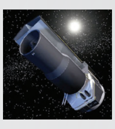
Are We Alone?

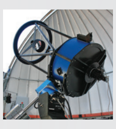
Observing the TRAPPIST-1 System

Recent observations from NASA's Spitzer Space Telescope and seven ground-based telescopes have revealed seven Earth-sized exoplanets orbiting the nearby TRAPPIST-1 star. Three of the rocky planets are in the habitable zone—where the possibility for life exists.

1,333 observation hours*

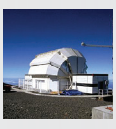


Spitzer Space Telescope Infrared Array Camera (IRAC)
518 hours



60-cm TRAPPIST–South
La Silla, Chile
469 hours

60-cm TRAPPIST–North
Oukaïmeden, Morocco
202 hours



2-m Liverpool Telescope Infrared Optical Imager (IO:O)
La Palma, Canary Islands
50 hours

4.2-m William Herschel Telescope Auxiliary-Port Camera (ACAM)
La Palma, Canary Islands
26 hours

4-m UK InfraRed Telescope (UKIRT) Wide-Field Camera (WFCAM)
Mauna Kea, Hawaii
25 hours

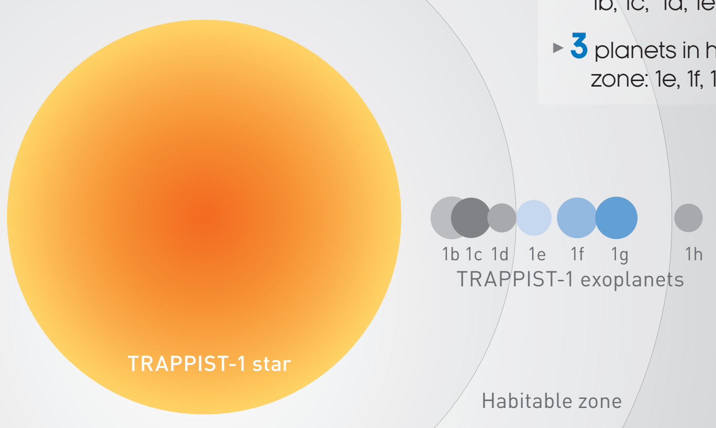
1-m SAAO with Sutherland High Speed Optical Camera (SHOC)
Sutherland, South Africa
11 hours

8-m Very Large Telescope (VLT) with High Acuity Widefield K-band Imager (HAWK-I)
Paranal Observatory, Chile
3 hours

*Including observations since December 2015 listed here

TRAPPIST-1 system

- **40** light years from Earth
- **1** ultracool dwarf star with mass **8%** of the Sun
- **7** Earth-sized exoplanets: 1b, 1c, 1d, 1e, 1f, 1g, 1h
- **3** planets in habitable zone: 1e, 1f, 1g



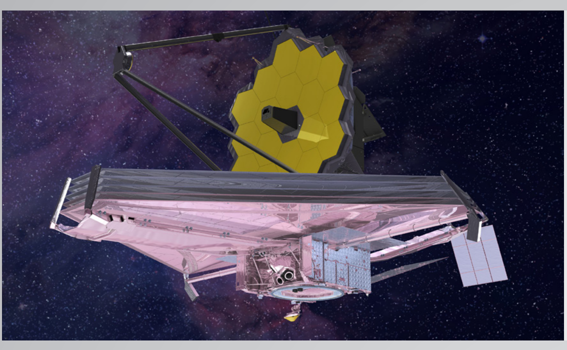
Detection & Analysis

Transit method of detection
The seven Earth-sized planets were detected by studying them as they passed across the face of the TRAPPIST-1 star, which is comparable in size to the planet Jupiter.

Habitable zone
The orbits of planets 1e, 1f and 1g are within the "habitable zone" in which a planet could support liquid water given sufficient atmospheric pressure.

Analyzing atmospheres
The star's small size relative to the transiting planets' signal makes these worlds well suited for future atmospheric study—especially by transmission spectroscopy.

What's next? The next generation of telescopes—the **James Webb Space Telescope**, the **Giant Magellan Telescope**, the **Thirty Meter Telescope** and the **European Extremely Large Telescope**—will soon join in the search.



The James Webb Space Telescope (JWST)

The JWST, scheduled to launch from French Guiana in October 2018, will have several innovative technologies to enable direct imaging of the exoplanets and to break apart the planets' light spectroscopically to reveal chemicals like oxygen and methane in the atmosphere—bringing us closer to detecting possible conditions for life.

JWST stats

LAUNCH DATE: October 2018
MISSION DURATION: 5–10 years
ORBIT: 1.5 million km from Earth, around the second Lagrange point (L2)
SIZE OF SUN SHIELD: 21.197 m x 14.162 m
OPERATING TEMPERATURE: <50 K
WAVELENGTH: Near to mid-infrared (0.6–28.5 µm)
TELESCOPE STYLE: Korsch
PRIMARY MIRROR: ~6.5 m
COLLECTING AREA: 25 m^2
FOCAL LENGTH: 131.4 m at λ=2 µm
RESOLUTION: ~0.1 arc-sec
WEBSITE: https://jwst.nasa.gov

Why orbit at the L2 point?

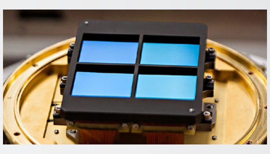
Orbiting the sun at the second Lagrange point (L2) keeps the telescope in line with the Earth as it moves around the sun, allowing the satellite's large sunshield to protect the telescope from the light and heat of the sun and Earth.

Why observe in the infrared?

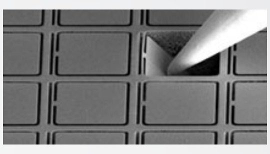
At infrared wavelengths the molecules in the atmospheres of exoplanets have the largest number of spectral features.

Observing in the infrared

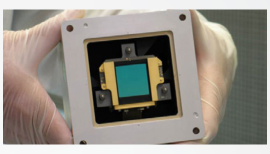
The JWST will observe primarily in the infrared and will have four science instruments—housed in the Integrated Science Instrument Module (ISIM)—to capture images and spectra.



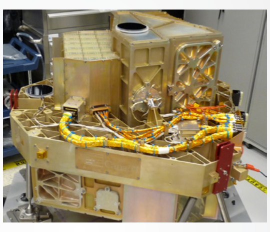
1. Near-Infrared Camera (NIRCam)
Provided by the University of Arizona
The NIRCam is Webb's primary imager and will cover the infrared wavelength range 0.6–5 µm.



2. Near-Infrared Spectrograph (NIRSpec)
Provided by ESA, with NASA/GSFC components
The NIRSpec will operate over a wavelength range of 0.6–5 µm and is designed to observe 100 objects simultaneously.



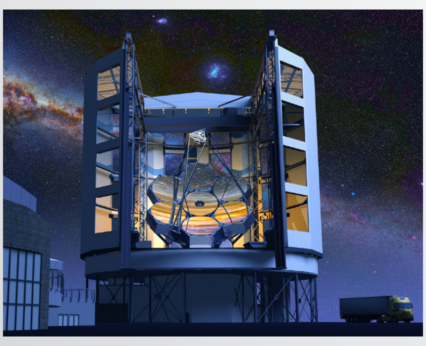
3. Mid-Infrared Instrument (MIRI)
Provided by ESA and NASA JPL
The MIRI has both a camera and a spectrograph that sees light in the mid-infrared region of the spectrum, 5–28 µm.



4. Fine Guidance Sensor/ Near InfraRed Imager and Slitless Spectrograph (FGS/NIRISS)
Provided by the Canadian Space Agency
Specialized 0.8–5.0 µm instrument that helps keep JWST pointed precisely (FGS) and that performs detailed exoplanet detection and characterization (NIRISS).

Extremely Large Telescopes

The next generation of ground-based infrared telescopes will have resolving power far beyond what is available today, and will use coronographs and high-resolution spectroscopy to further analzye the planets' atmospheres.



Giant Magellan Telescope (GMT)

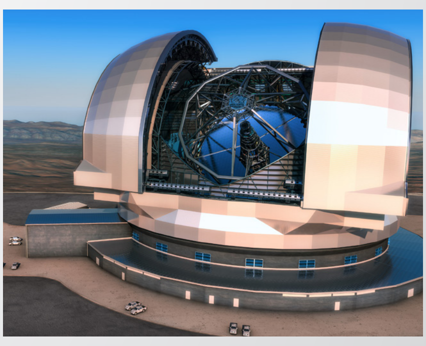
The GMT will have resolving power 10 times greater than the Hubble Space Telescope and will be the largest optical observatory in the world at the time of its first light.

FIRST LIGHT: 2021
OPERATED BY: GMT Consortium
LOCATION: Las Campanas, Chile
ALTITUDE: 2,516 m
PRIMARY MIRROR: 25 m
TELESCOPE STYLE: Gregorian
WAVELENGTH: 0.32–25 µm
COLLECTING AREA: 368 m^2
MOUNTING: Altazimuth
WEBSITE: www.gmto.org

Thirty Meter Telescope (TMT)

TMT will have 144 times the collecting area and more than a factor of 10 better spatial resolution relative to the Hubble Space Telescope.

FIRST LIGHT: 2022 (prior to permit problem)*
OPERATED BY: TMT Int'l Observatory
LOCATION: Mauna Kea, Hawaii, USA
ALTITUDE: 4,050 m
PRIMARY MIRROR: 30 m
TELESCOPE STYLE: Ritchey–Chrétien
WAVELENGTH: 0.31–28 µm
COLLECTING AREA: 655 m^2
MOUNTING: Altazimuth
WEBSITE: www.tmt.org



The European Extremely Large Telescope (E-ELT)

The E-ELT will be the largest telescope in the world. It will have a five-mirror design—three-mirror on-axis anastigmat, plus two fold mirrors used for adaptive optics.

FIRST LIGHT: 2024
OPERATED BY: European Southern Observatory
LOCATION: Cerro, Chile
ALTITUDE: 3,060 m
PRIMARY MIRROR: 39 m
TELESCOPE STYLE: Reflector
WAVELENGTH: 0.37–14 µm
COLLECTING AREA: 978 m^2
ACTIVE OPTICS: 2.60 m adaptive mirror using six laser guide star units
MOUNTING: Altazimuth
WEBSITE: www.eso.org

*The State Supreme Court of Hawaii invalidated the facility's building permits in December 2015, after local protests halted construction the previous year. TMT is working to regain permits to resume construction in Hawaii; La Palma, Canary Islands, Spain has been identified as an alternative site.

Sources: M. Gillon et al., Nature, doi:10.1038/nature 21360 (2017); www.nasa.gov; www.eso.org; https://jwst.nasa.gov; www.gmto.org; www.tmt.org; Wikipedia / Infographic by Alessia Kirkland