The Topic for Astro-1 Honors 2019 Seminar will be:
Is anybody out there?

https://www.youtube.com/watch?time_continue=56&v=yd18oZqdmdo
HOAX!
No, NASA did NOT Intercept An Intergalactic Distress Call in 1998

Andromeda, our closest galactic neighbor, 2.5 million light years away.

NASA has not issued any press release about such an intergalactic distress call. Nor are there any credible news or media reports about such a message.

“Dr. Viktor Kulakov” is neither a noted Russian space scientist nor is he in charge of any United Nations research group. A “Viktor Kulakov” was a high-ranking military leader in the former Soviet Union, but he was not a space scientist. He died in May 2013.
Humans have been fascinated with the idea of alien civilizations and UFOs for hundreds of years.

upper left: pure fiction

upper middle: view from the ground of the Falcon Heavy returning to Vandenberg

upper right: Pulsar

lower left: artist’s drawing of Parkes Telescope in Australia, catching a fast radio burst from space
Historic fascination with communicating with aliens – claimed UFO sightings.

A photo of a purported UFO over Passaic, New Jersey in 1952

*Roswell Daily Record*, July 8, 1947, announcing the "capture" of a "flying saucer"
Earliest recorded purported sighting: Ancient Egypt, 1440 BC

<table>
<thead>
<tr>
<th>Date</th>
<th>Name</th>
<th>City, State</th>
<th>Country</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>ca. 1440 BC</td>
<td>Fiery disks</td>
<td>Lower Egypt</td>
<td>Ancient Egypt</td>
<td>According to the disputed <a href="#">Tulli Papyrus</a>, the scribes of the pharaoh Thutmose III reported that &quot;fiery disks&quot; were encountered floating over the skies.</td>
</tr>
</tbody>
</table>

Most alleged sightings are not supported by hard evidence, and some are explained as air force trainings or large contrails from launches, for example: SpaceX
“UFOlogist” J. Alan Hynek studied UFO sightings; published book in 1972 *The UFO Experience: A Scientific Inquiry*

**Hynek Scale: Close Encounters**

**Nocturnal Lights**
Lights in the night sky

**Daylight Discs**
UFOs seen in the daytime, generally having discoidal or oval shapes

**Radar-Visual**
UFO reports that have radar confirmation. These seem to offer harder evidence that the objects are real, although radar propagation can often be unreliable.

**Close Encounters of the First Kind**
Visual sightings of an unidentified flying object, seemingly less than 500 feet away, that show an appreciable angular extension and considerable detail
Close Encounters of the Second Kind

A UFO event in which a physical effect is alleged. This can be interference in the functioning of a vehicle or electronic device; animals reacting; a physiological effect such as paralysis or heat and discomfort in the witness; or some physical trace like impressions in the ground, scorched or otherwise affected vegetation, or a chemical trace.[10]

Close Encounters of the Third Kind

UFO encounters in which an animated creature is present. These include humanoids, robots, and humans who seem to be occupants or pilots of a UFO.[11]

The extraterrestrial hypothesis (ETH) proposes that some unidentified flying objects (UFOs) are best explained as being physical spacecraft occupied by extraterrestrial life or non-human aliens, or non occupied alien probes from other planets visiting Earth.
NO ALIENS HAVE BEEN FOUND.

But that does not stop us from searching!
What questions and associations does this topic bring up for you?
Discuss with neighbors, write on board.
Broad questions associated with searches for ETIs:

1. Are we alone in the galaxy?

   The universe?

   How can we know?
1. Are we alone in the galaxy? The universe? How can we know?

2. What is the likelihood that life developed elsewhere, contemporaneously with, or before or after, life on Earth?
1. Are we alone in the galaxy? The universe? How can we know?
2. What is the likelihood that life developed elsewhere, contemporaneously with life on Earth?

3. If we are not alone, where are the others, and why have we not detected any signals from them?
1. Are we alone in the galaxy? The universe? How can we know?
2. What is the likelihood that life developed elsewhere, contemporaneously with life on Earth?
3. If we are not alone, where are the others, and why have we not seen (optically) or heard (via radio waves) or detected (via microwaves) any signals from them?

4. Is water the only basis for life? Or just the most likely? Could there be other life forms based on carbon or silicon? If so, how could we communicate with them?
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5. If we are not alone, what is the likelihood that terrestrial life was seeded by living organisms from elsewhere in our Solar System? Our galaxy? (a phenomenon known as panspermia)
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5. If we are not alone, what is the likelihood that terrestrial life was seeded by living organisms from elsewhere in our Solar System? Our galaxy? (a phenomenon known as panspermia)

6. Should we be spending money and time looking for ETs?
To authorize the programs of the National Aeronautics and Space Administration for fiscal years 2018 and 2019...

Subtitle B—Astronomy and Astrophysics

SEC. 311. SEARCH FOR THE ORIGIN, EVOLUTION, DISTRIBUTION, AND FUTURE OF LIFE IN THE UNIVERSE.

AUTHORIZED FUNDING.—Subject to the availability of appropriations, the Administrator shall make available at least $10,000,000 for each of fiscal years 2018 and 2019 for the search for technosignatures.
1. Are we alone in the galaxy? The universe? How can we know?
2. What is the likelihood that life developed elsewhere?

**hypothetical prediction: The Drake Equation**

<table>
<thead>
<tr>
<th>Term</th>
<th>Value</th>
</tr>
</thead>
<tbody>
<tr>
<td>The number of civilizations in our galaxy</td>
<td>known</td>
</tr>
<tr>
<td>The average rate of star formation per year in our galaxy</td>
<td>ALL?</td>
</tr>
<tr>
<td>The fraction of those stars with planets</td>
<td>unknown</td>
</tr>
<tr>
<td>The average number of those planets that may develop an ecosystem</td>
<td>unknown</td>
</tr>
<tr>
<td>The fraction of those planets that succeed in developing life</td>
<td>unknown</td>
</tr>
<tr>
<td>The fraction of those planets with intelligent life that develop interstellar communication</td>
<td>unknown</td>
</tr>
<tr>
<td>The average length of time such civilizations survive and continue to send communications</td>
<td>unknown</td>
</tr>
</tbody>
</table>

Dr. Frank Drake  
Professor of Astronomy, Cornell University  
Director, National Astronomy and Ionosphere Center at Arecibo, Puerto Rico
Where would intelligent life most likely arise? Around stars not too different from our Sun: Single, of mass 0.4 to 1.4 times the Sun's mass, and inhabiting a calm galactic neighborhood for three or more billions of years.

Stellar Influences on the Emergence of Intelligent Life, Martin Cohen, 1981

https://history.nasa.gov/CP-2156/contents.htm

Kepler and K2 Missions found thousands of planets orbiting other stars in our galactic neighborhood – actually more planets than stars!
Region of our galaxy imaged by Kepler and K2 Missions, looking for exoplanets

https://www.youtube.com/watch?v=3yij1rJOefM
Types of planets discovered by Kepler and K2 compared to Earth, Neptune, and Jupiter
**HABITABLE ZONE**: the range of orbits around a star within which a planetary surface can support liquid water given sufficient atmospheric pressure.
### TABLE IV

**Habitable Zones about Main-Sequence Stars**

<table>
<thead>
<tr>
<th>Stellar mass ((M/M_☉))</th>
<th>Approximate spectral type</th>
<th>Continuously habitable zone</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td></td>
<td>(r_{\text{inner}}) ((\text{AU}))</td>
</tr>
<tr>
<td>1.20</td>
<td>F7</td>
<td>1.543</td>
</tr>
<tr>
<td>1.15</td>
<td>F8</td>
<td>1.370</td>
</tr>
<tr>
<td>1.10</td>
<td>F9</td>
<td>1.221</td>
</tr>
<tr>
<td>1.05</td>
<td>G0</td>
<td>1.083</td>
</tr>
<tr>
<td>1.00</td>
<td>G2</td>
<td>0.958</td>
</tr>
<tr>
<td>0.95</td>
<td>G5</td>
<td>0.840</td>
</tr>
<tr>
<td>0.90</td>
<td>G8</td>
<td>0.732</td>
</tr>
<tr>
<td>0.85</td>
<td>K0</td>
<td>0.634</td>
</tr>
<tr>
<td>0.80</td>
<td>K2</td>
<td>0.542</td>
</tr>
<tr>
<td>0.75</td>
<td>K4</td>
<td>0.460</td>
</tr>
<tr>
<td>0.715</td>
<td>K5</td>
<td>0.407</td>
</tr>
</tbody>
</table>

*Our Sun*
Approximate relationship between Mass and Luminosity:

\[ L \sim M^{3.5} \]

for main sequence stars
A Hertzsprung-Russell (H-R) diagram

- Surface temperature (K)
- Luminosity ($L_\odot$)
- Absolute magnitude
- Spectral type (O5 B0 A0 F0 G0 K0 M0 M8)

**White dwarfs**

**Giants**

**Supergiants**

The red curve is the main sequence.
H-R diagram with masses

Greater mass means greater central pressure & temperature and greater luminosity...

Greater core pressure increases the RATE of nuclear reactions, resulting in greater luminosity.
These numbers are in “solar masses” where our Sun has 1 solar mass.

NOTE: More massive stars are more luminous!!
Kepler’s Small Habitable Zone Planets

As of May 10, 2016
Why do we define the habitable zone as the region where the planet can maintain liquid water on its surface?

Because basically all life forms on Earth are water based.

Hypothetical silicon-based life form
Proxima Centauri: Red dwarf star in long period orbit around Alpha Centauri. Proxima b orbits Proxima Centauri in its habitable zone, but is Proxima b habitable?

closest star system to us: Alpha Centauri System, ~4.2 ly
Red dwarf stars, the most common types of stars in the galaxy and the oldest, often have unpredictable flares, and hence any planets orbiting them are not likely to have evolved life.
Life needs sufficient time to develop.
It takes a helluva long time for intelligent life to develop!
Looking out in space = looking back in time. In an expanding universe the distance between galaxies increases over time.

We see neighboring galaxies as they were when the light we see “now” left them.
Thus if intelligent life has developed in other galaxies parallel with us, we can never communicate with them as they “are now” unless they or we can travel to each other’s galaxy.

“As I understand it, they want an immediate answer. Only trouble is, the message was sent out 3 million years ago.”
Thus far, every unusual signal from space that was at first suspected to be from alien civilizations has turned out to be from a newly discovered astrophysical phenomenon – pulsars, quasars, and fast radio bursts.
For next week: Ponder the question of how Earth civilization would change if we actually found a signal from an intelligent extra terrestrial civilization, given the constraints we have discussed today.