

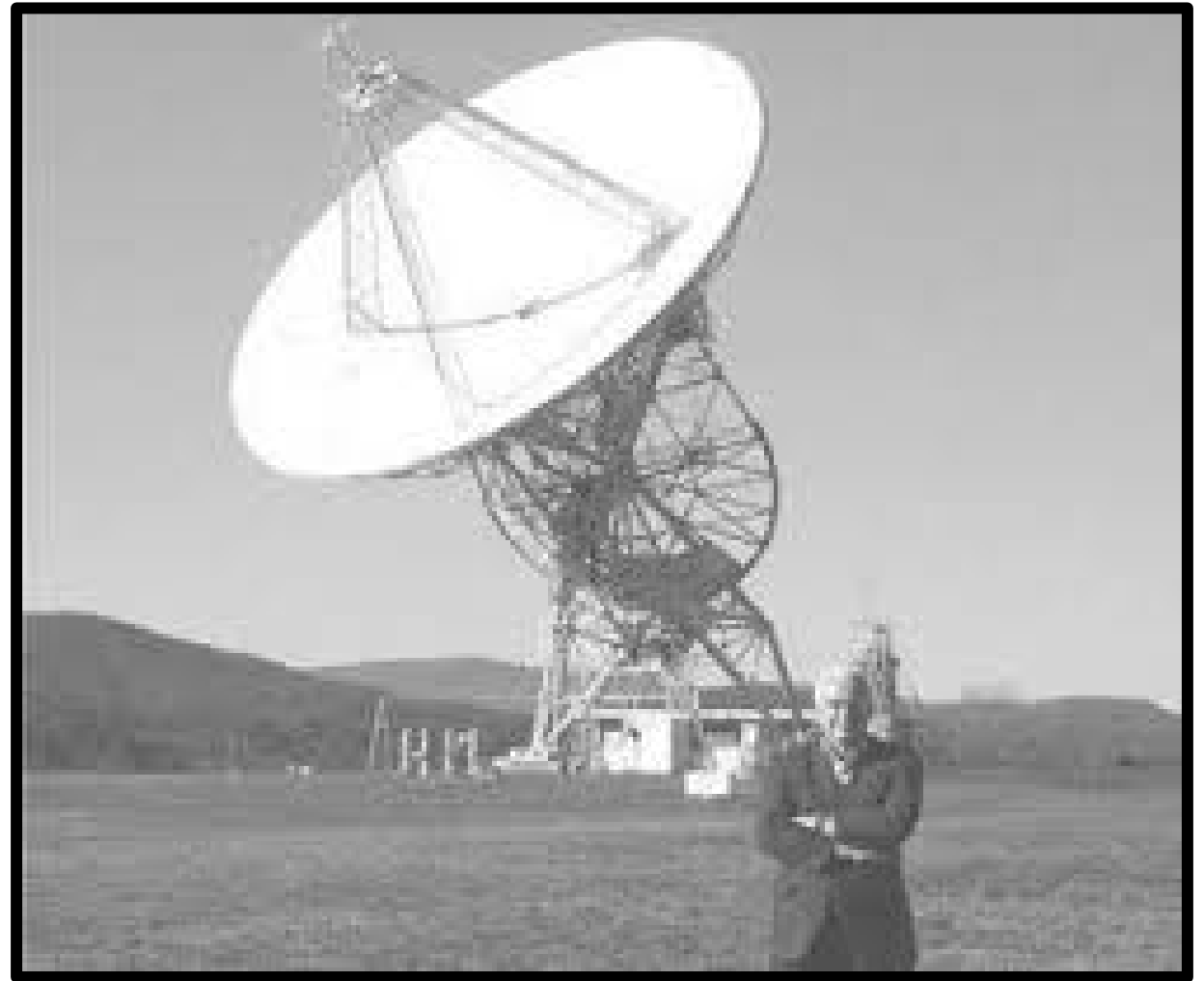


20th Century CETI/SETI
A Scientific, Technical, and Political History

Ken Kellermann
NRAO

Project OZMA

21 cm



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 discrimina-

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

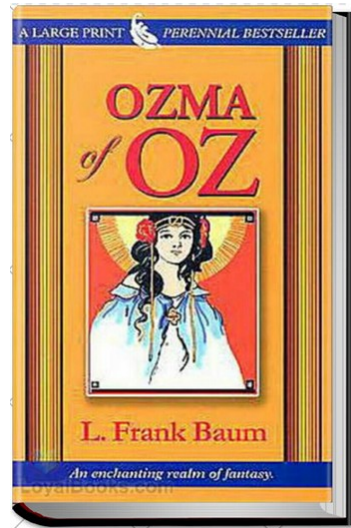


Phil Morrison

Giuseppe Cocconi

Hydrogen is the most abundant element in the Universe
Simplest and most natural frequency to search

Project Ozma

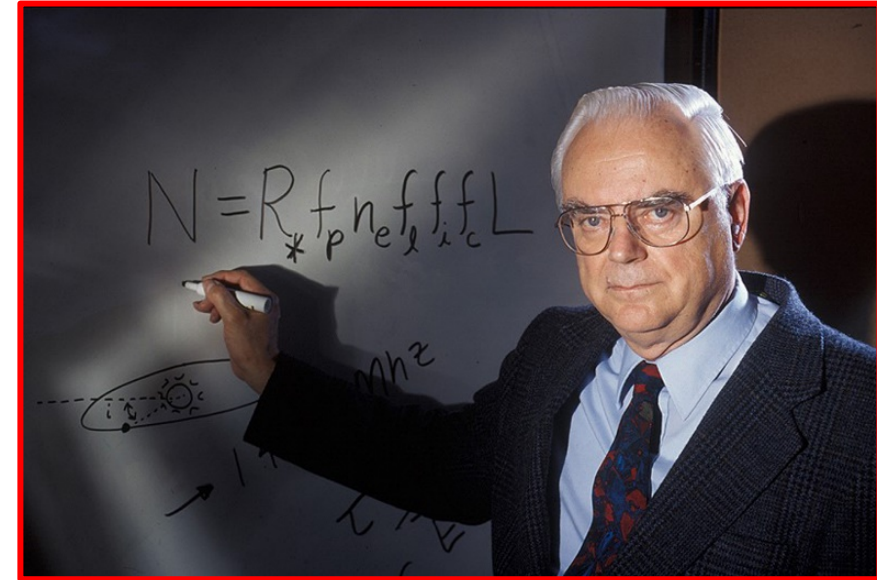


April, 1960
 Tau Ceti & Epsilon Eridani
 150 hours
 100 Hz resolution
 Negative results

D. #	Start	Stop	OP	Dir	REV	
0	0800	1400	TH, RW	FDD	OZMA	
3	1400	1600	Mern			No observing - source set.
"	1600	2100	R	CRL	ED	
"	2100	2400	R	CMW	ED	
4	0000	0800	G	CMW FDD	ED OZMA	
"	1800	2100	R	CRL	ED	
"	2100	2400	R	CMW	ED	
5	0000	0800	G	CMW FDD	ED OZMA	
"	1600	2100	R	CRL	ED	
"	2100	2400	R	CMW	ED	
6	0000	0800	THG	CMW FDD	ED OZMA	
6 May 60	1600	2100	R	CRL	ED	12M
"	2100	2400	R	CMW	ED	12M
7 June 60	0000	0800	THG	CMW FDD	ED OZMA	
25 June 60	0800	1315	R/L	FDD	OZMA	Interference from 1000 to 1100
"	1315	1800	R/L	MAIN		
"	1600	2100	AD	CRL	E-D	R/R very unstable
"	2100	2400	"	CMW	"	
"	0000	0800	THG	CMW FDD	ED OZMA	
"	0800	1330	JTC	FDD	OZMA	
"	1330	1400	JTC	MAIN	E-D	service elevator
"	0000	0800	THG	CMW FDD	ED OZMA	
9 June 60	0800	1322	BLM	FDD	OZMA	T Ceti NEW LOCKS INSTALLED ON
9 June 60	1430	1600				ED 22m SETUP FOR REV UNDERWOOD.
"	1600	1645	AD			a visit from The Hon. Gov
"	1645	2100	"	CRL	ED/airc	
"	2100	2400	"	CMW	"	
10 June 60	0000	0300	RLU	CMW	ED	
"	0300	0800	RLU	FDD	FDD	
10 June	0800	1320	BLM	FDD	OZMA	T Ceti TO LIMIT
10 June	1445	1620	BLM	DSH	ED	NOISE FIGURE MEASUREMENTS.
"	1620	1700	AD	"	"	" " " "
"	1700	2400	"	"	"	" " " "
11 June	0000	0300	RLU	CRL	ED	
"	0300	0800	RLU	FDD	OZMA	
11 June	0800	1315	BLM	FDD	OZMA	T Ceti
11 June	1400	1530	BLM			PRASS ASSOCIATION TOURS.
"	1600	2400	AD	DSH	21CH	
12 June	0000	0300	RLU	CRL	ED	
"	0300	0800	RLU	FDD	OZMA	
12 June	0800	1500	BLM	FDD	OZMA	T ERIDANI TO LIMITS.
"	1600	2400	AD	CRL	21ED	Lightning int.
13 June	0000	0300	RLU	CRL	ED	
"	0300	0800	RLU	FDD	OZMA	
"	0800	1400	AD	CRL	ED	

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

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

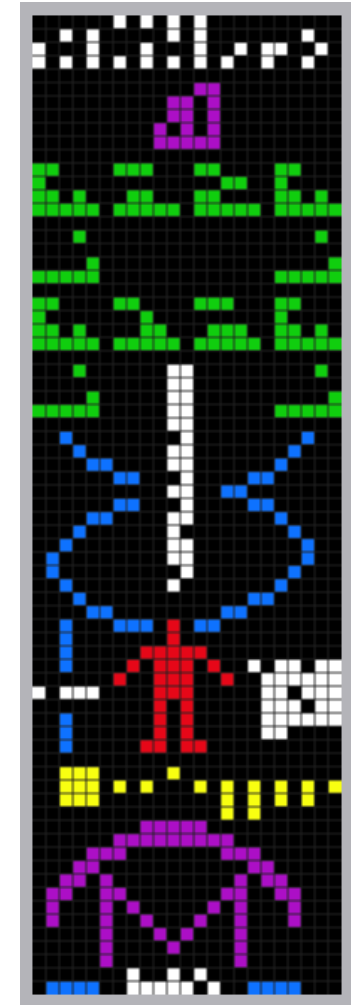
- R_* = mean rate of star formation over galactic history
- f_p = fraction of stars with planetary systems
- n_e = number of planets per planetary system with conditions ecologically suitable for the origin and evolution of life
- f_l = fraction of suitable planets on which life originates and evolves 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

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) = H₂O!
- Infrared/lasers (Charlie Townes)
- Optical SETI (Paul Horowitz)
- Dyson Spheres – engineering artifacts
- Solar System artifacts, (Bracewell) Galactic Club
- USSR (Troitsky) Broad band pulses
- Gamma rays
- Neutrinos?
- Gravity Waves?
- Extreme astrophysics

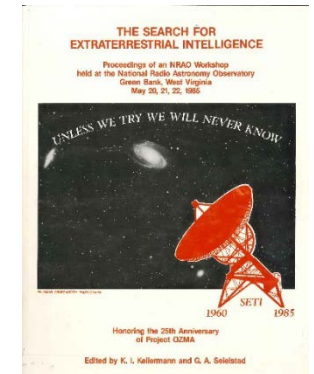
SETI after Ozma

- 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

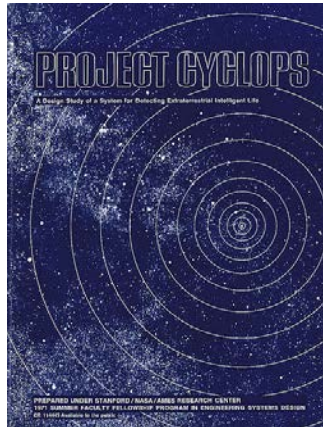
Workshops, Studies, and Reports

Project Cyclops (1971)

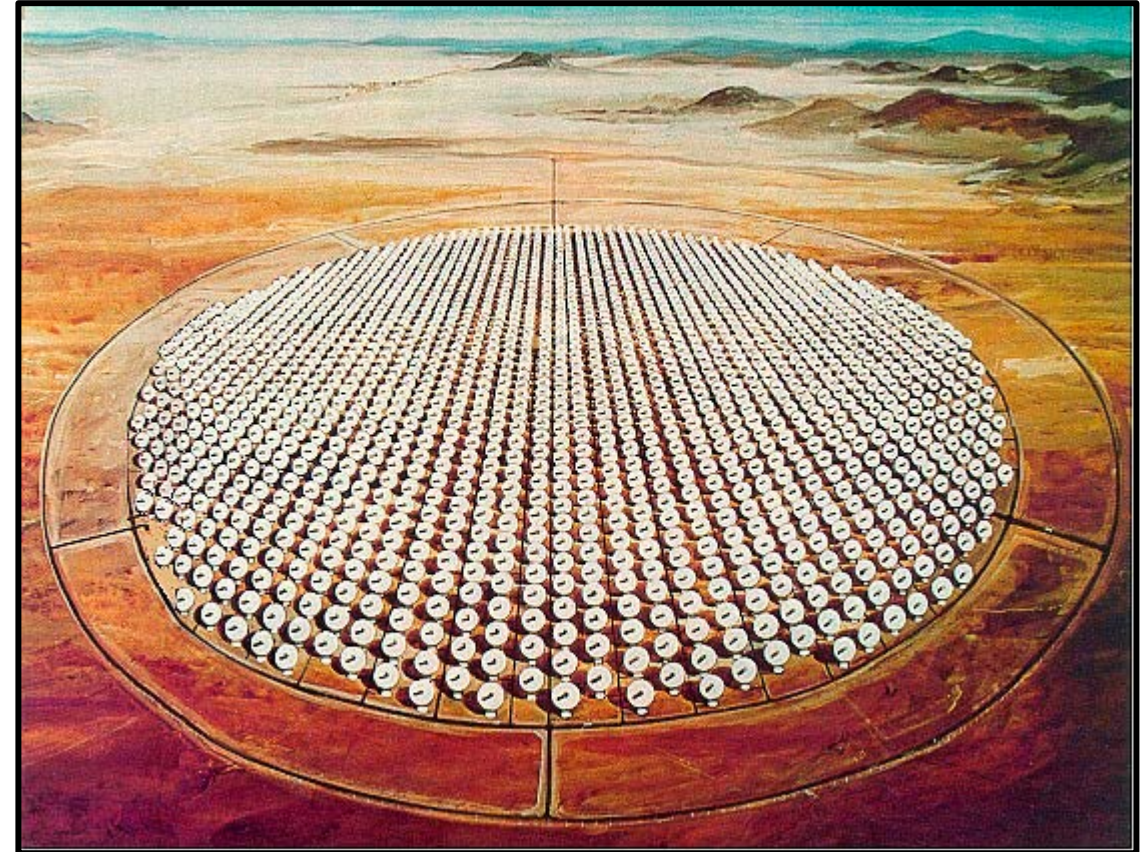
- Led by Oliver and Billingham
- 1000 x 100m antennas
- Cost ~\$10 billion - \$10 M/antenna



John
Billingham



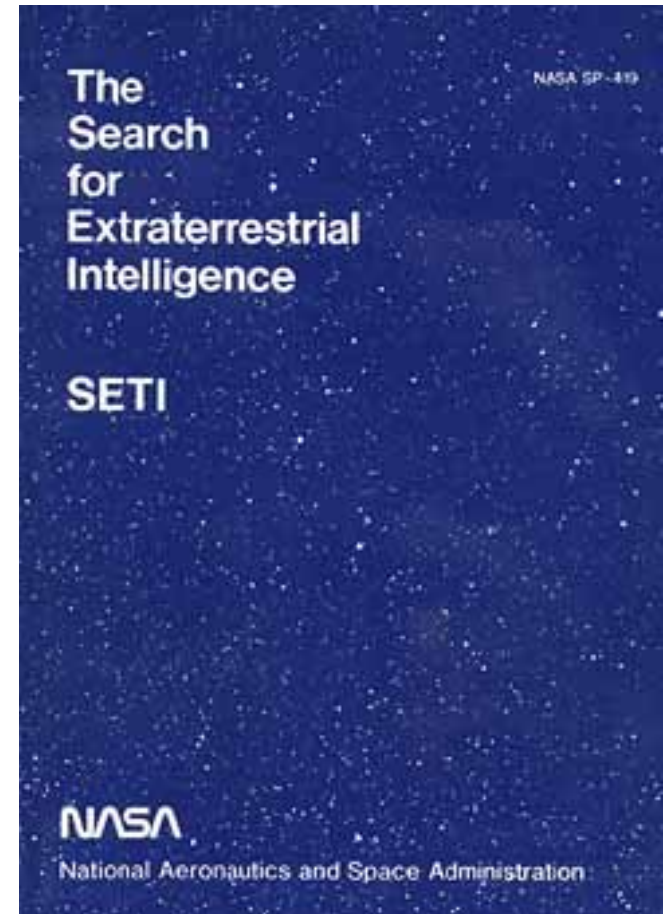
Barney
Oliver



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

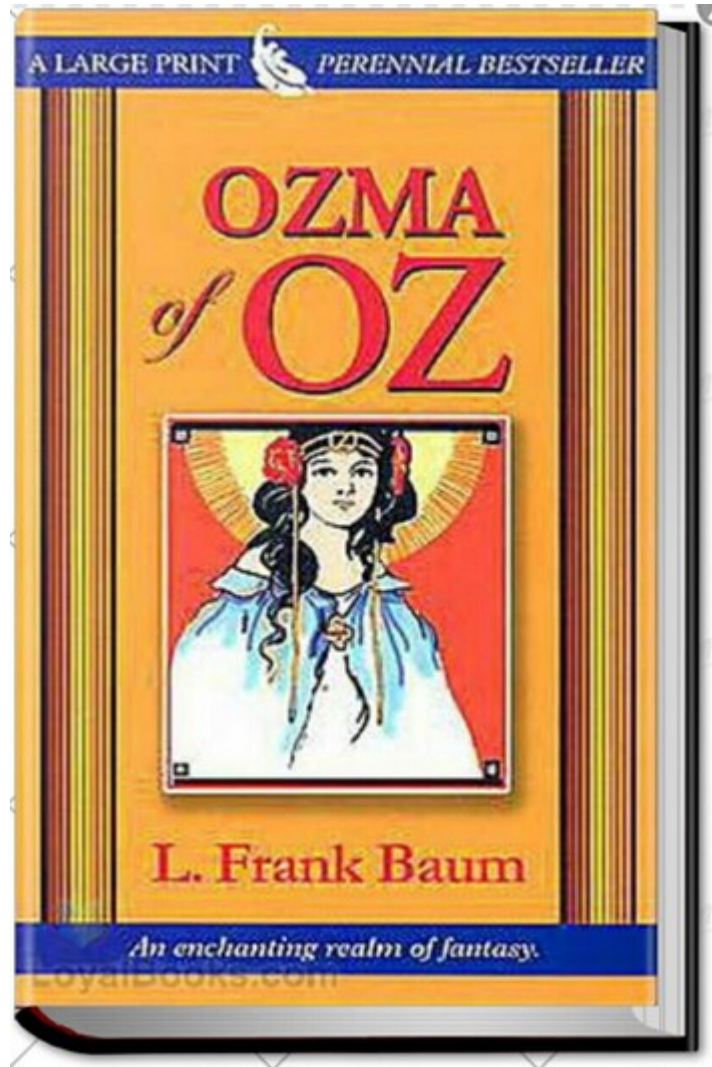




SETI Goes Private

- 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



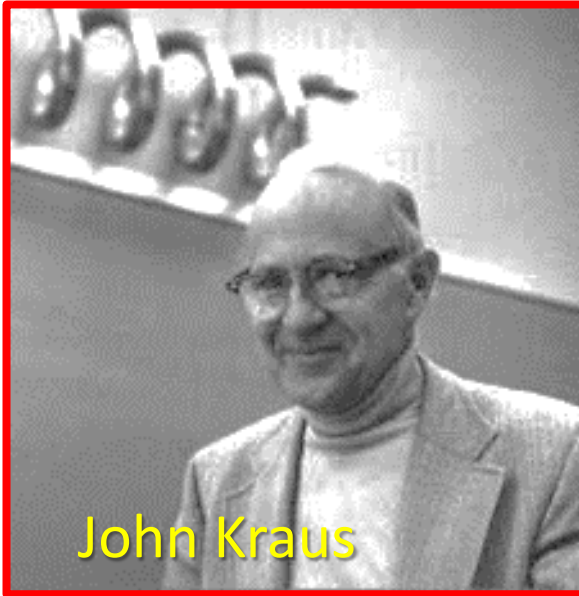


OZMA

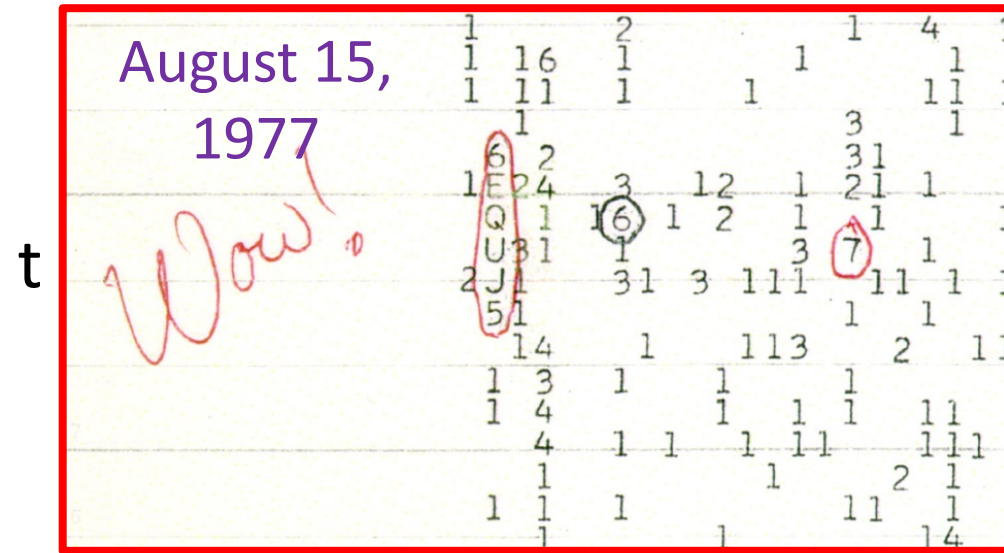




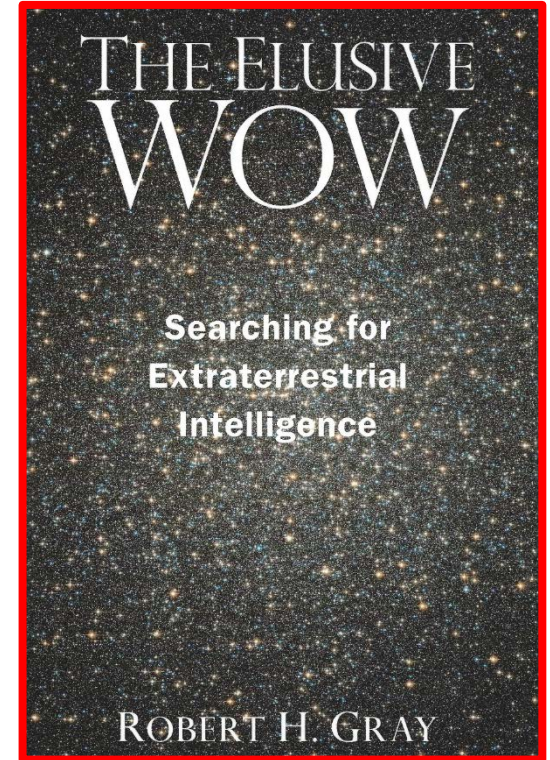
The WOW Signal



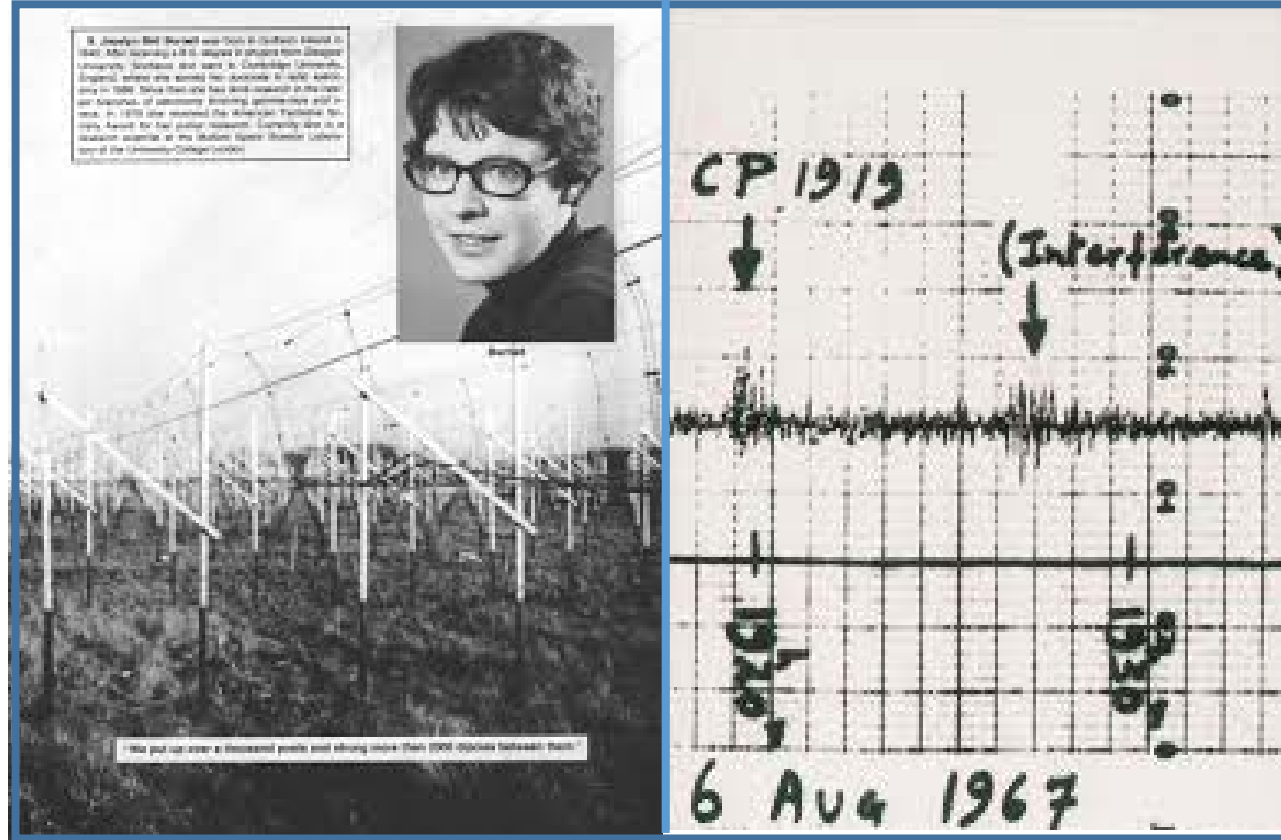
John Kraus



frequency



Pulsars aka LGM



Cambridge, UK

SETI 2020 (1997-1999)

Organized by SETI Institute

Chair: Ron Ekers

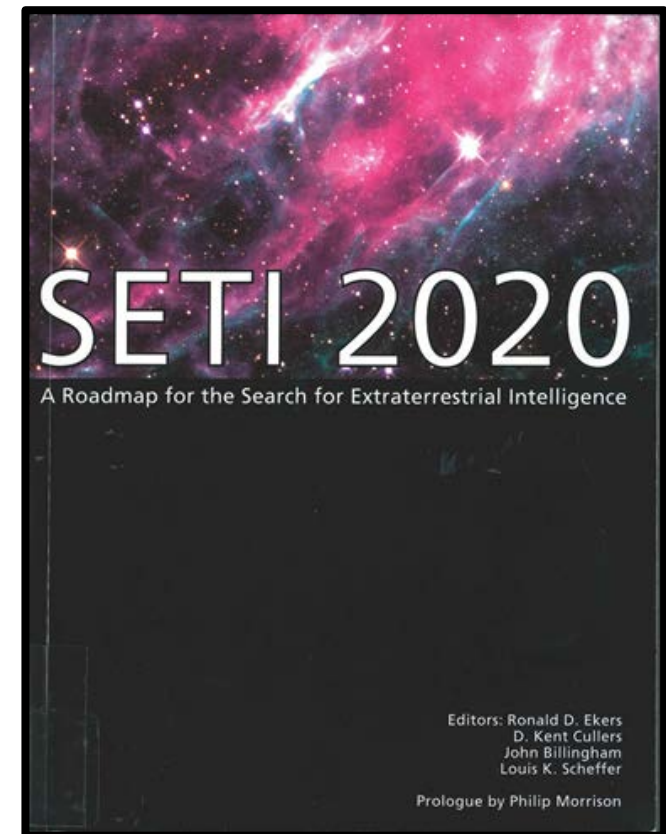
Reviewed Strategy

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



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

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



Doesn't expecting
the unexpected
make the
unexpected expected

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?
 - NASA bigger budget, but mission oriented, political baggage - historical
 - NSF, PI grants; bi partisan Congressional support
 - Private (Allen Telescope, Breakthrough Listen, SETI Institute)
- 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?