreal) Joint Session SETI
- 1981 Tallin, Estonia
- 1985 Ozma@25, Green Bank
- 1991 Santa Cruz, CA
- 2009 Ozma@50, Green Bank
- 2019 Ozma@60, Green Bank
- ~~2020 FDD@90, Green Bank~~

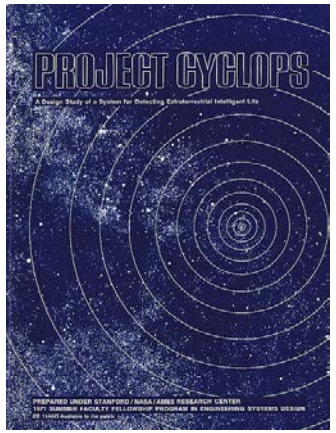


SETI
Workshops, Studies, and Reports

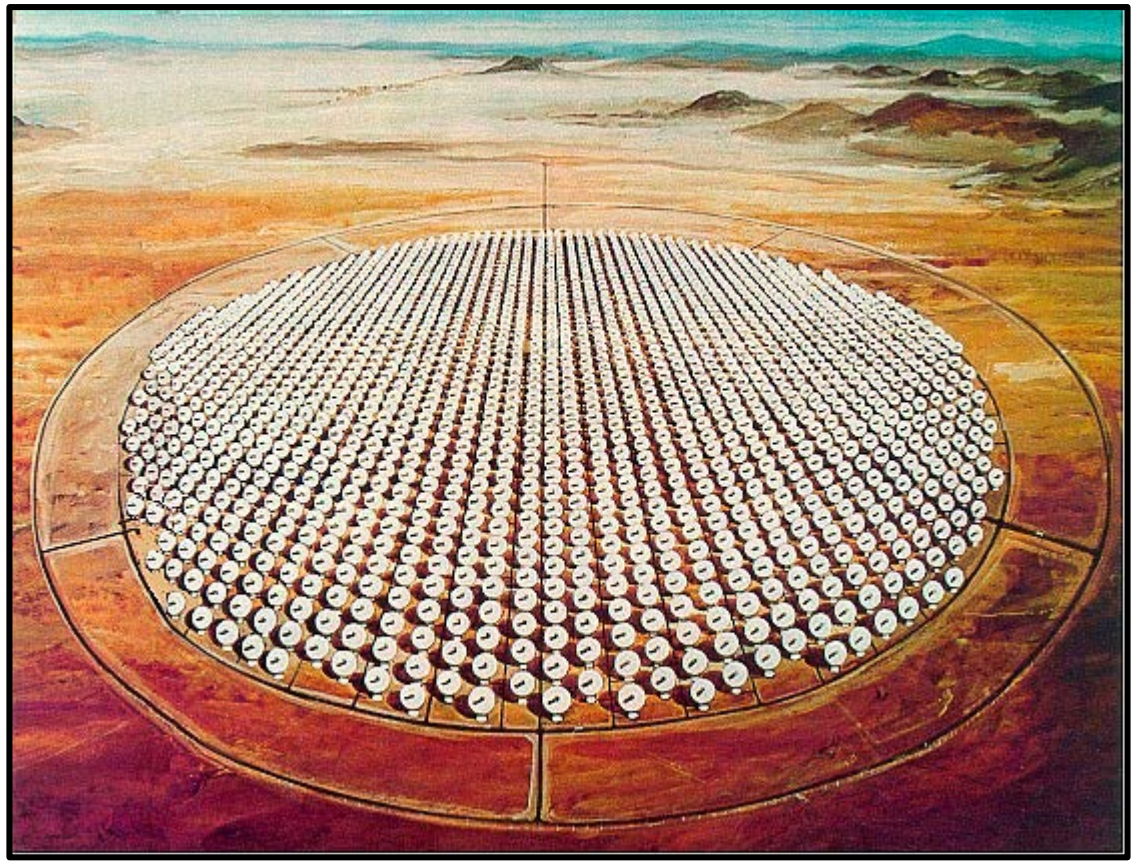
Project Cyclops (1971)

- Led by Oliver and Billingham
- 1000 x 100m antennas
- Cost ~$10 billion - $10 M/antenna

John Billingham

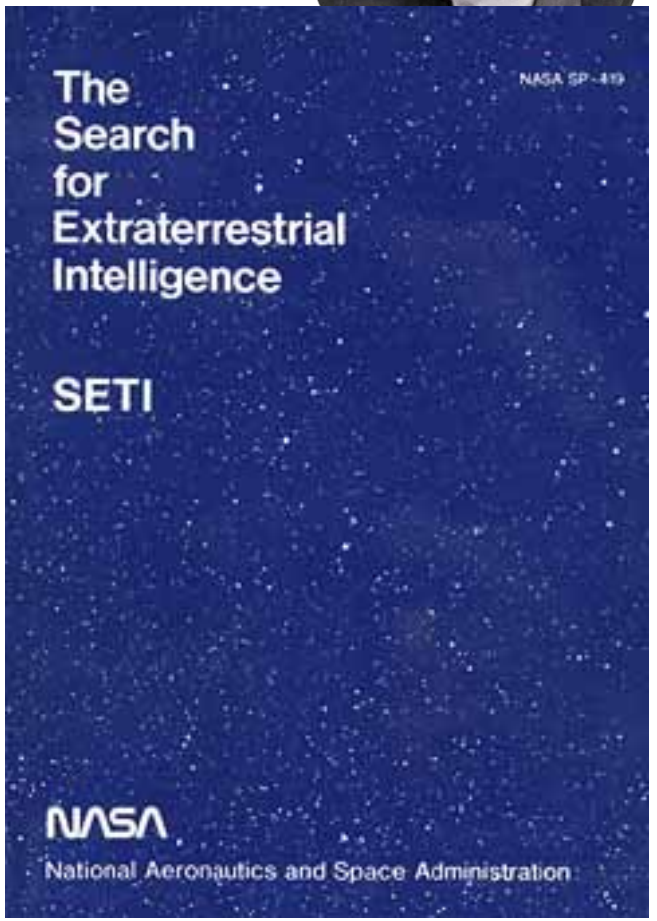


Barney Oliver



1975/1976 NASA SETI Workshops
Phil Morrison, Chair

1. It is both timely and feasible to begin a serious search for extraterrestrial intelligence
2. A significant SETI Program with substantial potential secondary benefits can be undertaken with only modest resources
3. Large systems of great capability can be built if needed
4. SETI is intrinsically an international endeavor in which the United States can take a Lead



NASA SETI Science Support Working Group
Billingham & Drake, 1980-1981

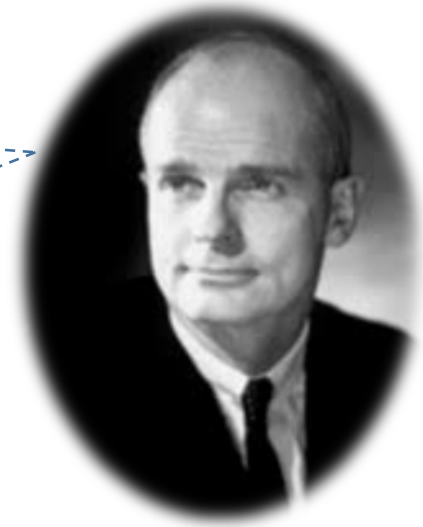
- Six meetings – 5 year R&D
- Reaffirmed existence of ETI
- Best place to search is microwaves
- Noted Urgency (RFI?)
- Balanced program of
  - —Target observations (Ames: Arecibo 1-3 GHz)
  - —Survey observations (JPL: DSN 1-10 GHz)
- NASA Focal point of SETI?
- Recommended funding for PIs

SETI Becomes Respectable

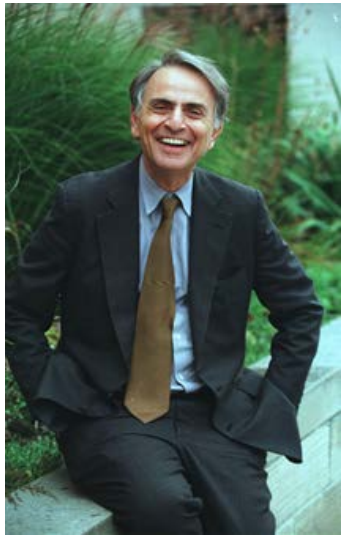
- 1975/1976 and 1980/1981 NASA Workshops
- 1975 -- Congressional Report, Marcia Smith
  - —Possibility of Intelligent Life Elsewhere in the Universe
- 1982 IAU Commission on Bioastronomy and SETI
- 1982, **1991**, 2001 NAS Astronomy Decade Reviews
  - — MOP for $100 M
  - — University based program @ $500 K/yr
- > 1992 Discovery of Exoplanets

Proxmire's 1978 Golden Fleece Award

Postpone SETI a few million light-years



1981 – NASA SETI defunded
1982 – SETI restored to NASA budget (Sagan)
1992 – NASA Ames/JPL HRMS (MOP)



Microwave Observing Project
High Resolution Microwave Search

Ten year project "mission"
Cost: $108 million

Targeted Search System
GB 140 ft, Parkes 210 ft, Arecibo 1000 ft)
vs.
All Sky Survey - DSN antennas

Launch: Oct 12, 1992

Senator Richard Bryan (Nev) – 1993

As of today millions have been spent and we have yet to bag a single little green fellow. Not a single Martian has said take me to your leader, and not a single flying saucer has applied for FAA approval.

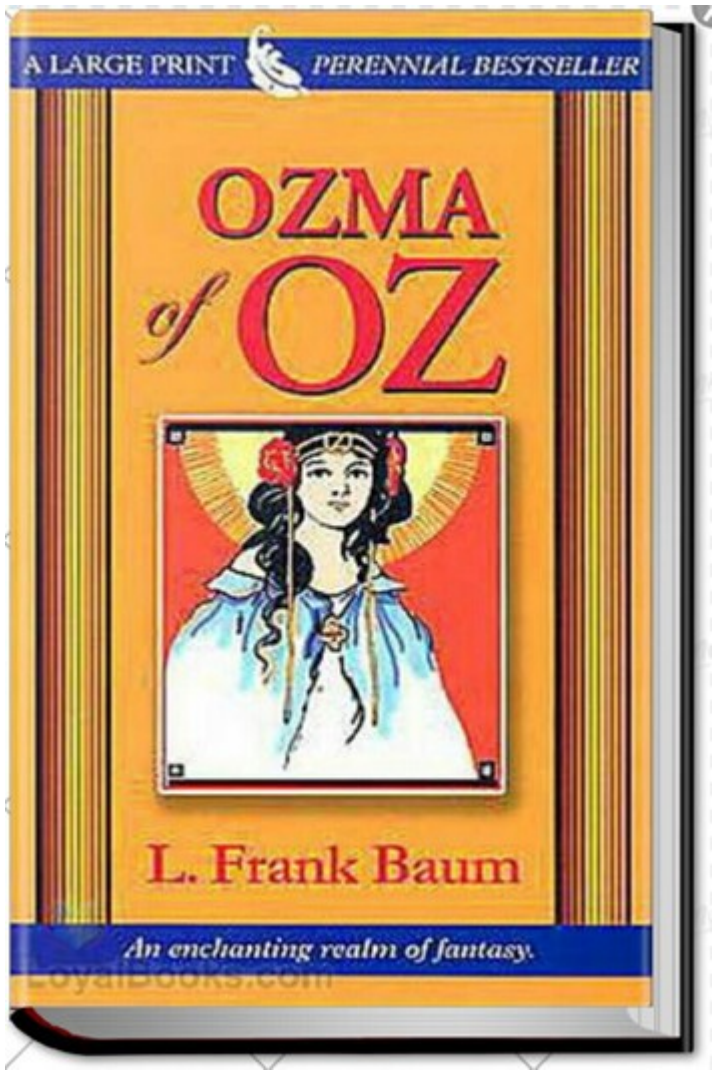
—HUD Bill amendment killed HRMS Funding

—Impacted NSF as well NASA

SETI Goes Private

- SETI Institute – Project Phoenix – 1995-1998
  - —Targeted Search – 800 nearby stars
  - —Green Bank 140 ft, Arecibo, Parkes, Nancay
- SERENDIP
  - —GB and Arecibo piggy-back
- Ohio State – Cosmic Search
- SETI@home
  - —tens of million computers in 200 countries
- Breakthrough Listen

OZMA


A LARGE PRINT
PERENNIAL BESTSELLER
OZMA
of OZ
L. Frank Baum
An enchanting realm of fantasy.


Ozma

SETI 2020 (1997-1999)

Organized by SETI Institute

Chair: Ron Ekers

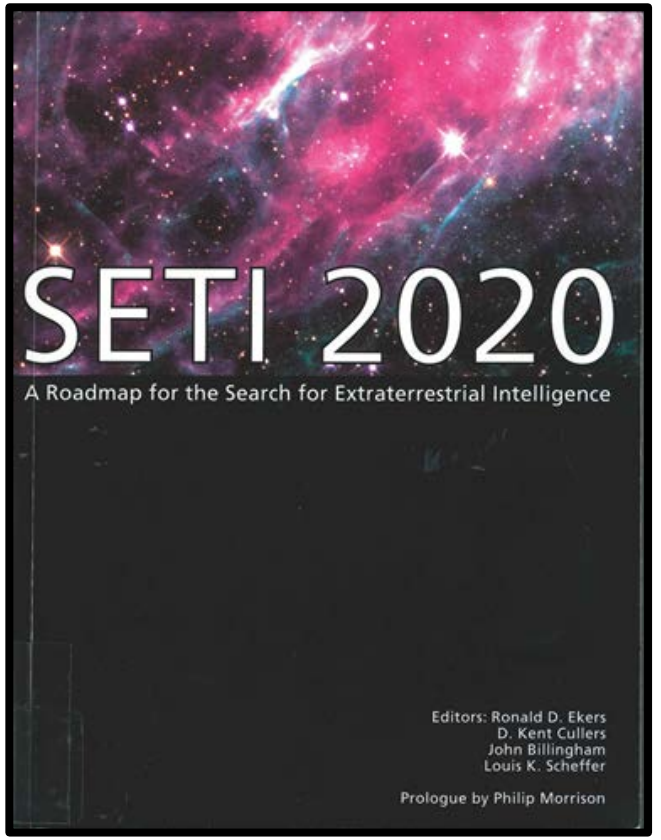
Reviewed Strategy

Roadmap 2000-2020

Large N small D

1hT Allen Telescope Array

Square Kilometre Array



Challenges to SETI

- Technical (Needle-in-Haystack problem)
- Funding: Based on negative results
- Considered science fiction
- Connected to UFOs - Oumuamua?
- Career advancement?
- Not falsifiable

Doesn’t expecting
the unexpected
make the
unexpected expected