2024 Fall semester (September 1, 2025)

Extraterrestrial Planets and Life

Building #43-1-402 (14:00-15:15)

Course Number: C40.122

Lecture Number: 001

Instructor: Masateru ISHIGURO

Department of Physics and Astronomy,

Seoul National University

Contents of today's class

- Quota-exceeding course registrations (QECR)
- How can you contact us?
- How can you get lecture notes?
- How will you be evaluated?
- How will we check your attendance?
- Class Schedule
- Exams
- About the lecturer (self-introduction)
- Scope of the class

0. Quota Exceeding Course Registration

- I will allow about 6 quota-exceeding course registrations (QECR).
- Please raise your hand if you wish to apply for QECR.
- The QECR is closed at this time to ensure smooth lecture management in the future.

1-1. How can you contact me or the TA?

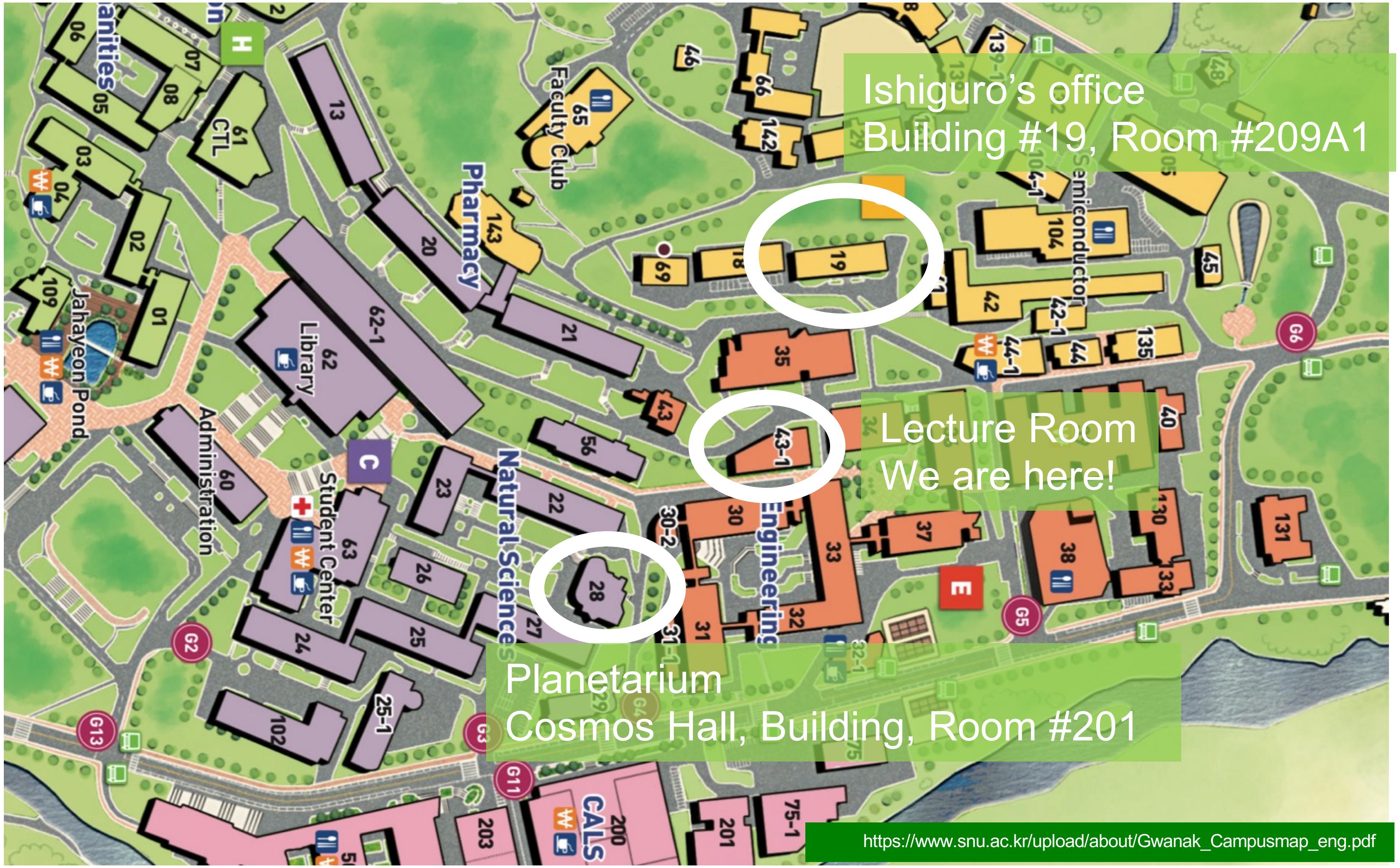
Contact Addresses

- Lecturer
  Masateru ISHIGURO — ishiguro@snu.ac.kr
  ishigrmt@gmail.com
  Building 19, Room 209A1
  010-6367-1496

- Teaching Assistants
  Seung-Yoo Lee — studymoon@snu.ac.kr

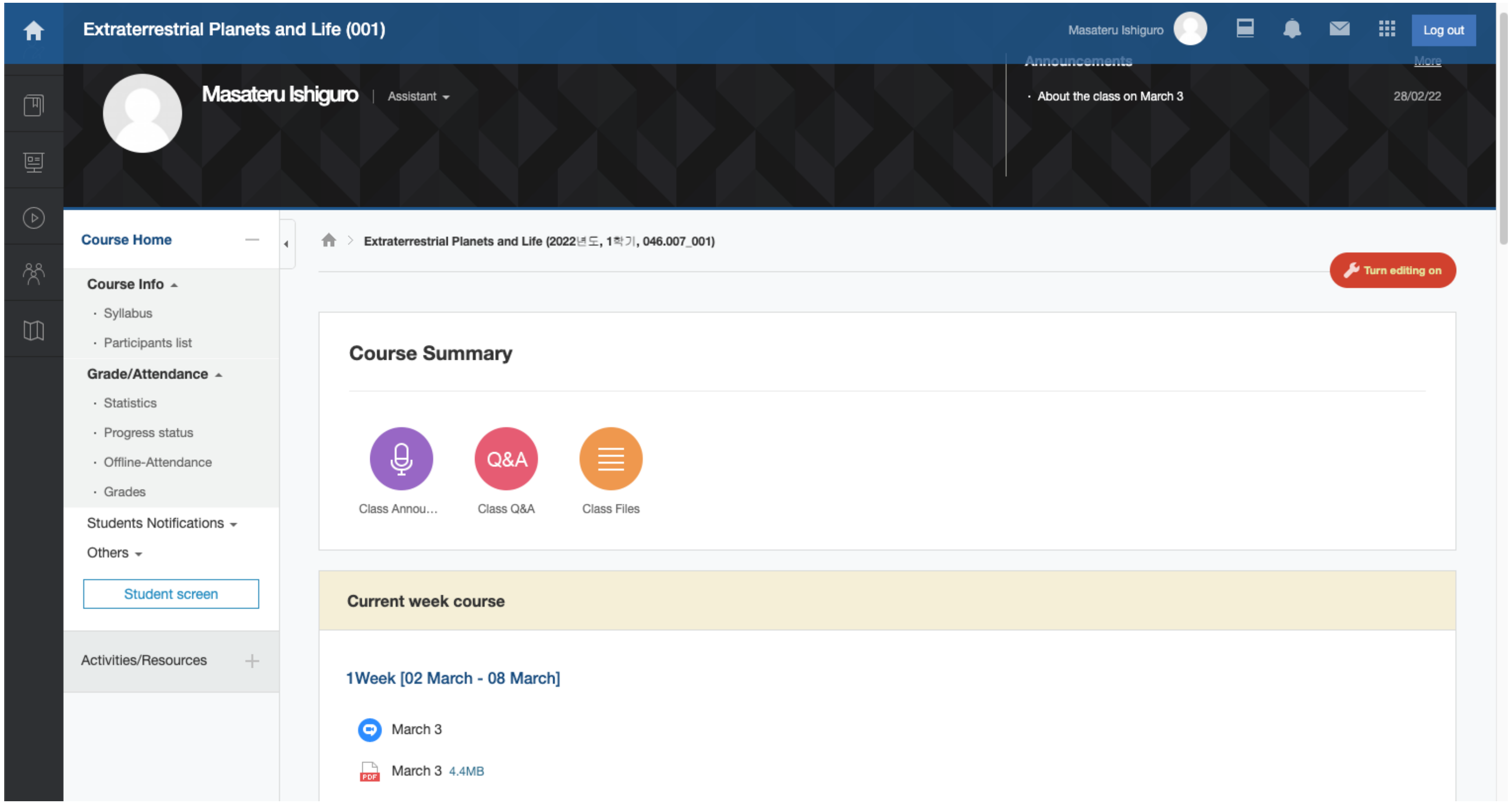
If you have any questions about the class, please do not hesitate to contact M. Ishiguro or Seung-Yoo (as the TA). When you want to visit us, we would appreciate it if you could email us in advance to confirm our available time.

1-2. Important locations



Planetarium session will be given once or twice this semester.
We will announce the date via eTL once the schedule is fixed.

2. How can you get lecture materials?



I plan to upload the lecture materials before the classes.

http://etl.snu.ac.kr/

4. How will you be evaluated?

(%)

Attendance	Assignment	Midterm exam	Final exam	Attitude	Total
25	0	35	35	5	100

As: 20−30 %
Bs: 30−40 %
and others (C, D, F)

Students who are absent for over 1/3 of the class will receive a grade of 'F'. (Exceptions may be granted if the instructor deems the reason for absence unavoidable)

If you have an official reason for the absence, please submit a certificate to the TA.

5. How will we check your attendance?

- Attendance requirements: You should arrive within 10 minutes of the lecture start and attend the class until the end.
- Late Arrival (tardiness): You should arrive within 45 minutes of the start of the lecture and attend until the end of the lecture. Late arrivals are counted as 2/3 attendance.
- If you are going to leave early, please contact your TA or the instructor and explain. Leaving early without permission is prohibited.
- Regarding the attendance issue, please contact TA.

6. Tentative schedule

Monday	Wednesday
9/1 (today)	9/3
9/8	9/10
9/15	9/17
9/22	9/24
9/29	10/1
10/6 (holiday)	10/8 (holiday)
10/13	10/15
10/20 (midterm)	10/22
10/27	10/29
11/3	11/5
11/10	11/12
11/17	11/19
11/24	11/26
12/1	12/3
12/8 (Final exam)	12/10 (no class)

7. Exams

- Midterm Exam (35%)

  The midterm exam will take place on October 20. We plan to conduct the exam offline.

- Final Exam (35%)

  The final exam will take place on December 8. Similarly, we plan to conduct the exam offline.

- Answers should be written in English.

- The exam questions consist of multiple-choice and descriptive questions. The ratio of the distribution of points is approximately 30:70.

8. Who am I?

Astronomer

Planetary Scientist

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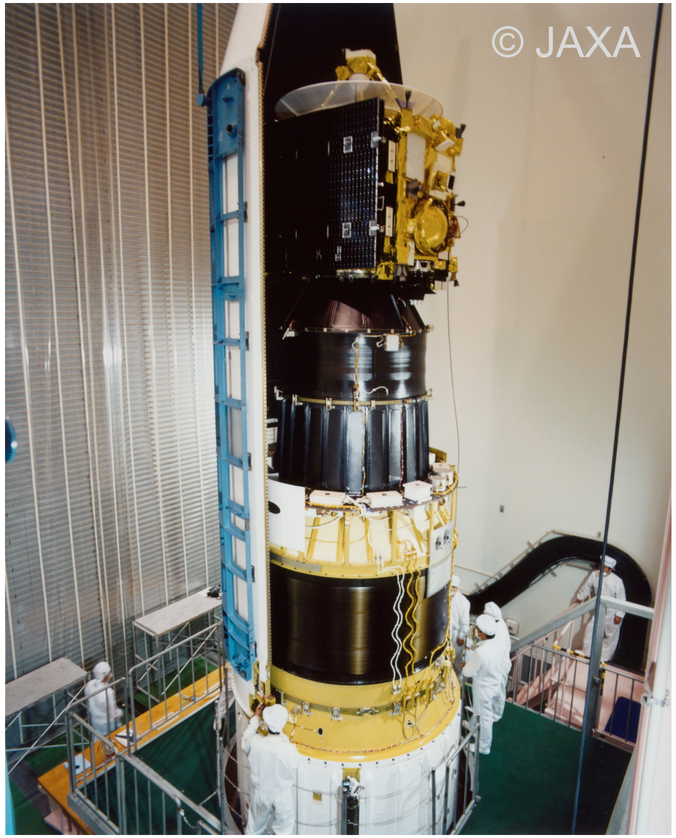
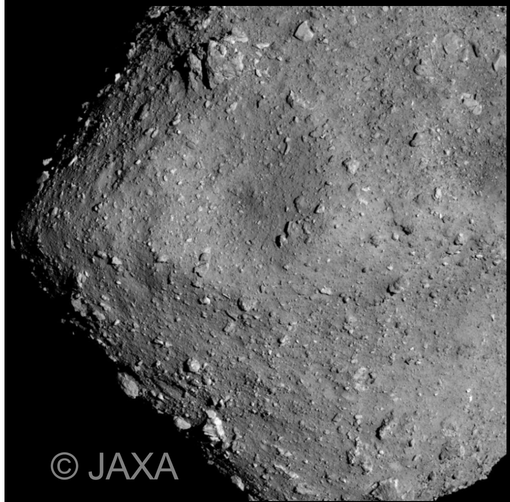
Astronomer



Planetary Scientist

9. My Research at SNU

Origin of water



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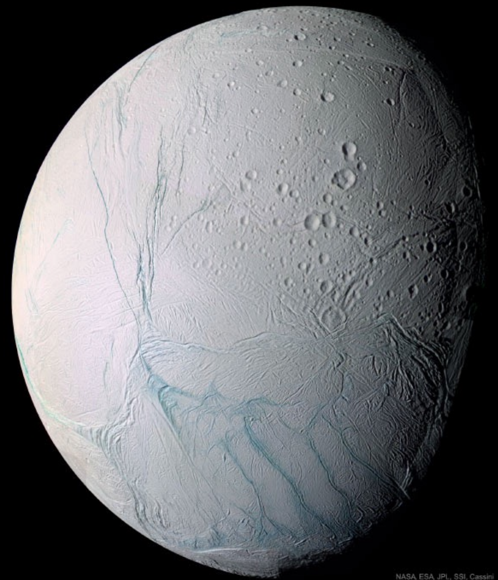
Evolution of the solar system

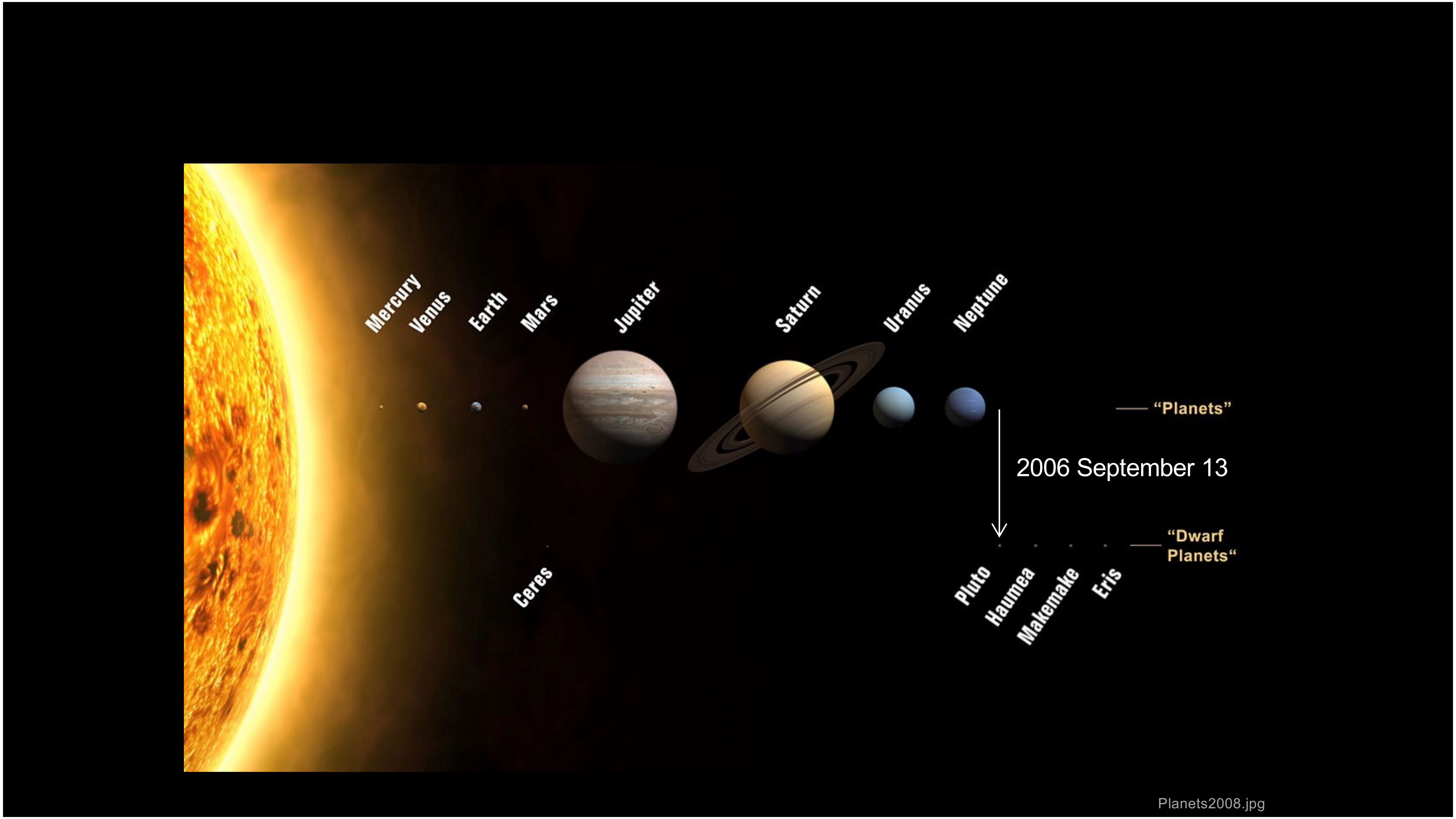
Ice in the solar system



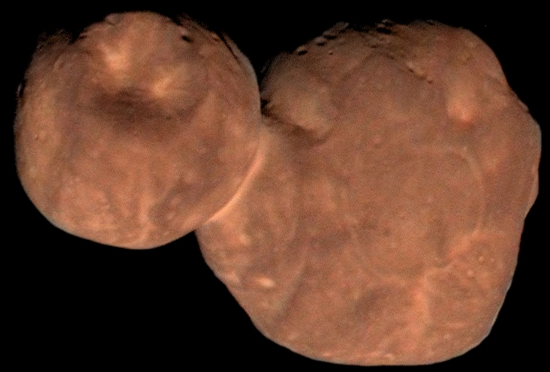
© NASA

10. Objective of the Course

- People have long speculated about the possibility of life outside of the Earth.
- We seek the generality of Earth-like planets and life in the universe and consider the place of human beings in the universe.


Mercury
Venus
Earth
Mars
Jupiter
Saturn
Uranus
Neptune
"Planets"
2006 September 13
"Dwarf Planets"
Ceres
Pluto
Haumea
Makemake
Eris
Planets2008.jpg

New Horizon was launched on 2006 January 19 and flew by the Pluto on July 14, 2015.



43 astronomical units from the sun

Image credit: NASA

New Horizon conducted a flyby of a Kuiper-belt object, Arrokoth, on 2019 January 1.

10. Purpose of the Course

- People have long speculated about the possibility of life outside of the Earth.
- We seek the generality of Earth-like planets and life in the universe and consider the place of human beings in the universe.
- In recent years, various kinds of materials related to life have been found by astronomical observations and space exploration. These discoveries suggest an exogenous origin of organic matter on the early Earth.

- Murchison meteorite: one of the most studied meteorites collected in 1969
- Over 100 amino acids have been identified in the meteorite, such as glycine, alanine, and glutamic acid, as well as unusual ones on the Earth→ contamination?

Image credit: JAXA

- Hayabusa2 delivered asteroid materials to Earth on 2020 December 15. From this sample, amino acids have been detected in the returned samples!

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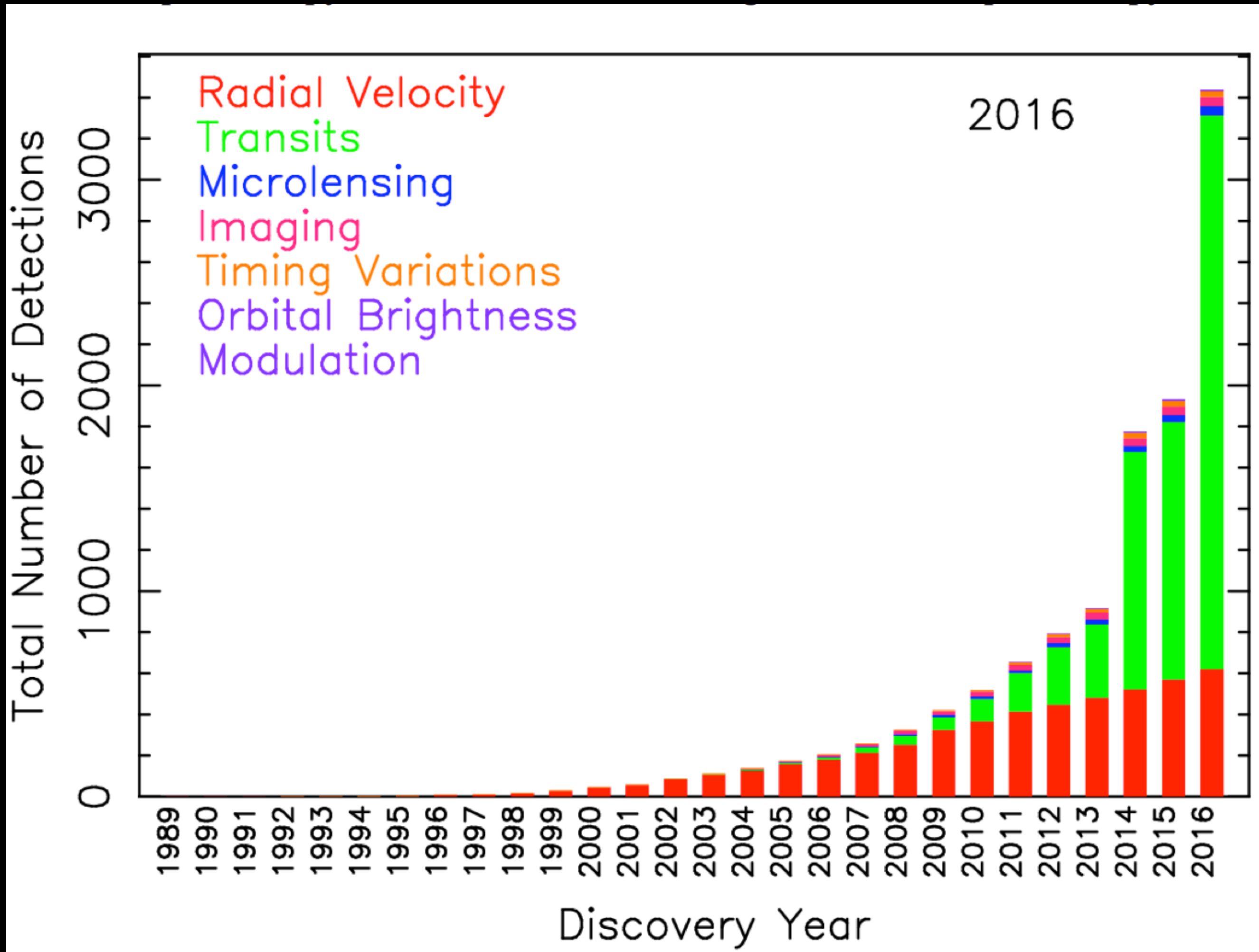
- In recent years, various kinds of materials related to life have been found by astronomical observations and space exploration. These discoveries invoke an exogenous origin of organic matter to the early Earth.

- On the other hand, advances in the astronomical instrumentation technique have increased the detection of the exoplanetary systems. Earth-like planets (in terms of size and temperature) have been confirmed.



https://exoplanets.nasa.gov/

LETTER

doi:10.1038/nature21360

Seven temperate terrestrial planets around the nearby ultracool dwarf star TRAPPIST-1

Michaël Gillon[1], Amaury H. M. J. Triaud[2], Brice-Olivier Demory[3,4], Emmanuël Jehin[1], Eric Agol[5,6], Katherine M. Deck[7], Susan M. Lederer[8], Julien de Wit[9], Artem Burdanov[1], James G. Ingalls[10], Emeline Bolmont[11,12], Jeremy Leconte[13], Sean N. Raymond[13], Franck Selsis[13], Martin Turbet[14], Khalid Barkaoui[15], Adam Burgasser[16], Matthew R. Burleigh[17], Sean J. Carey[10], Aleksander Chaushev[17], Chris M. Copperwheat[18], Laetitia Delrez[1,4], Catarina S. Fernandes[1], Daniel L. Holdsworth[19], Enrico J. Kotze[20], Valérie Van Grootel[1], Yaseen Almleaky[21,22], Zouhair Benkhaldoun[15], Pierre Magain[1] & Didier Queloz[4,23]

One aim of modern astronomy is to detect temperate, Earth-like exoplanets that are well suited for atmospheric characterization. Recently, three Earth-sized planets were detected that transit (that is, pass in front of) a star with a mass just eight per cent that of the Sun, located 12 parsecs away[1]. The transiting configuration of these planets, combined with the Jupiter-like size of their host star—named TRAPPIST-1—makes possible in-depth studies of their atmospheric properties with present-day and future astronomical facilities[1–3]. Here we report the results of a photometric monitoring campaign of that star from the ground and space. Our observations reveal that at least seven planets with sizes and masses similar to those of Earth revolve around TRAPPIST-1. The six inner planets form a near-resonant chain, such that their orbital periods (1.51, 2.42, 4.04, 6.06, 9.1 and 12.35 days) are near-ratios of small integers. This architecture suggests that the planets formed farther from the star and migrated inwards[4,5]. Moreover, the seven planets have equilibrium temperatures low enough to make possible the presence of liquid water on their surfaces[6–8].

Among the three initially reported TRAPPIST-1 planets, one of them—called 'TRAPPIST-1d' in the discovery publication[1]—was identified on the basis of only two transit signals, observed at a moderate signal-to-noise ratio. The second transit signal, blended with a transit signal from planet c, was also observed with the High Acuity Widefield K-band Imager (HAWK-I), an infrared imager mounted on the Very Large Telescope (VLT) in Chile. When we analysed the VLT/HAWK-I data—after we submitted the discovery paper—we uncovered a light curve of high enough precision to firmly reveal the triple nature of the observed eclipse (Extended Data Fig. 1). This intriguing result motivated us to intensify our photometric follow-up of the star; this resumed in February and March 2016, with observations of six possible transit windows of TRAPPIST-1d with the Spitzer Space Telescope. Follow-up continued in May 2016 with intense ground-based observations of the star using the TRAPPIST-South telescope ... Observatory 1.0-metre telescope. Our photometric campaign culminated on 19 September 2016 with the start of a 20-day, nearly continuous monitoring of the star by the Spitzer Space Telescope at a wavelength of 4.5 μm.

The light curves obtained before 19 September 2016 enabled us to discard the 11 possible periods of TRAPPIST-1d that we inferred previously[1], indicating that the two observed transits originated from different objects. Furthermore, these light curves showed several transit-like signals of unknown origins that we could not relate to a single period (Extended Data Figs 2, 3). The situation was resolved with the 20-day photometric monitoring of the star by Spitzer. The resulting light curve shows 34 clear transits (Fig. 1), which—when combined with the ground-based dataset—enabled us to unambiguously identify four periodic transit signals of periods 4.04 days, 6.06 days, 8.1 days and 12.3 days. These signals correspond to four new transiting planets, named, respectively, TRAPPIST-1d, TRAPPIST-1e, TRAPPIST-1f and TRAPPIST-1g (Fig. 1 and Extended Data Figs 2, 3). This unique solution is supported in several ways: first, enough unique transits were observed per planet (Table 1); second, the shapes of the transit signals were consistent for each planet (see below); and finally, the Spitzer light curve is nearly continuous and its duration was longer than the periods of the four planets. The Spitzer photometry also shows an orphan transit-shaped signal with a depth of around 0.35% and a duration of about 75 minutes, occurring at around Julian Day 2,457,662.55 (Fig. 1); we attribute this signal to a seventh, outermost planet of unknown orbital period—TRAPPIST-1h. We combed our ground-based photometry in search of a second transit of this planet h, but found no convincing match.

We analysed our extensive photometric dataset in three phases. First, we performed individual analyses of all transit light curves with

Gillon et al. Nature 542, 456–460 (23 February 2017)

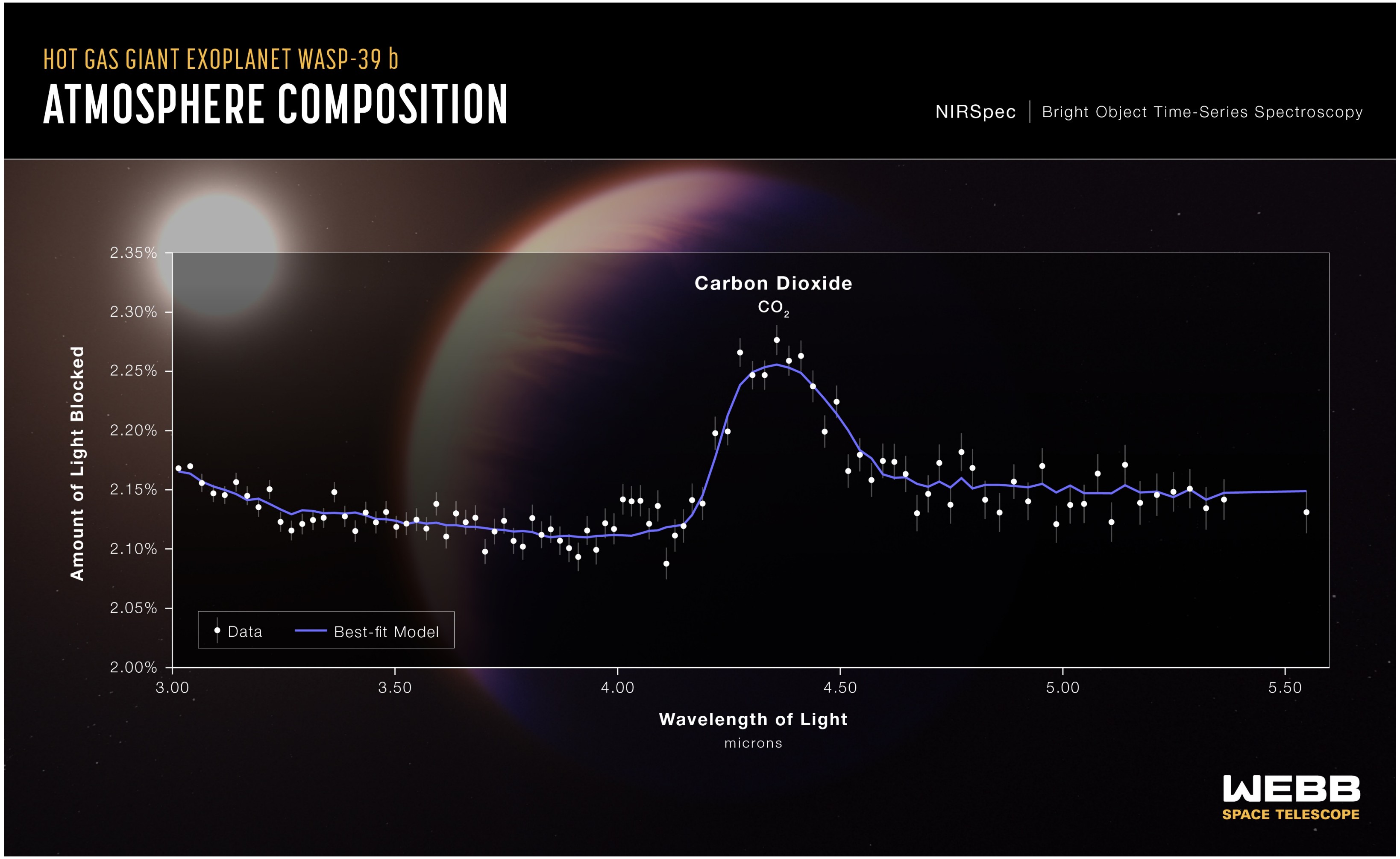
NASA Telescope Reveals Largest Batch of Earth-Size, Habitable-Zone Planets Around Single Star

This illustration shows the possible surface of TRAPPIST-1f, one of the newly discovered planets in the TRAPPIST-1 system. Scientists using the Spitzer Space Telescope and ground-based telescopes have discovered that there are seven Earth-size planets in the system.

Credits: NASA/JPL-Caltech

View this and many more images, as well as several videos, in an extensive multimedia gallery highlighting this discovery.

Feb 23, 2017



A transmission spectrum of the hot gas giant exoplanet WASP-39 b captured by Webb's Near-Infrared Spectrograph (NIRSpec) July 10, 2022, reveals the first clear evidence for carbon dioxide in a planet outside the solar system. This is also the first detailed exoplanet transmission spectrum ever captured that covers wavelengths between 3 and 5.5 microns. ***Credits: Illustration: NASA, ESA, CSA, and L. Hustak (STScI); Science: The JWST Transiting Exoplanet Community Early Release Science Team***

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- On the other hand, advances in the astronomical instrumentation technique have increased the detection of exoplanetary systems. Earth-like planets have been confirmed.
- In such a situation, we aim to acquire a broad range of general knowledge and expertise by studying the evolution of the universe, the origin of life, and exoplanetary systems. To understand these topics, students are expected to have a basic knowledge of physics and astronomy.

Please enjoy this class. I hope you like it ☺