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Looking for Life

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Looking for Life

Abstract

The topic of aliens is not just about conspiracy theories and tinfoil hats, through the years numerous respected scientists have weighed in and put thought into the topic. The Search for Extraterrestrial Intelligence (SETI) is closely tied to the Fermi Paradox and the Drake Equation. The Fermi Paradox considers why humans haven't already interacted with aliens if they exist, and the Drake Equation outlines potential variables that would influence the chances of humanity receiving radio contact from an alien civilization.

Keywords

Aliens, Drake, Fermi, SETI, Probability

Disciplines

Other Astrophysics and Astronomy | Probability

Comments

This poster was created based on work completed for FYS 146-3 Probability, Prediction, & Paradox, and presented as a part of the eighth annual CAFE Symposium on February 8, 2023.
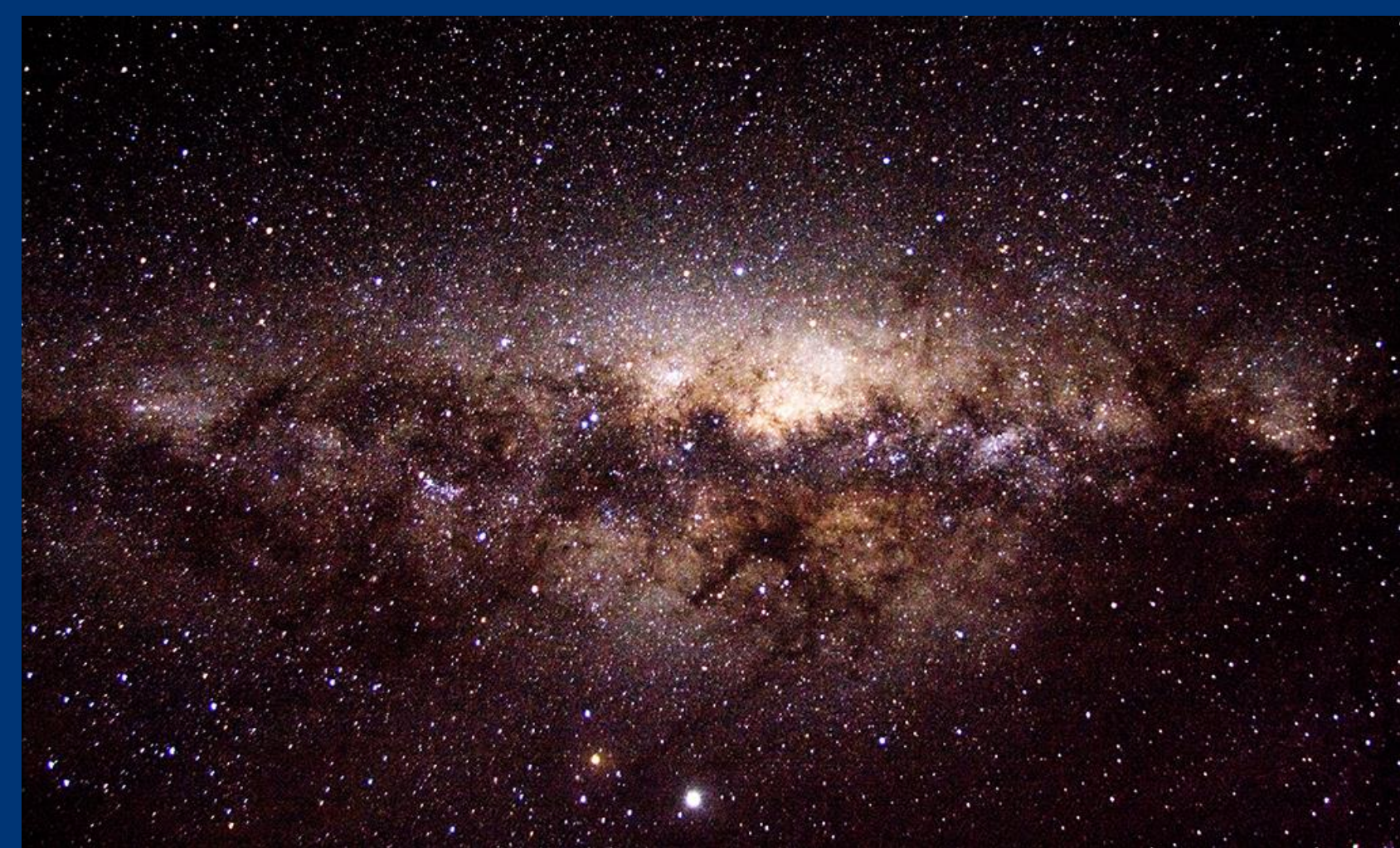
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Looking for Life

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First Year Seminar - Probability, Prediction, & Paradox, Gettysburg College, Gettysburg, PA

Gettysburg COLLEGE

Background

- The Search for Extraterrestrial Intelligence (SETI) is often associated with conspiracy theories, tin foil hats, and The History Channel's *Ancient Aliens*, but in reality it is a topic that many respected scientists have weighed in on, from Carl Sagan to Stephen Hawking.

- Since the mid-20th century some scientists have believed there could be highly advanced aliens in the universe now, that could have great potential for exploration and colonization. This belief is in great part to the age, about 14 billion years, and size, potentially 4×10^{22} stars, of the universe, and how unlikely it seems that humans are alone in intelligence among it all.

- Particularly for SETI, radio communication from alien civilizations is what they are interested in discovering. Radio-astronomers have been actively listening out into space for nearly 70 years – still to no avail, which on a universal scale is barely a drop in the bucket.

- Modern SETI largely began with a conference in Green Bank, West Virginia, 1961, to bring together researchers who were considering the alien question. It is impossible to talk about SETI without the Fermi Paradox, and Drake Equation.

- Another important concept when it comes to SETI, and science in general, is the Evidence of Absence fallacy, which states "an absence of evidence is not evidence of absence."

- When considering the possibility of extraterrestrial life, the important distinctions are made between mere existence, communication, and contact.

Fermi and his Paradox

- Dr. Enrico Fermi was one of the most brilliant physicists of the early 20th century, he was accomplished in both theoretical and experimental physics, he was the first person to create a functional nuclear reactor, the first to hypothesize about a subatomic neutrino, and the recipient of the 1938 Nobel Prize in Physics.

- In the summer of 1950, he was working in Los Alamos, New Mexico, and the national buzz about aliens was growing, from stories of stolen trash cans, media coverage, and movies all playing into the hype.

- He was at a lunch with colleagues of his, where he was known to give conversation stimulating questions, when he said, "Where is everybody?" The topic of discussion had been flying saucers, so after a moment his colleagues realized what he meant.

- Fermi was basically saying was, "is aliens are real, why haven't we met them already?" After some quick calculations, which were unfortunately not saved, Fermi estimated the number of alien civilizations, and from that determined humanity should have already received communication or direct contact even.

- This is the foundation for the eponymously named, Fermi Paradox, which states that if life really is abundant in the universe, then Earth should have already been visited and humans should be well aware of their existence.

Equation Variables

- $N =$ — The number of radio-communicative civilizations in the Milky Way Galaxy
- R — The rate of formation of "sun-like" stars in the galaxy *
- f_p — The probability a "sun-like" star has planets
- n_e — The average number of "Earth-like" planets per "sun-like" star
- f_l — The probability that life forms on an "Earth-like planet"
- f_i - The probability that **intelligent** life develops on a planet with life
- f_c — The probability that the technology needed to communicate into space is created on a planet with intelligent life
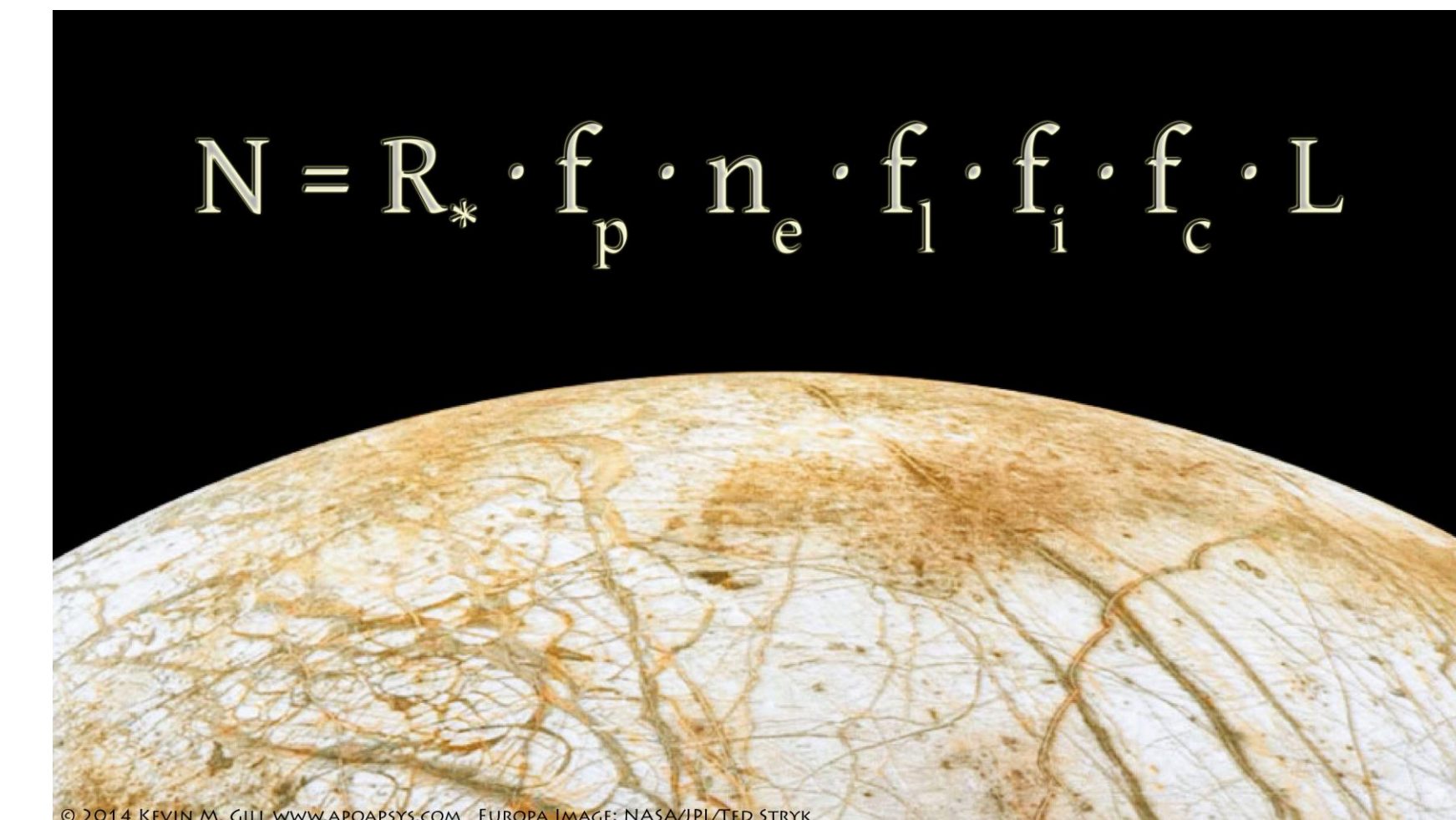- L — The average of a radio-communicative civilization

* R is the only value scientists have determined to any real degree of accuracy, that value being about 7 new stars formed in the Milky Way per year.
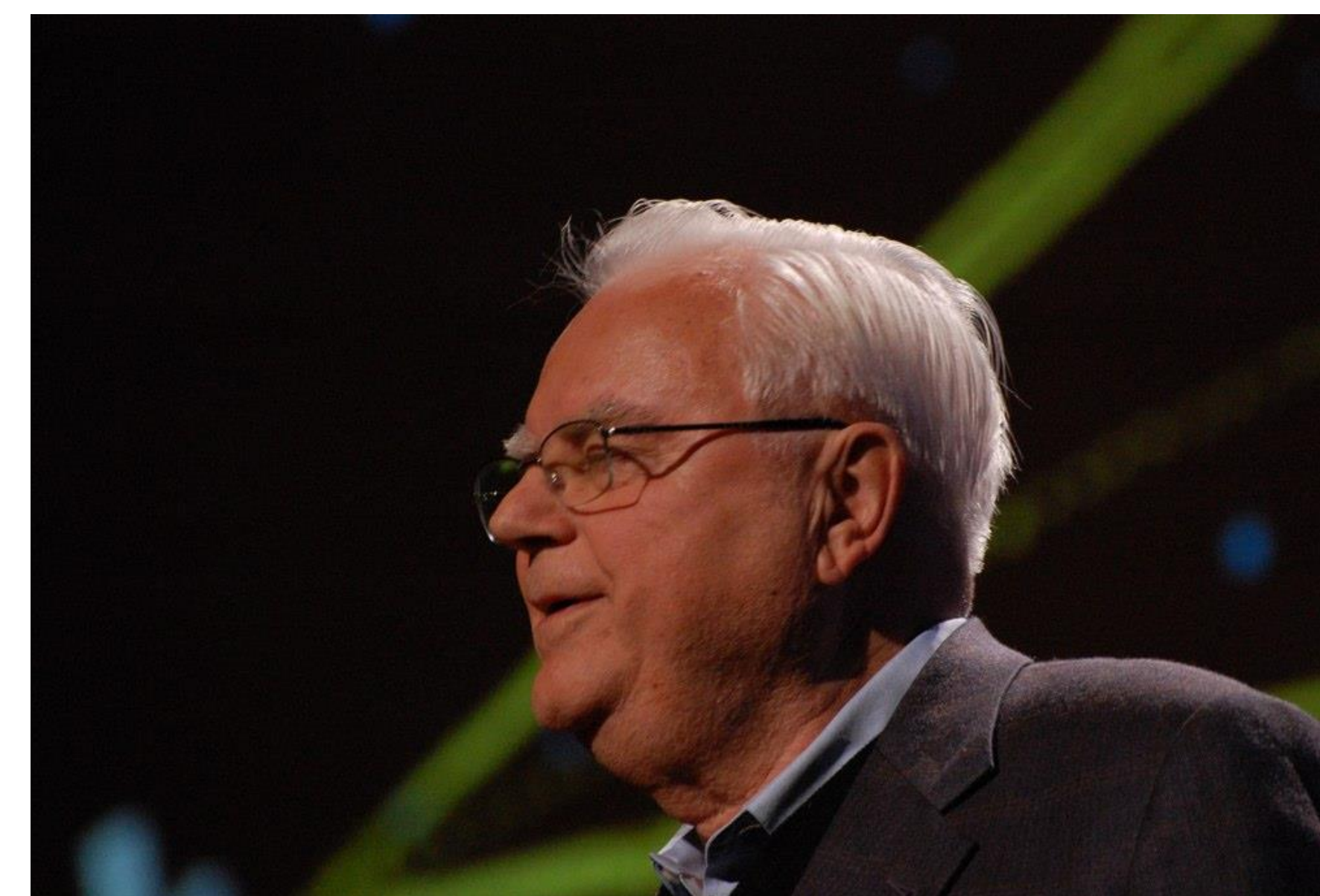
Project Ozma

The Drake Equation

$$N = R_* \cdot f_p \cdot n_e \cdot f_l \cdot f_i \cdot f_c \cdot L$$
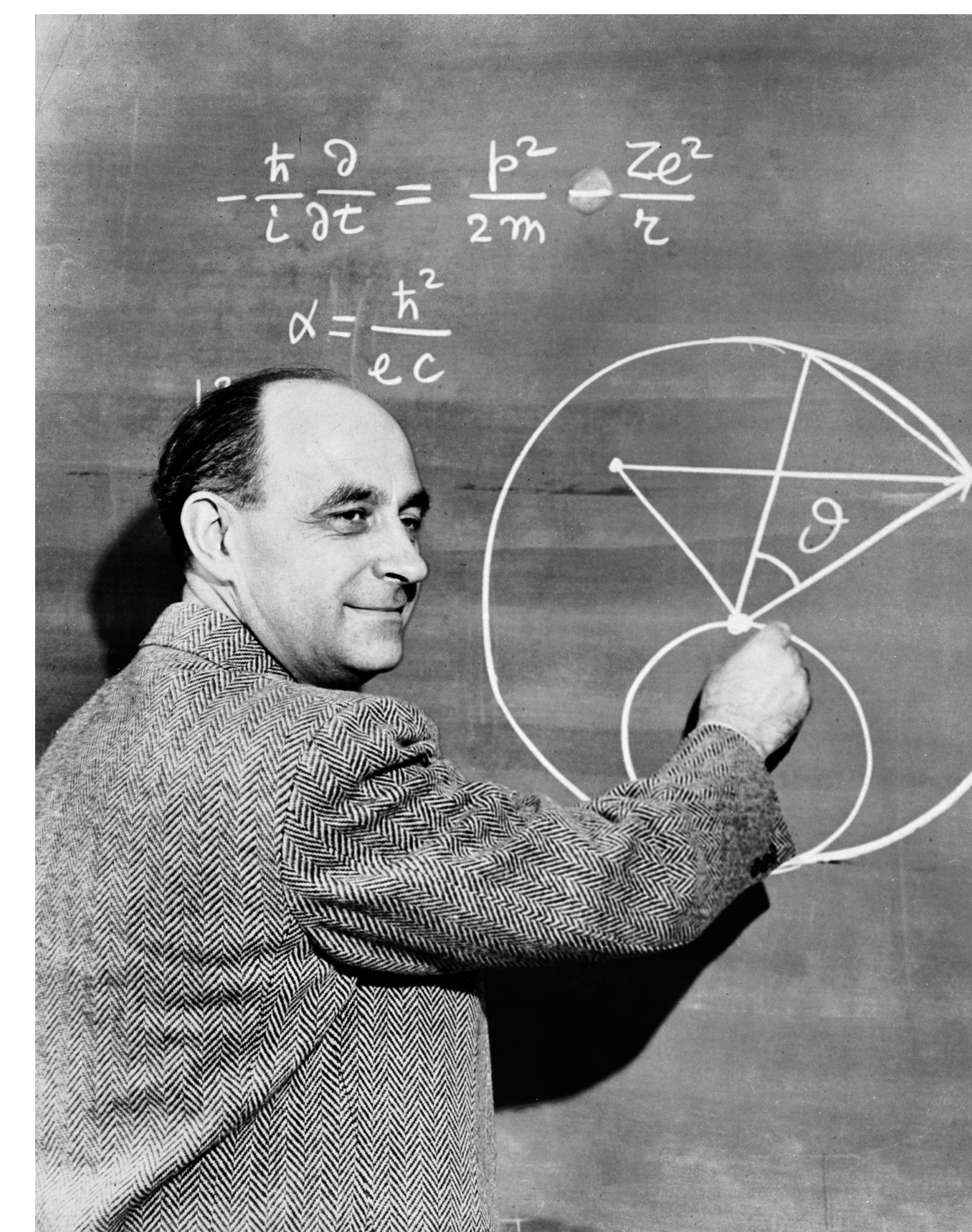
Frank Drake

Enrico Fermi

Drake and his Equation

- Dr. Frank Drake was working at a newly constructed observatory in 1961 when he decided to attempt to listen for extraterrestrial radio signals. He built the attachments for the 85-foot telescope himself to enable him to listen for space signals.

- He dubbed his effort **Project Ozma**, aiming the telescope at two relatively close sun-like stars, Tau Ceti and Epsilon Eridani. Though he didn't have any positive findings, this helped to spark the modern SETI.

- It was for the SETI conference in Green Bank, West Virginia, that Drake created his eponymous equation. Equation is a bit of a misnomer, as it less exactly calculates a value, and acts more as a thought experiment about important factors and possible values.

- In the equation, as in probability, the variables can be multiplied together, under the assumption that they are independent. In a Fermat-ian probability kind of way, Drake defines the probabilities as the number of planets of interest by total planets in that category.

Potential Explanations

Fermi Paradox & Drake Equation Solutions

- One explanation is that humans really are alone in the universe, thus making the probability of meeting them 0. This comes from the viewpoint that the evolutionary steps are too complex, improbable, and downright freakish, making Earth the unlikely outlier. If any variable is close to 0, the resulting N will be in all practicality 0.

- Drake's own belief was that all variables would cancel or be equal to 1, and only L would matter, which by his estimate was 10,000.

- An important distinction Drake made in his equation was that the life be **intelligent**. There could be microbial life humans would never encounter.

The simplified example below shows how most of the middle fractions would cancel out in the probabilistic variables.

f_p	$\times$	n_e	$\times$	f_l	$\times$	f_i	$\times$	f_c
$\frac{250\ star\ w/\ planets}{1000\ total\ stars}$	$\times$	$\frac{avg.\ 2\ Earth-like\ planets}{star\ with\ planets}$	$\times$	$\frac{100\ planets\ w/\ life}{500\ Earth-like\ planets}$	$\times$	$\frac{50\ planets\ w/\ intelligence}{100\ planets\ w/\ life}$	$\times$	$\frac{2\ communicating\ planets}{50\ planets\ w/\ intelligence}$

Legacy

More recently another work was published building upon the existing Drake Equation. In 2012 Claudio Maccone wrote a paper entitled *The Statistical Drake Equation*, and in it he approaches the question from a mathematically more rigorous point of view. He creates statistical models, and more heavily emphasizes the evolutionary factor, about which slightly more is know now than when the equation was first imagined.

For now, though, humanity can only wait: wait to be found, or wait to find others.