WHERE ARE THEY?

The Fermi Paradox

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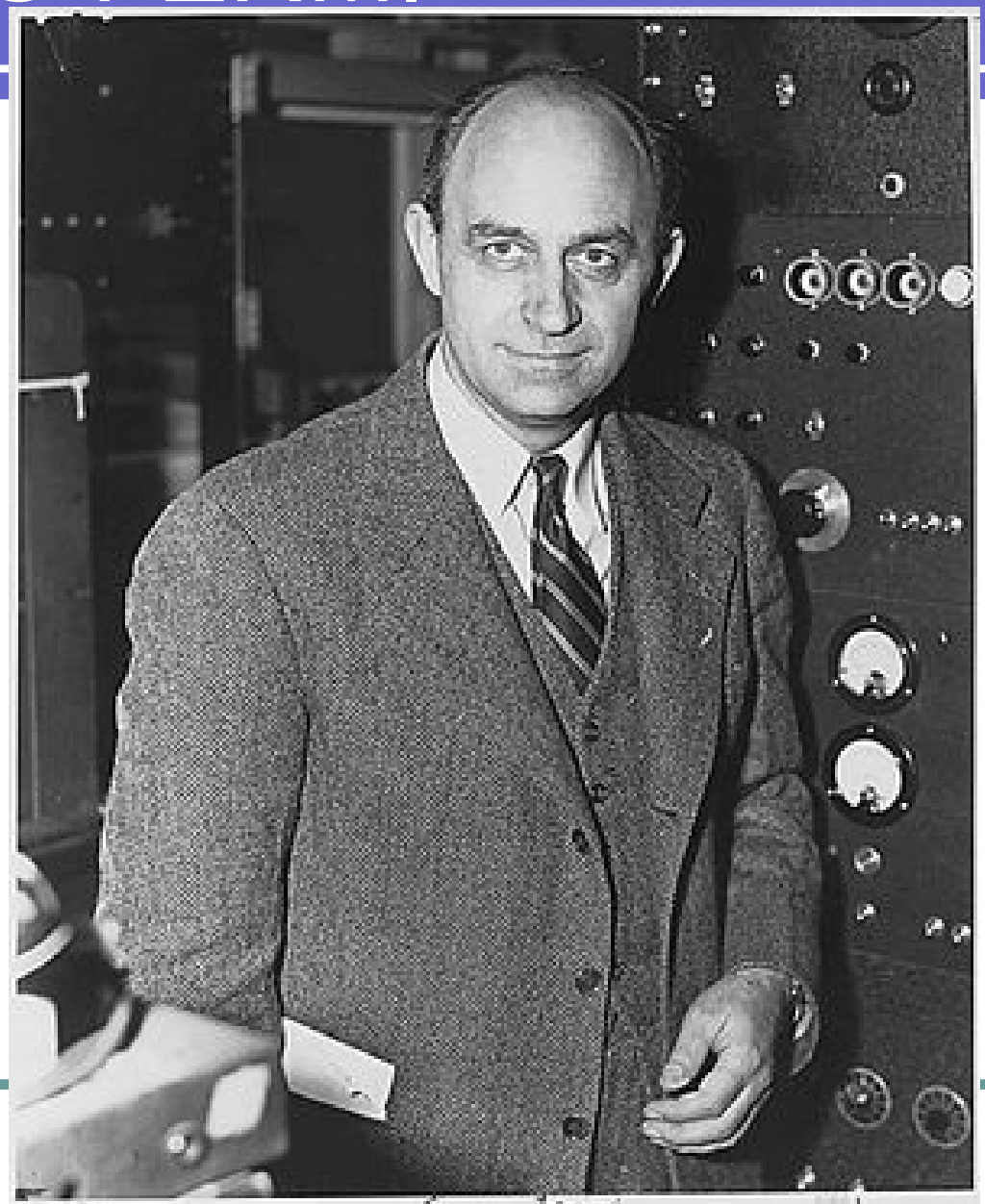
ENRICO FERMI



- FERMI PARADOX
- Or GREAT SILENCE (Brin 1983)
- Or ASTROSOCIOLOGICAL PARADOX (Gindlis & Rudnitskii 1993)

- 1931 - Radio Astronomy "discovered" by Bell Labs physicist Karl Jansky.
- 1950 – Enrico Fermi: “Where are they?”
- 1959 - First proposal to look - Cocconi and Morrison
- 1960 - Frank Drake begins Project Ozma, the first search for extraterrestrial intelligence. Two stars, Tau Ceti and Epsilon Eridani are observed for two weeks.
- 1961 - Drake Equation is created for the first SETI conference (Green Bank).
- 20-23 May 1964 Byrakan conference
- (Iosif Shklovskij, Dimitrij Martinov, Nikolai Kardashev)

- 12 April 1965 false alarm due to CTA 102
- 1967 - Discovery of pulsars cause false alarm
- 1971 - International SETI conference is held at the Byurakan Astrophysical Observatory in Armenia, USSR.
- 1972 - Pioneer 10 & 11 sent with plaques
- 1977 - The WOW signal detected
- 1977 - Voyager 1 & 2 sent with discs
- 1996 – Bil Clinton announce the discovery of traces of life on Mars (Meteorite ALH8001 false alarm)

Frank Drake (28.05.1930)

THE DRAKE EQUATION

The Drake Equation was developed by Frank Drake in 1961
as a way to focus on the factors which
determine how many intelligent, communicating civilizations
there are in our galaxy. The Drake Equation is:

$$N = N^* f_p n_e f_l f_i f_c f_L$$

The equation can really be looked at as a number of questions:

N = N* fp ne fl fi fc fL

- **N*** represents the number of stars in the Milky Way Galaxy
- **Question**: How many stars are in the Milky Way Galaxy?
- **Answer**: Current estimates are 100 billion.
- **fp** is the fraction of stars that have planets around them
- **Question**: What percentage of stars have planetary systems?
- **Answer**: Current estimates range from 20% to 50%.
- **ne** is the number of planets per star that are capable of sustaining life
- **Question**: For each star that does have a planetary system, how many planets are capable of sustaining life?
- **Answer**: Current estimates range from 1 to 5.

N = N* fp ne fl fi fc fL

- **fl** is the fraction of planets in **ne** where life evolves
- **Question**: On what percentage of the planets that are capable of sustaining life does life actually evolve?
- **Answer**: Current estimates range from 100% (where life can evolve it will) down to close to 0%.
- **fi** is the fraction of **fl** where intelligent life evolves
- **Question**: On the planets where life does evolve, what percentage evolves intelligent life?
- **Answer**: Estimates range from 100% (intelligence is such a survival advantage that it will certainly evolve) down to near 0%.
- **fc** is the fraction of **fi** that communicate
- **Question**: What percentage of intelligent races have the means and the desire to communicate?
- **Answer**: 10% to 20%

N = N* fp ne fl fi fc fL

- **L** is fraction of the planet's life during which the communicating civilizations live
- **Question**: For each civilization that does communicate, for what fraction of the planet's life does the civilization survive?
- **Answer**: This is the toughest of the questions. If we take Earth as an example, the expected lifetime of our Sun and the Earth is roughly 10 billion years. So far we've been communicating with radio waves for less than 100 years. How long will our civilization survive? Will we destroy ourselves in a few years like some predict or will we overcome our problems and survive for millennia? If we were destroyed tomorrow the answer to this question would be 1/100,000,000th. If we survive for 10,000 years the answer will be 1/1,000,000th.
- When all of these variables are multiplied together we obtain:
- **N**, the number of communicating civilizations in the galaxy.

- DRAKE AND SAGAN: 1 MILLION CIVILIZATIONS IN OUR GALAXY

THREE TYPES OF CIVILIZATIONS (N. Kardashev – Byrakan 1964)

- I. Civilizations with the level of development similar to our. Need for energy around 10(+20) erg/s.
- II. Civilizations which controle the energy radiated by their star. Need for energy per second is equal to the energy radiated by Sun (4 x 10(+33) erg/s). Traces could be seen up to 10 millions light years.
- III Civilizations using energy of their galaxy. Need for energy around 10(+44) erg/s. Traces could be seen up to 10 billions light years.

SEARCH FOR EXTRATERRESTRIAL INTELIGENCE

WHERE TO SEARCH?

Shklovskij: LATE SPECTRAL TYPES (SOLAR TYPE) WITH SMALL ROTATION VELOCITY

WHICH WAVELENGTH?

Cocconi and Morrison: 21 cm

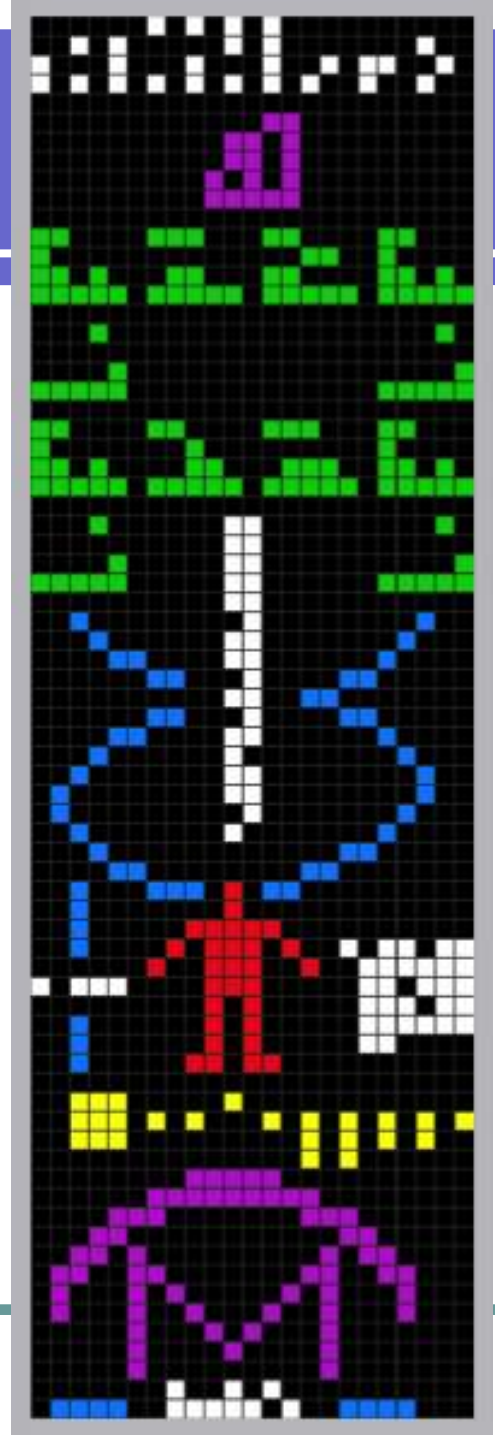
N. Kardashev 1.5 mm (Maximum in background radiation distribution)

1960. F. Drake TAU CETI, EPSILON ERIDANI (21 cm – OZMA project)

1974 Drake and Oliver: Arecibo 300 m radio telescope. RADIO MESSAGE TOWARDS GLOBULAR CLUSTER M13 IN HERCULES (30 000 stars – 25 000 ly)

Arecibo message

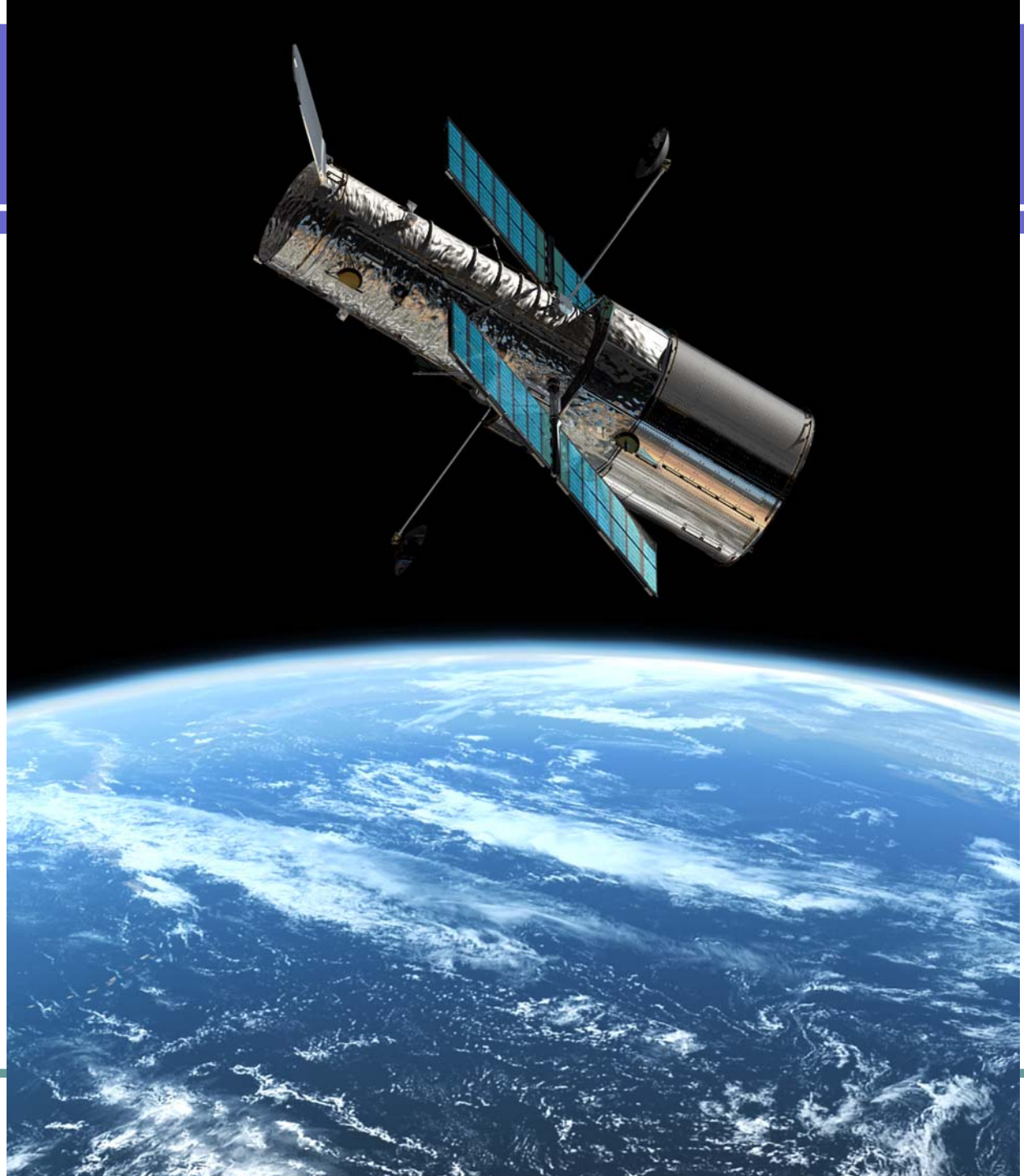
- 16. 11. 1974
- M 13, 30 000 stars

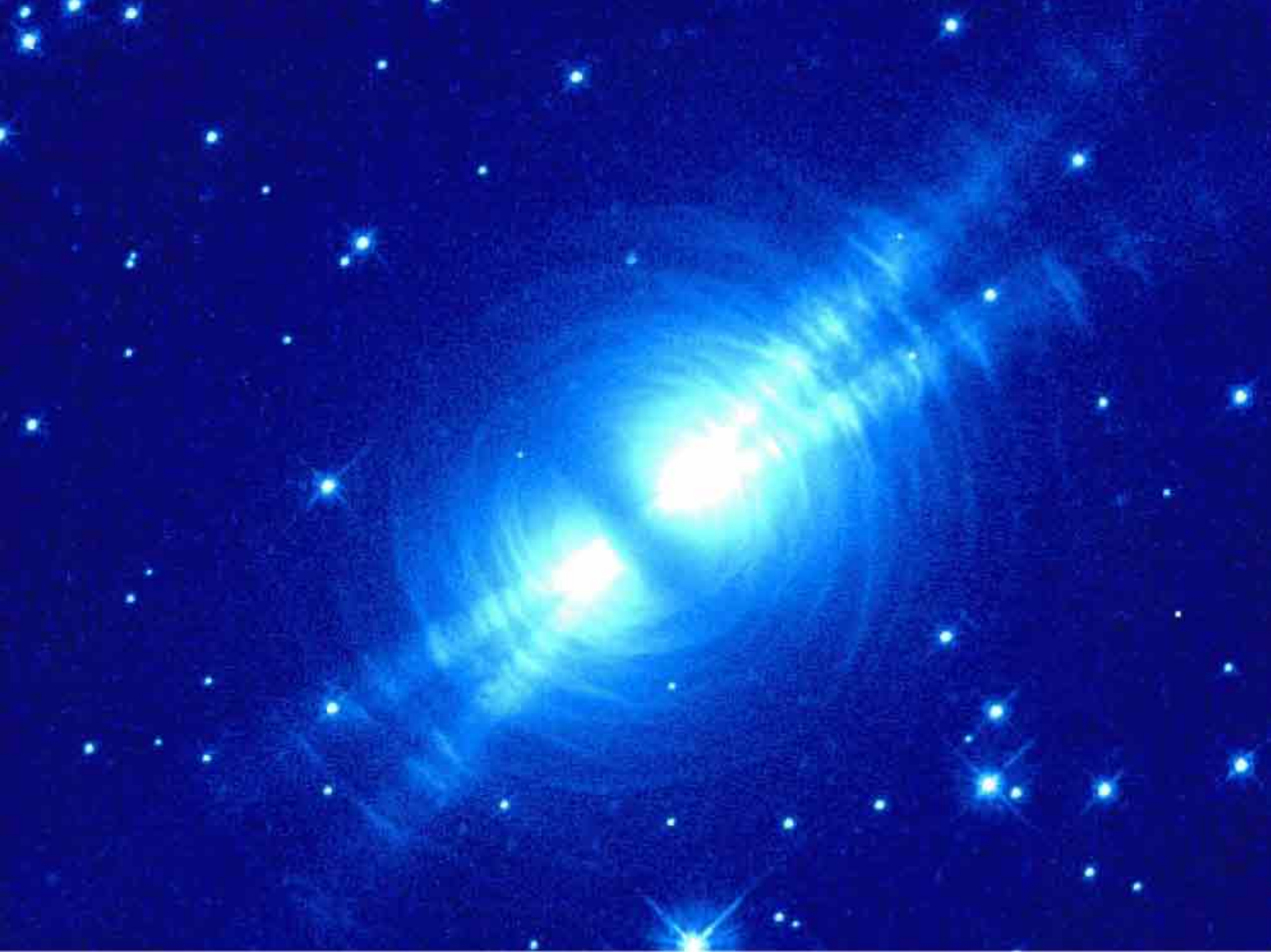


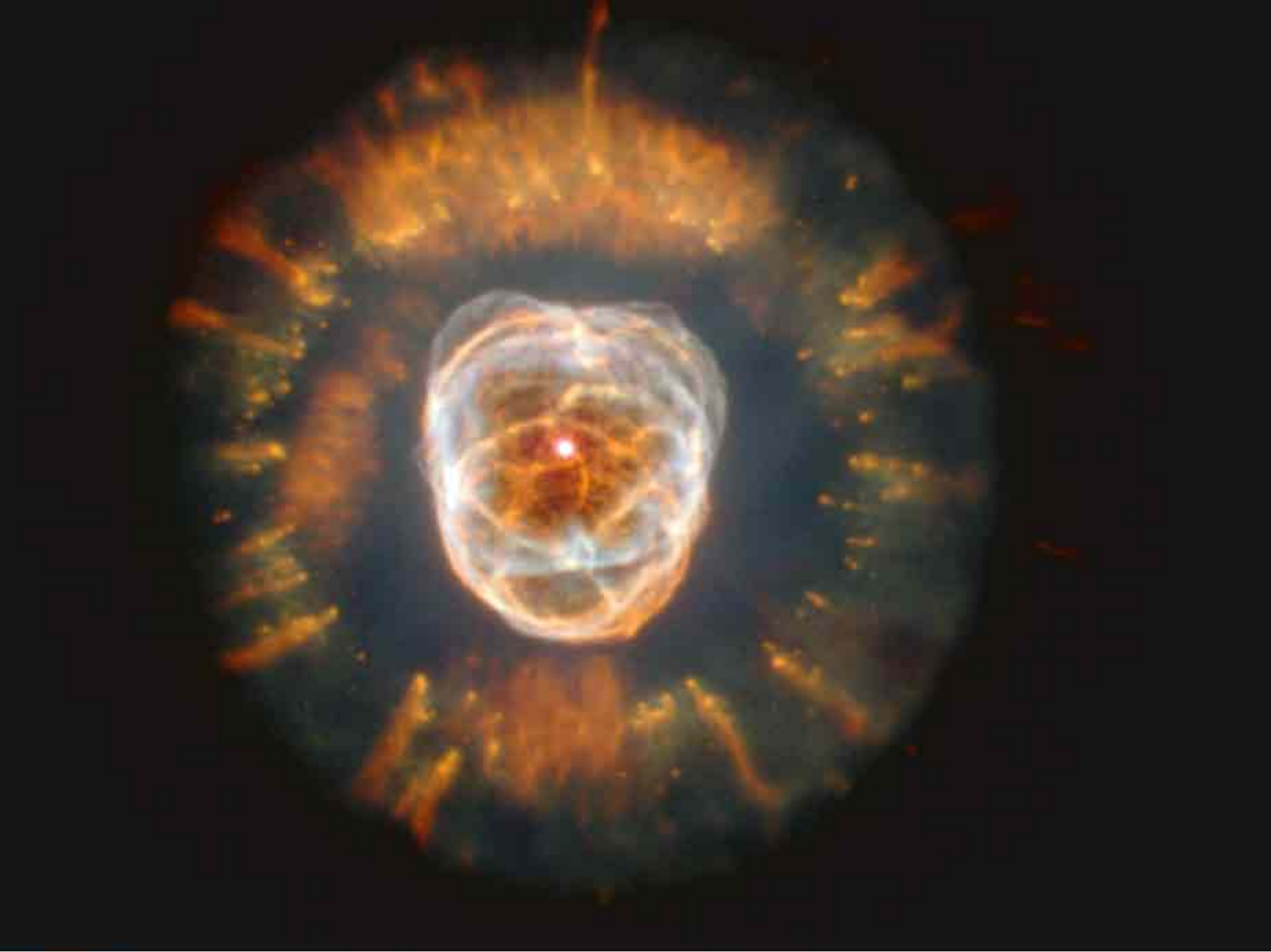
SIGNS OF ADVANCED CIVILIZATIONS

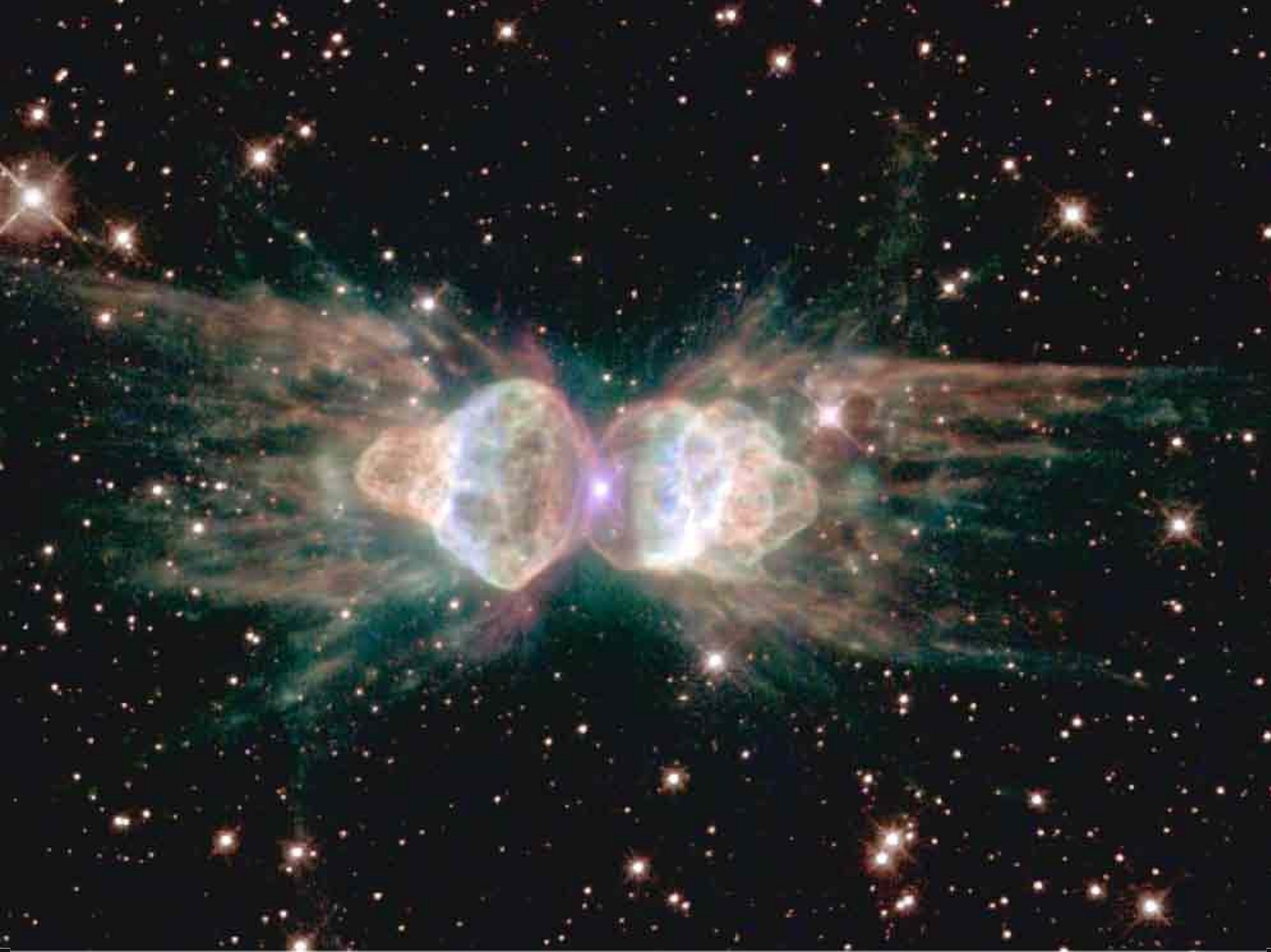
- Dyson shell (Freeman Dyson 1960) (looking from the outside like an infrared shell)
- Traces of burning antimater fuel (Harris 2002, Jugaku & Nishimura 2003)

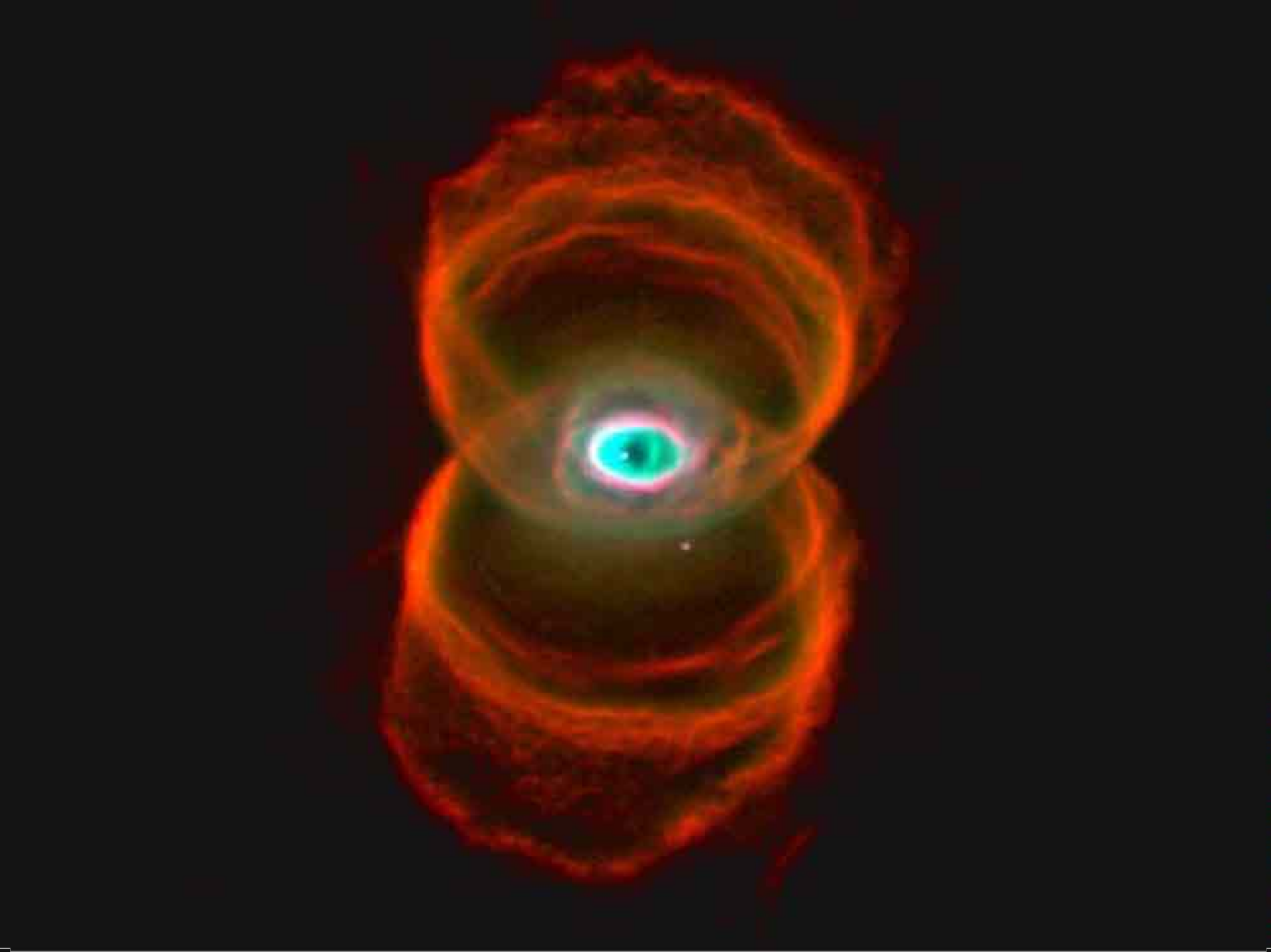
HST





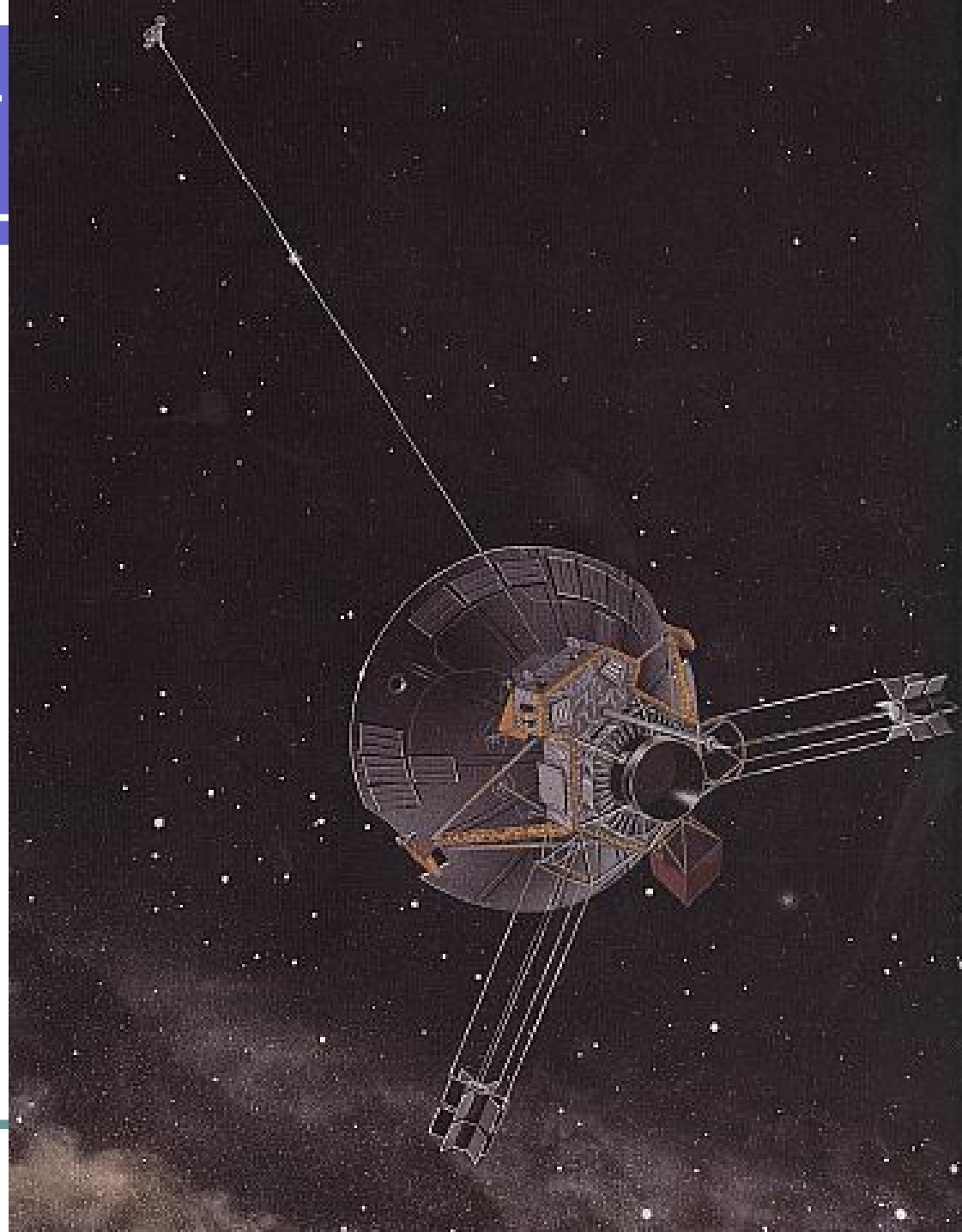


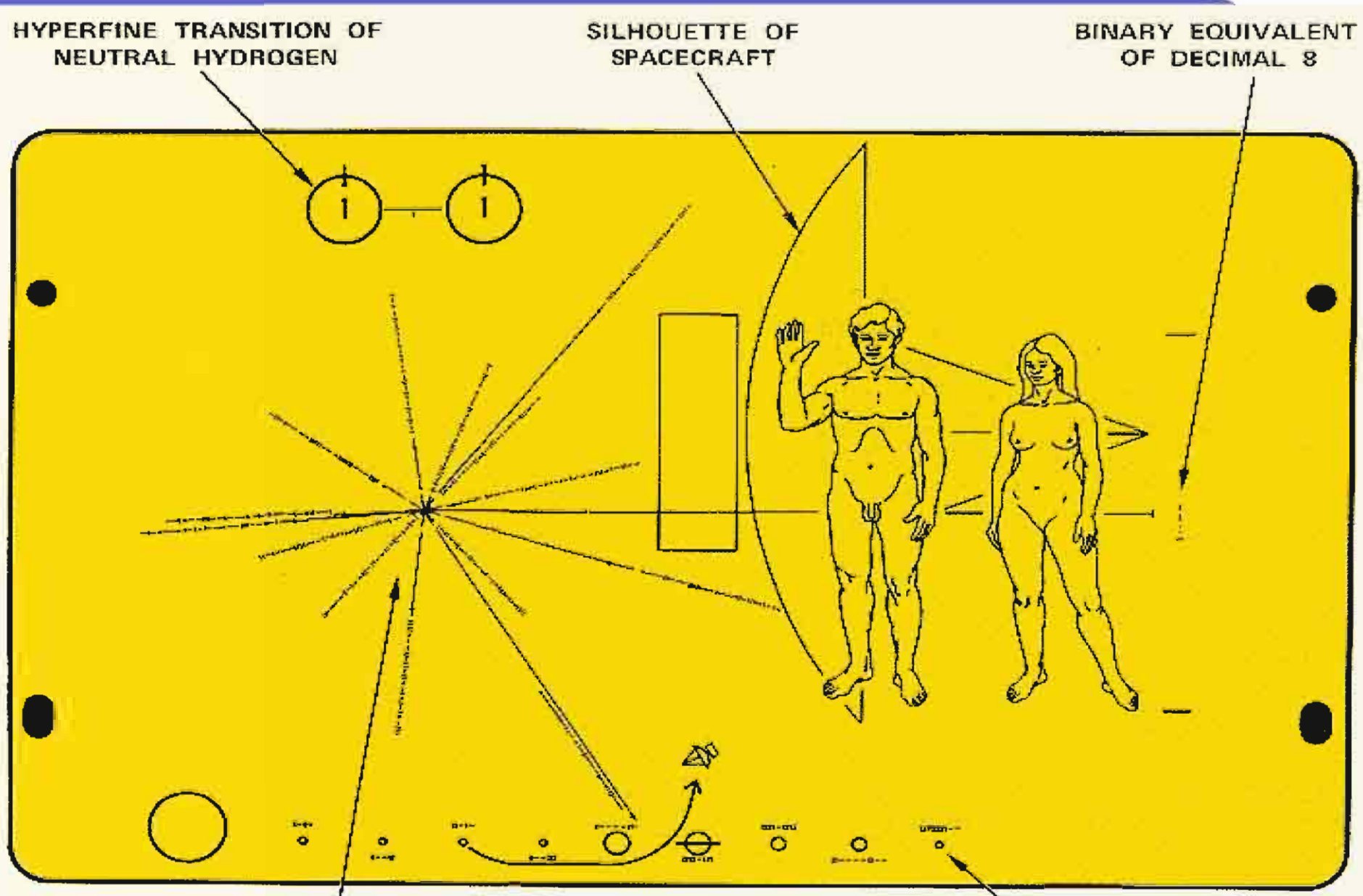




- Weinberger & Hart (2002) from Insbruk
- -Palomar Observatory Sky Survey I & II
- - Atlas ESO & SERC
- They worked 25 years
- There is no II & III type civilizations 10000 – 20000 ly around

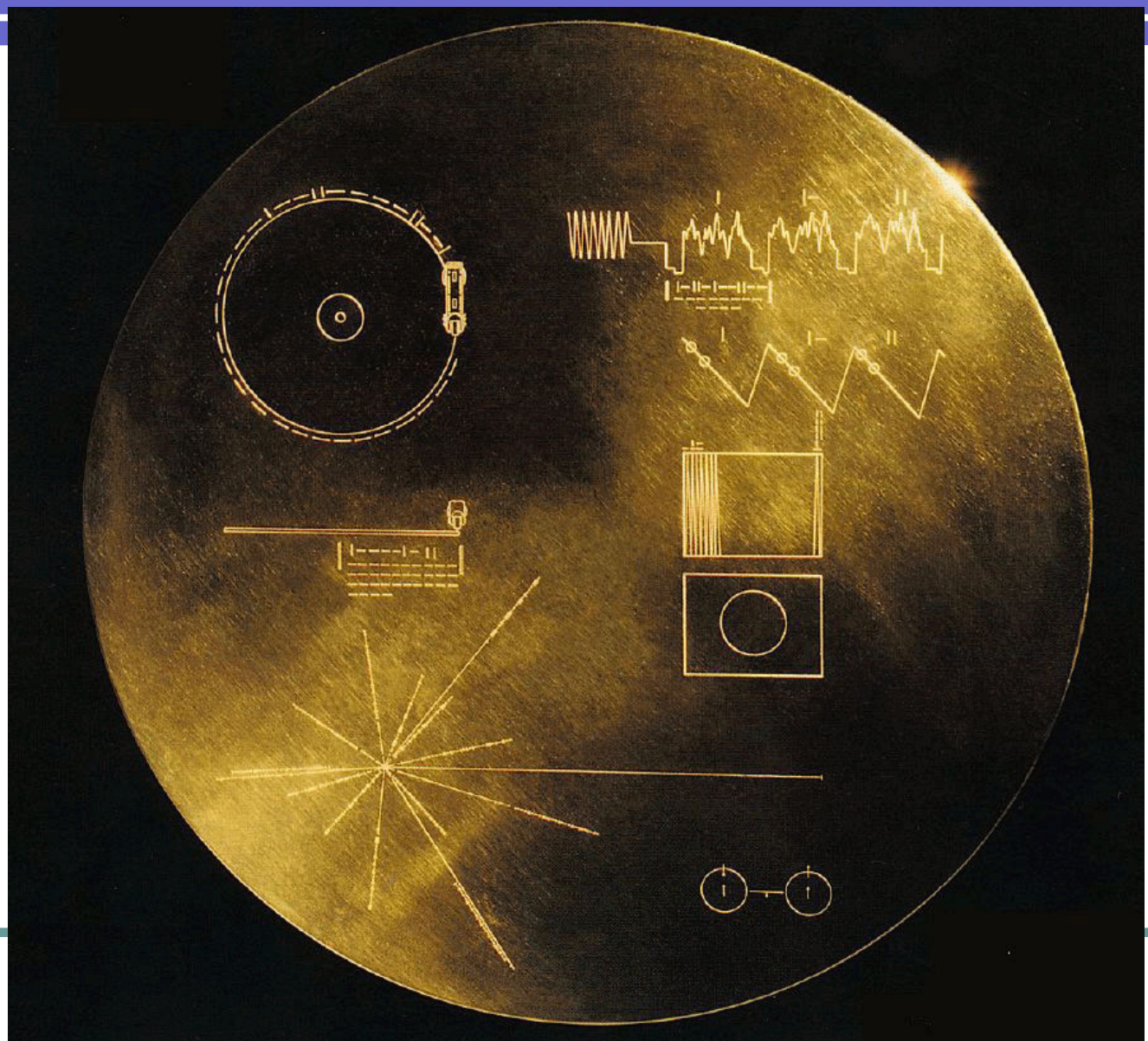
PIONEER 10-11



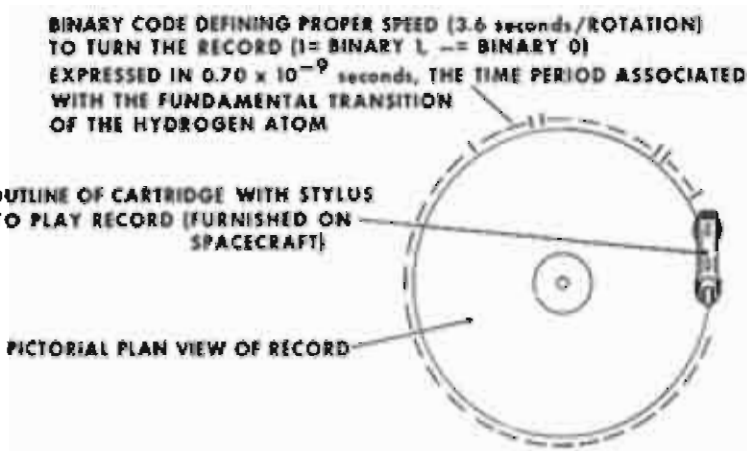

HYPERFINE TRANSITION OF NEUTRAL HYDROGEN
SILHOUETTE OF SPACECRAFT
BINARY EQUIVALENT OF DECIMAL 8
1
1
POSITION OF SUN RELATIVE TO 14 PULSARS AND THE
PLANETS OF SOLAR SYSTEM AND BINARY RELATIVE DISTANCES

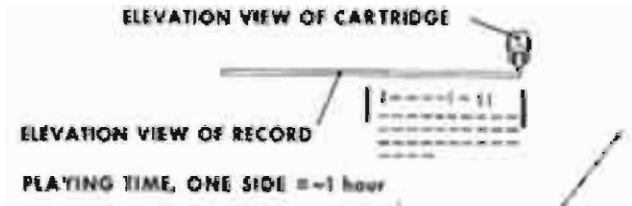
VOYAGER 1-2

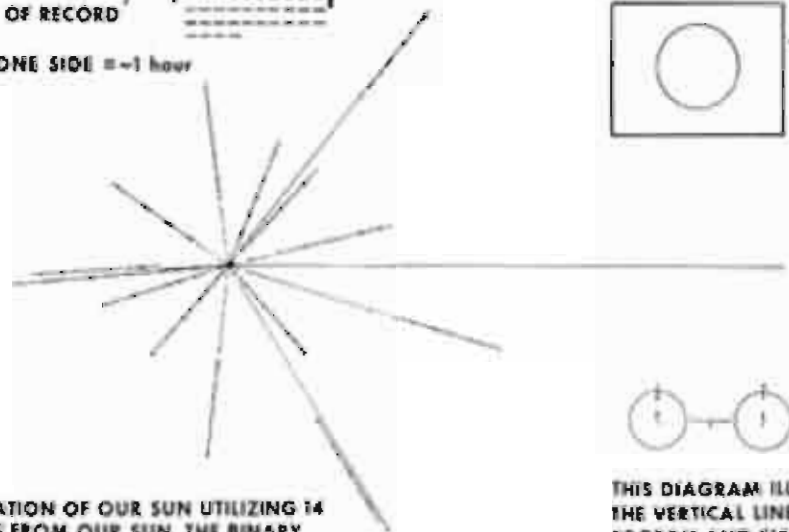
Voyager golden plaque – cover



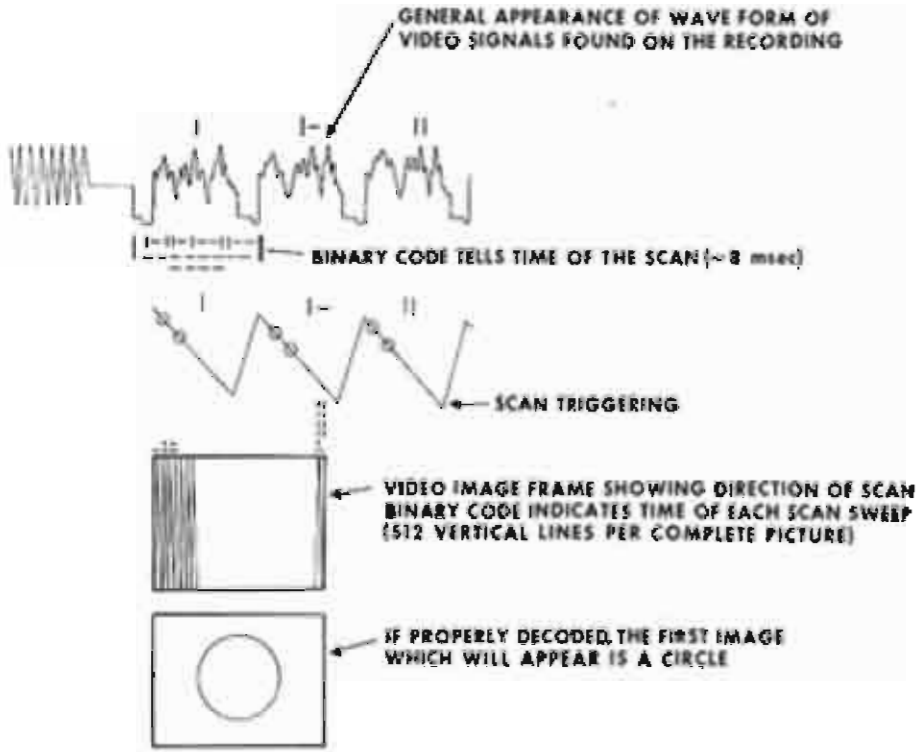
THE DIAGRAMS BELOW DEFINE THE VIDEO PORTION OF THE RECORDING







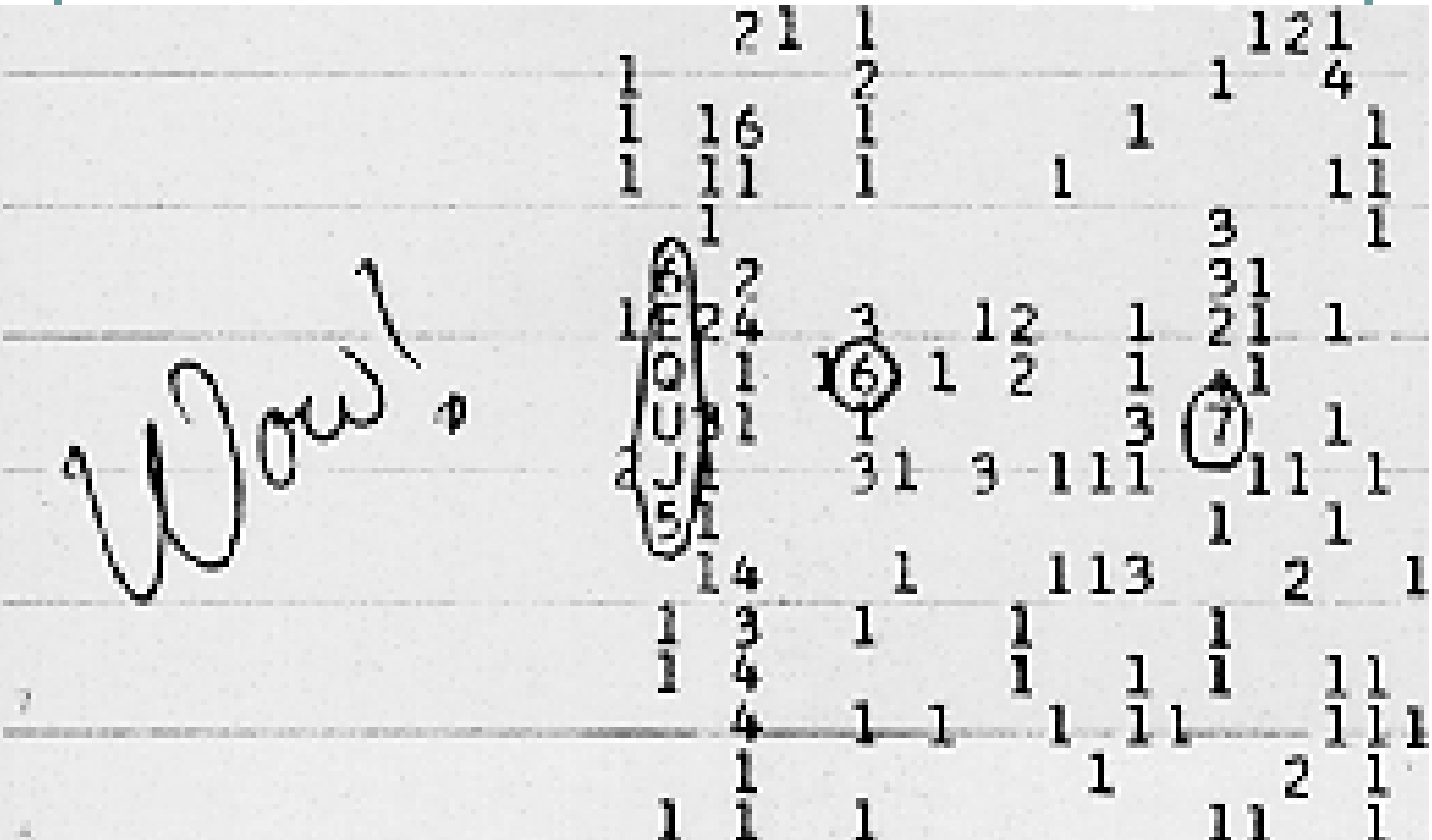
THIS DIAGRAM DEFINES THE LOCATION OF OUR SUN UTILIZING 14 PULSARS OF KNOWN DIRECTIONS FROM OUR SUN. THE BINARY CODE DEFINES THE FREQUENCY OF THE PULSES.

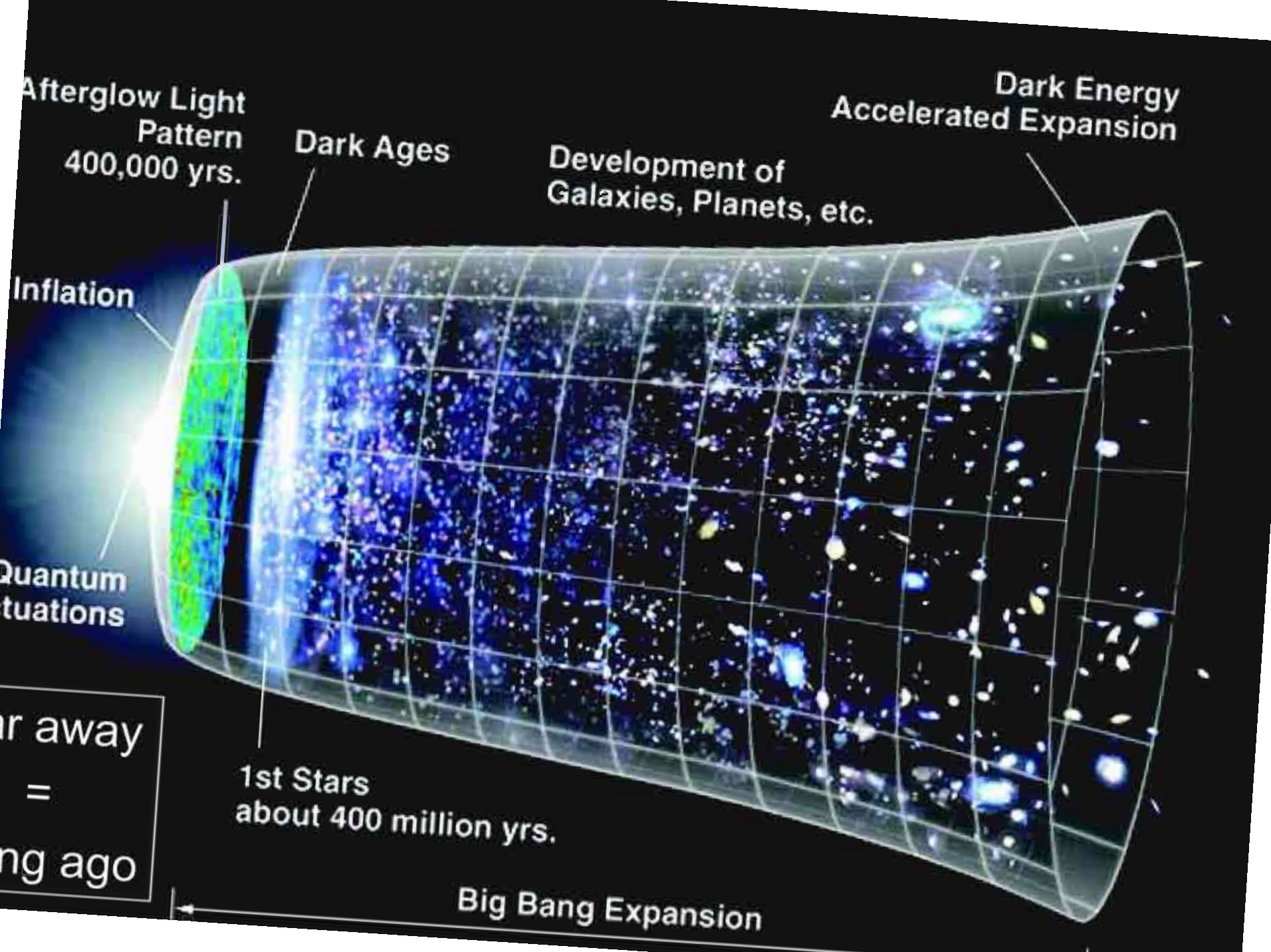


THIS DIAGRAM ILLUSTRATES THE TWO LOWEST STATES OF THE HYDROGEN ATOM. THE VERTICAL LINES WITH THE DOTS INDICATE THE SPIN MOMENTS OF THE PROTON AND ELECTRON. THE TRANSITION TIME FROM ONE STATE TO THE OTHER PROVIDES THE FUNDAMENTAL CLOCK REFERENCE USED IN ALL THE COVER DIAGRAMS AND DECODED PICTURES.


THE
SOUNDS
OF
EARTH
PLANET EARTH

WOW signal, August 15, 1977
Jerry Ehman




Afterglow Light
Pattern
400,000 yrs.
Dark Ages
Development of
Galaxies, Planets, etc.
Dark Energy
Accelerated Expansion
Inflation
Quantum
tuations
r away
=
ng ago
1st Stars
about 400 million yrs.
Big Bang Expansion

TRIPLER'S SOLUTION

- Frank Tripler 1980: Our civilization is the only one in our Galaxy!
- -Small probabilty that advanced forms of life will evolve
- -High probability that if they did arise, they would colonize entire galaxy
- V=0.1 c R = 5 ly t = 50 y
- Computers as John von Neuman devices

- Michael Papagiannis:
- Large space stations capable of housing 100 to 1000 people. It would be relatively easy that they become interstellar sojourners.
- V = 0.02 c, R = 10 ly, t = 500 y
- 500 y to start next journey
- V1 = 1ly/100 y

- Drake: Million civilizations now ❾
- Billion in the past ❾ it is sufficient to look nearby stars

CRITICISM

- Computers with human intelligence
- Motivation (energy, price)

The day before the colonist boards the ship he has benefits of:

- The intelectual capital of an entire planet
- Occupational specialization and division of labor of an entire planet
- Thousand years of accumulated infrastructure, facilities and goods
- Accumulated knowledge about the available natural resources

The first day at the new planet:

- The intelectual capital of colonists and that “captured” in books
- Occupational specialization and division of labor of the colonists
- Infrastructure, facilities and goods carried on the ship
- Limited knowledge about the available natural resources

A possible solution of the Fermi paradox:

- Vastly reduced standard of living and technology of a new interstellar colony

ADAPTATIONIST SOLUTION

- Eliot Sober 1964
- Technological adaptation - intentional development of properties mimicking and improving certain adaptive features found in nature
- Reverse processes - appearance of properties mimicking some features of technology

GLOBAL REGULATION MECHANISM AS A POSSIBLE SOLUTION

- Annis (J. Brit. Interplanetary Soc., 1999, 52, 19)
- A dynamical process preventing or prohibiting the uniform emergence and development of life over the Galaxy

(Gamma Ray Bursts)

In Galaxy – phase transition from an essentially dead place on a short time scale to a place filled with high complexity life

POSSIBLE CONCLUSIONS

- 1. We are alone in our Galaxy
- 2. There are other civilizations but they are relatively short lived. Most become Type I and don’t get beyond it.
- 3. There are many Type II and Type III civilizations without interest for us (The ZOO hypothesis).

Thank you!