Science & Science Fiction

Major Question 4:
Are we alone in the universe?

Today…
The science behind the SETI project;
If we encounter ET, how will we communicate?

- **Exploration Paper 4 due today**
  - ➢ **Topics on Extraterrestrial Intelligence**
  - ➢ **Details on Canvas**

Announcements for Friday, Nov. 10

SCIENTIFIC AMERICAN

THE SEARCH FOR ALIEN LIFE

Science's latest insights on who's out there and how we might find them

INSIDE

How to talk to extraterrestrials

Supercharged space rockets

Mysterious radio signals from space

Visitors from outside our solar system

Are we alone in the Milky Way?

SciAm Special Collector's Edition, August 2022

Choose any article in this issue and explore the topic further, or just write about one of the original topics on Canvas

Additional choices for Exploration Paper on Extraterrestrial Intelligence…

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- **Quiz 5 next Monday, November 13**
  - ➤ **Ch. 5 + lectures this week**
  - ➤ **Given on Canvas, 25 points possible**

Next week…

Finding habitable planets in other star systems

Conditions necessary for intelligent life to exist

Last time…

When Worlds Collide

Directed by Rudolph Maté

Paramount (1951)

Finding planets in other star systems:
Movie illustration of the <u>Wobble Method</u>
(plus a method that didn't exist until 60 years later)

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Three standard methods plus **one brand new one (predicted in sci-fi):**

1. **Transit method (periodic dips in light intensity)**

2. **Doppler spectroscopy (red-shift or blue-shift in wavelengths of light, due to motion of star)**

3. **Wobble method (shift in position in the sky)**

4. **Direct photography (image of actual planet)**

Finding planets in other star systems

- **Conditions necessary for <u>habitable</u> planet ("Goldilocks Zone", atmosphere, moon/tides)**

- **Conditions necessary in the star system (age of star, habitable planet, gas giants)**

- **Conditions necessary in the universe (apparent fine-tuning of physical constants)**

What conditions are necessary for life (as we know it) to exist?

CONTACT

Directed by Robert Zemeckis

Warner Brothers (1997)

(opening scene 0:02:29)

**The science behind the search for ET…
Age and intensity of radio transmissions
versus distance from source**

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CONTACT

Directed by Robert Zemeckis
Warner Brothers (1997)

(Arecibo 0:03:38)

SETI and radio astronomy:
World's (2nd) largest single-dish radio telescope, Arecibo, Puerto Rico

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- 305 m dish
- Completed 1963
- World's largest for 53 years
- Surpassed by China's 500 m *FAST* 2016
- Collapsed Dec. 1, 2020

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World's (2nd) largest single-dish radio telescope, Arecibo, Puerto Rico

More of the science behind the systematic search for extraterrestrial intelligence (the SETI project)

Imagining what "first contact" might be like…
How will we communicate?

Today…

CONTACT

Directed by Robert Zemeckis
Warner Brothers (1997)

("powers of ten" 0:01:43)

Estimating the number of intelligent civilizations in the galaxy

There are 400 billion stars out there, just in our galaxy alone.

If only one out of a million of those had planets…

And only one out of a million of those had life…

And one out of a million of those had intelligent life…

There would be literally millions of civilizations in the galaxy.

Estimating the number of intelligent civilizations in the galaxy

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Drake Equation

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

Assumptions made (1960) to justify the SETI Project:

R^* = rate of star formation in the galaxy = 10 per year
f_p = fraction of stars with planets (<1)
n_e = number of Earth-type planets per star (>1)
f_l = fract'n of planets capable of supporting life (=1)
f_i = fract'n of habitable planets w/ intelligent life (=1)
f_c = fract'n of intelligent civ. w/ radio com. (=1)
L = lifetime of radio-communicating species (= 10^4 y)

Systematically searching for signs of extraterrestrial intelligence…
The Drake Equation and the SETI Project (1960)

There are 400 billion stars in our galaxy.
(4×10^{11} stars)

If only one out of a million of those had planets…

($4 \times 10^{11} / 10^6 = 4 \times 10^5$ planets)

And only one out of a million of those had life…

($4 \times 10^5 / 10^6 = 4 \times 10^{-1} = 0.4$ planets with life)

(Sorry, no more powers of 10 left.)

Estimating the number of intelligent civilizations in the galaxy
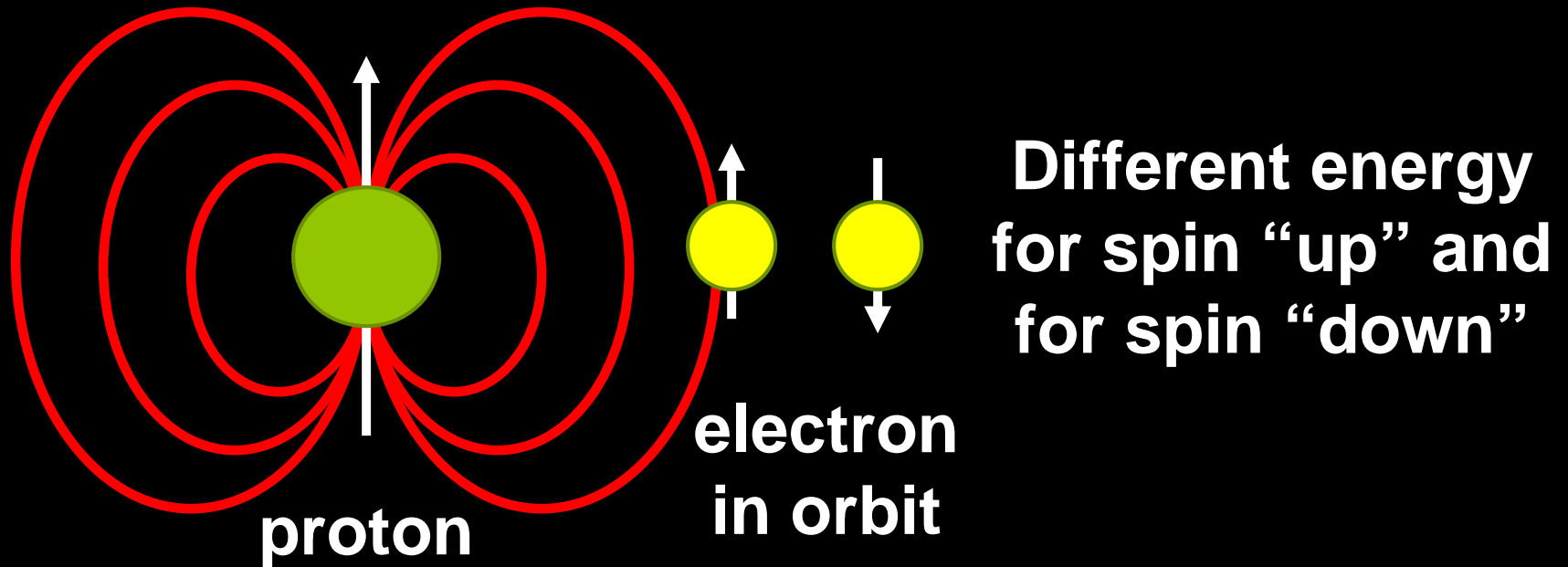**(but running out of powers of 10)**

CONTACT

Directed by Robert Zemeckis
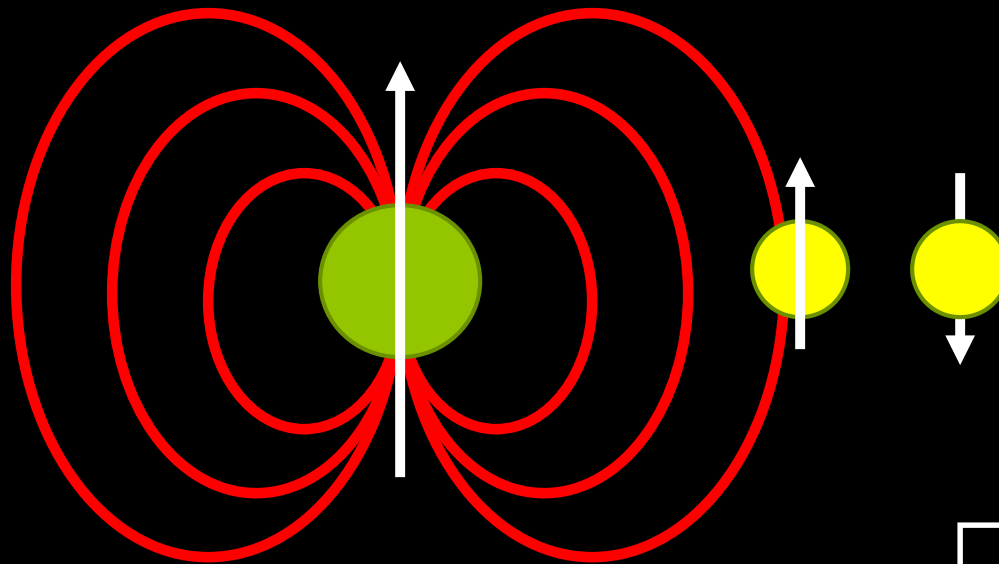## Warner Brothers (1997)

("VLA signal" 0:07:41)

SETI:
The science behind the search for extraterrestrial intelligence

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Interaction of the electron in Hydrogen with the magnetic field of the proton

Different energy for spin "up" and for spin "down"

proton

electron in orbit

4.462 gigahertz…
Hydrogen times Pi ?????

Interaction of the electron in Hydrogen with the magnetic field of the proton

Different energy for spin "up" and for spin "down"

Frequency emitted when spin flips:
f = 1.420 GHz

f x π = 4.462 GHz

4.462 gigahertz…
Hydrogen times Pi ?????

Enterprise
"Broken Bow"

Written by Rick Berman and Brannon Braga

Paramount (2001)

**First contact…
How will we communicate?
Machine learning: language translator technology**

Arrival

Directed by Denis Villeneuve

Paramount (2016)

First contact…
How will we communicate?
Teaching and learning each other's language

Men In Black

Directed by Barry Sonnenfeld
Columbia Pictures (1997)

Protecting us from the *dangerous aliens*

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Fifth Major Question:
What does it mean to be human?

Next time…