2023 Spring Undergraduate Research Festival

Quantifying the Ability of E-ELT(Direct Imaging) and JWST(Transit Method) to Detect Biosignatures

Huihao Zhang

Research Advisor: Ji Wang

THE OHIO STATE UNIVERSITY

COLLEGE OF ARTS AND SCIENCES

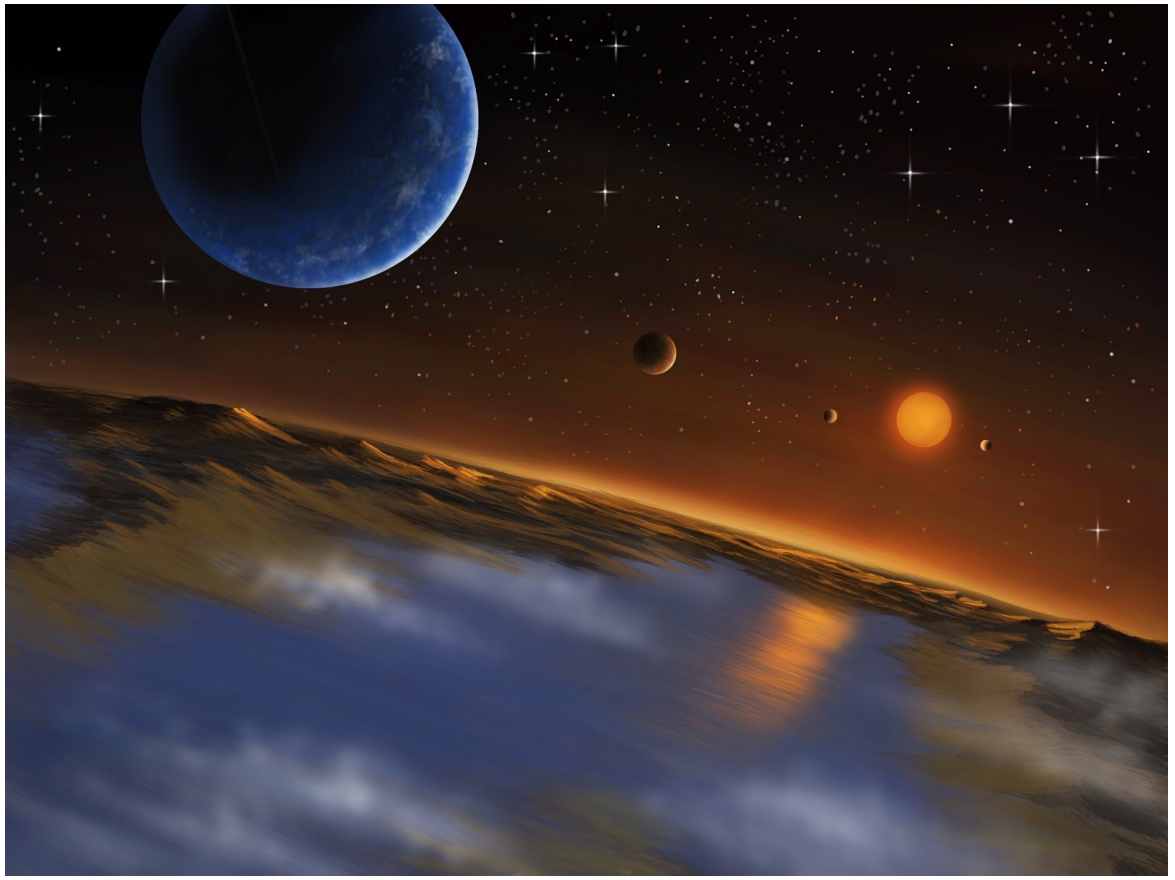
Target

Atmosphere of planet can not only reflect whether they are habitable, but also whether they may have life.

> If there were no life on Earth, there would not be as much oxygen as there is.

The goal of this project is to explore the ability of the next-generation telescopes to detect the atmospheres of exoplanets.

> The telescope selected for this project are JWST and E-ELT
>
> The target planet selected for this project: TRAPPIST-1 e



Credit: Danielle Futselaar - SETI Institute

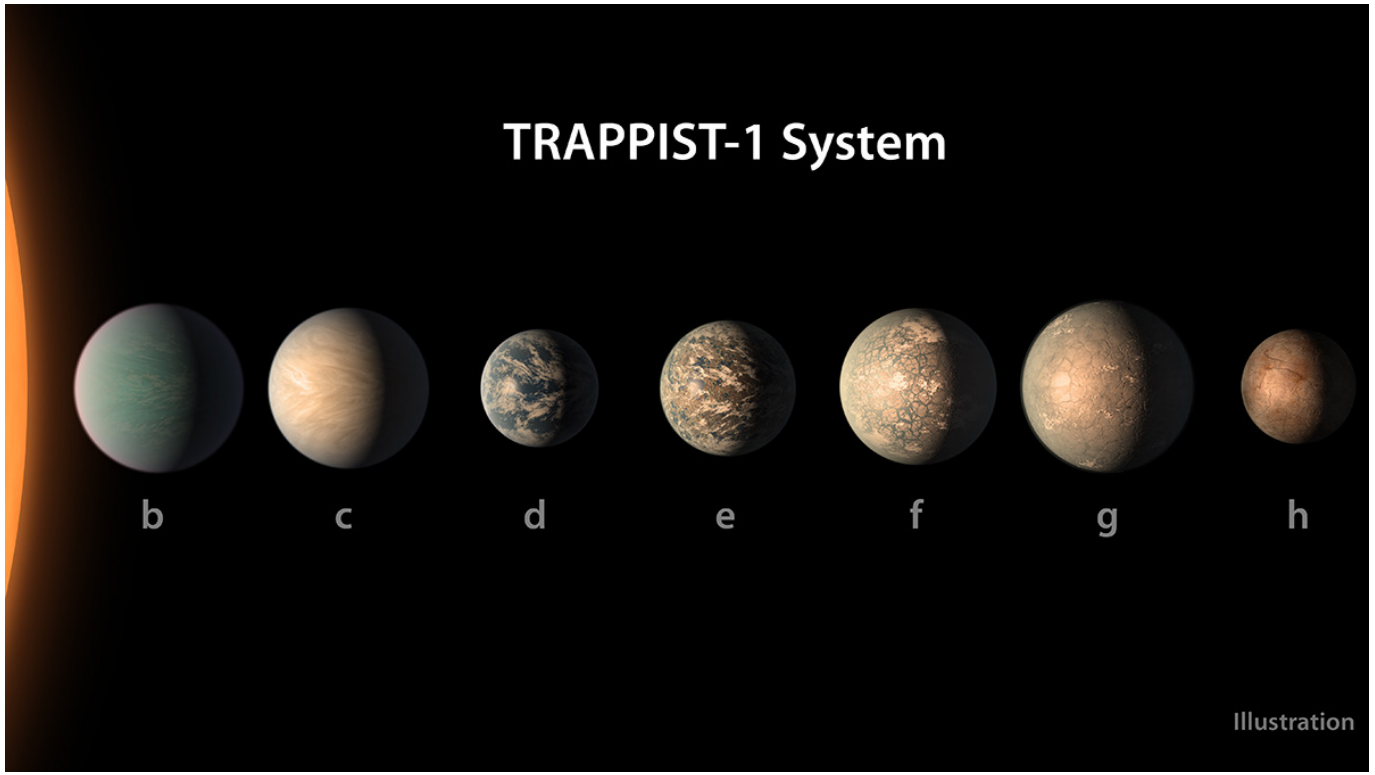
Why TRAPPIST-1 e?

Today, we have discovered more than 5,000 planets located outside the solar system.

TRAPPIST-1e is a rocky planet 39 light years from Earth.

Its radius and mass are similar to Earth. The temperature is about -10 F

TRAPPIST-1 e is an Earth-like planet. It has the potential to form an Earth-like atmosphere.



Credit: NASA/JPL-Caltech

What is JWST?

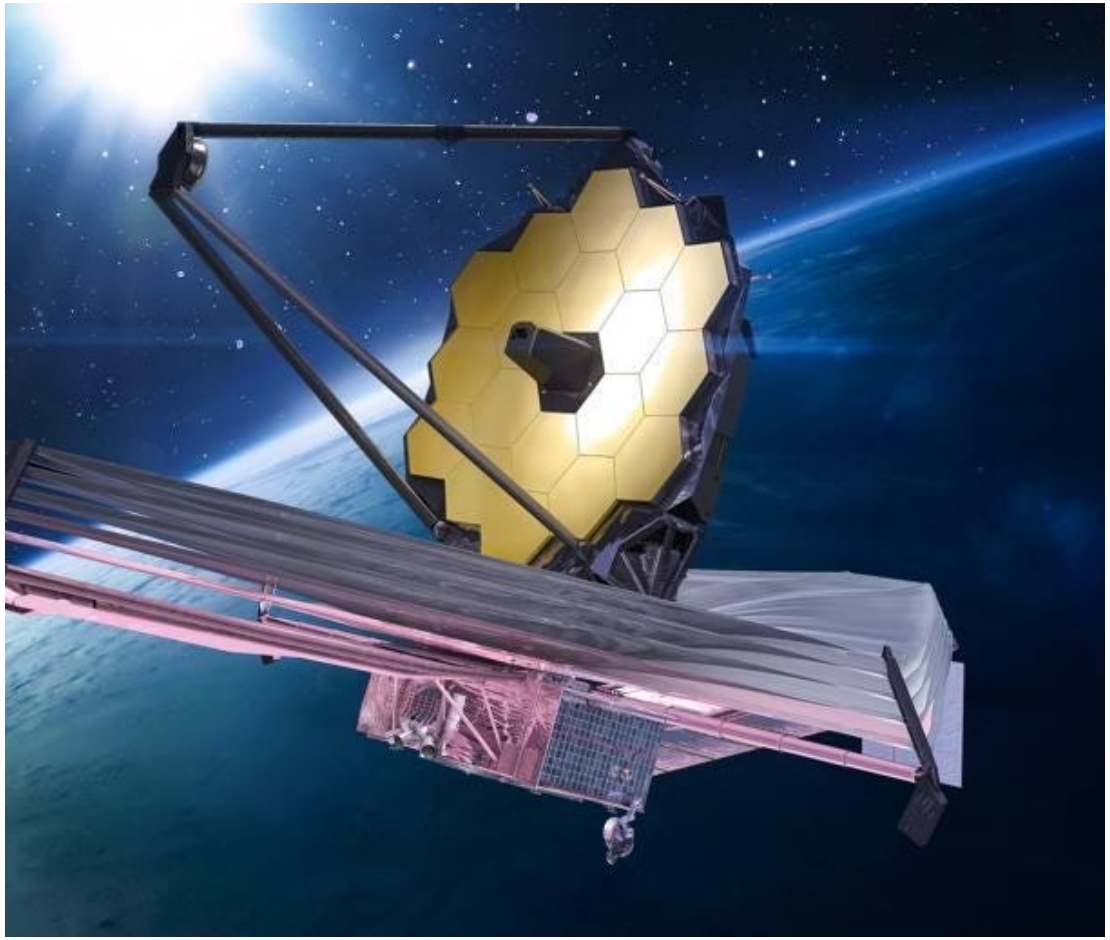
JWST is the most advanced space telescope so far.

Diameter: 6.5 meters.

Observation bands: 0.6 to 28.3 microns

Some gases will absorb photons in 0.5 to 12 microns

JWST may have the ability to detect planetary atmospheres.



Credit: NASA

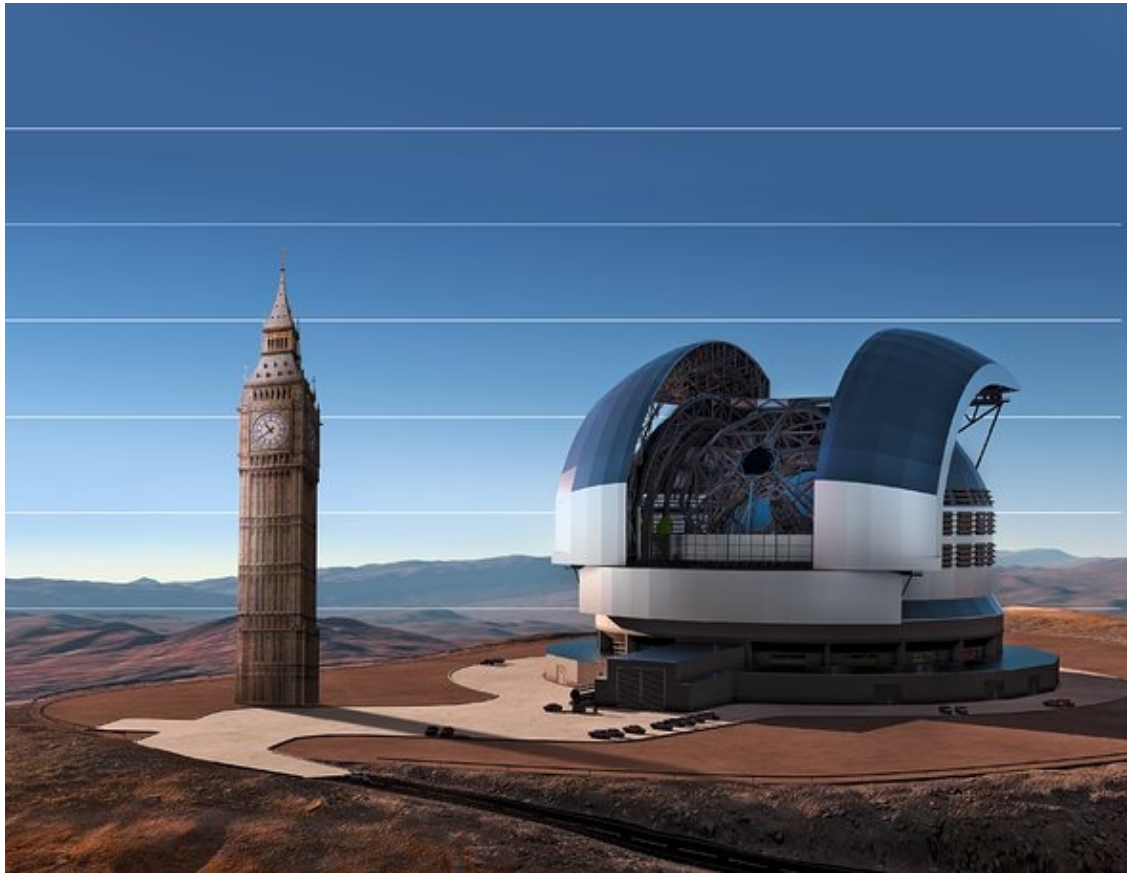
What is E-ELT

E-ELT will be the world's most advanced optical telescope

Diameter: 39.3 meters

Observation band also covers 0.5-12 microns

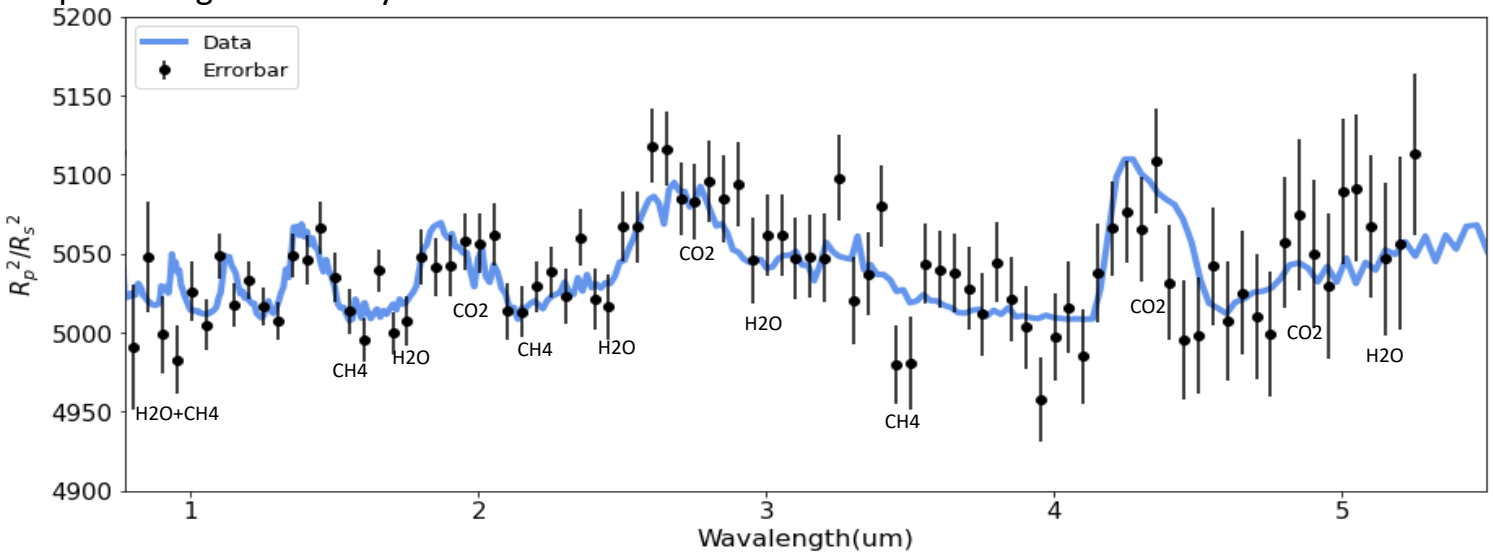
E-ELT also may have the ability to detect planetary atmospheres.



Credit: ESO

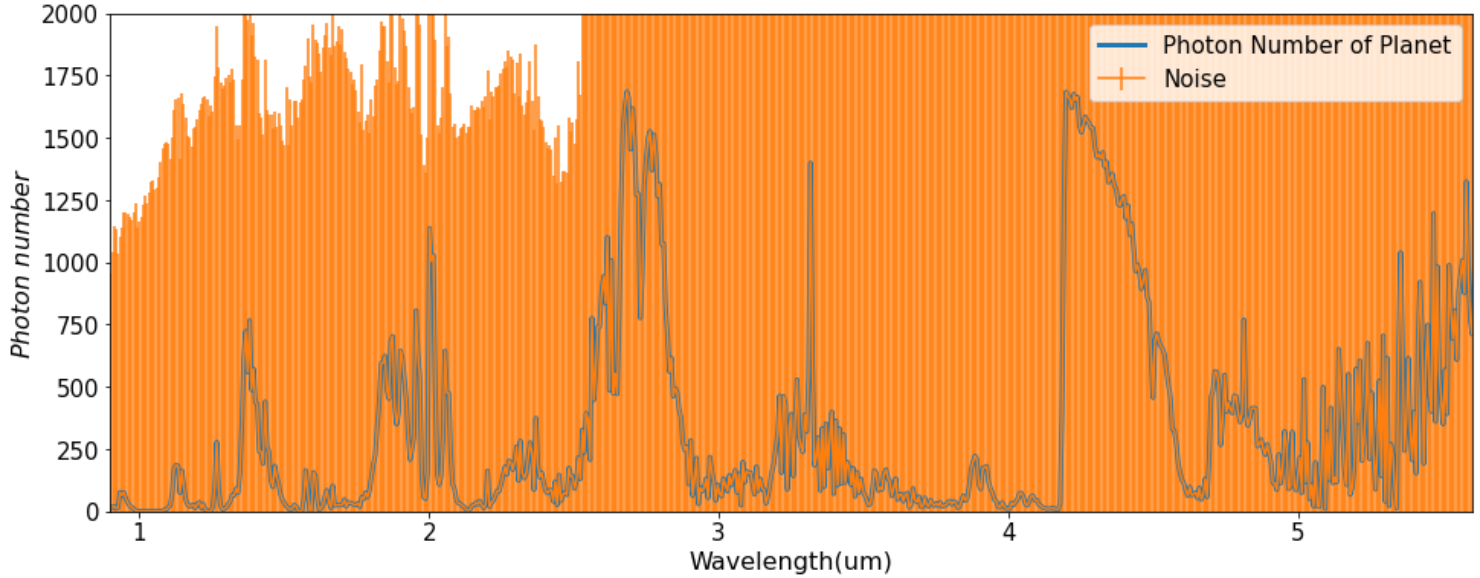
JWST

Spectrum generated by *PandExo*



E-ELT

Method of *Wang, Ji, et al.*



Resolution

JWST:150

E-ELT:150

Exposure time:

For JWST: 2.86 h

For E-ELT: 1 h

Analysis

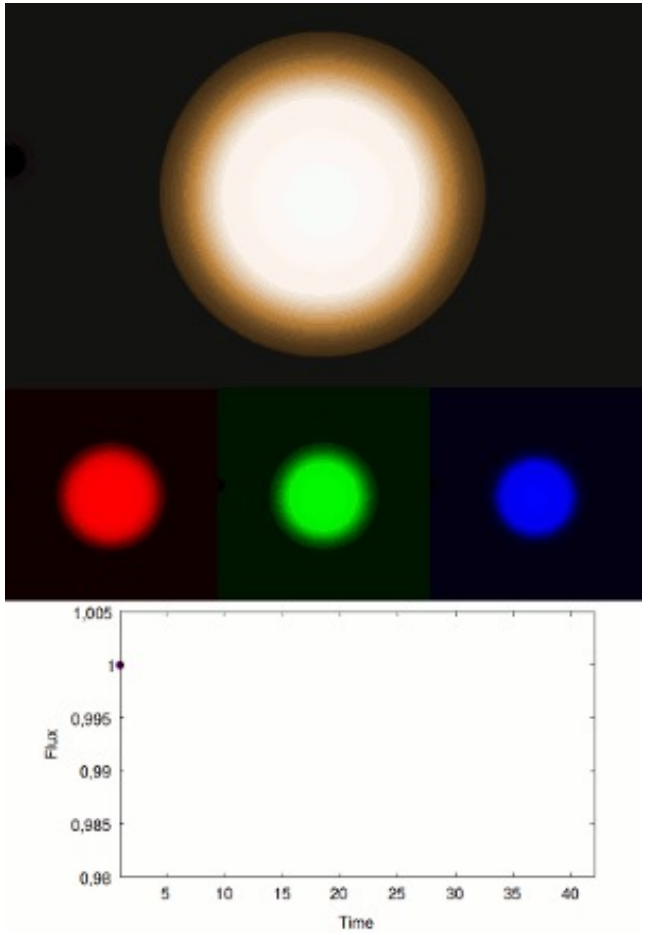
Different gases absorb light at different wavelengths.

We can identify gases based on their specific wavelength

We quantified the ability of E-ELT and JWST to detect CH4, CO2, O2, and H2O based on the data obtained.

All of these gases are related to the possibility of life existence.

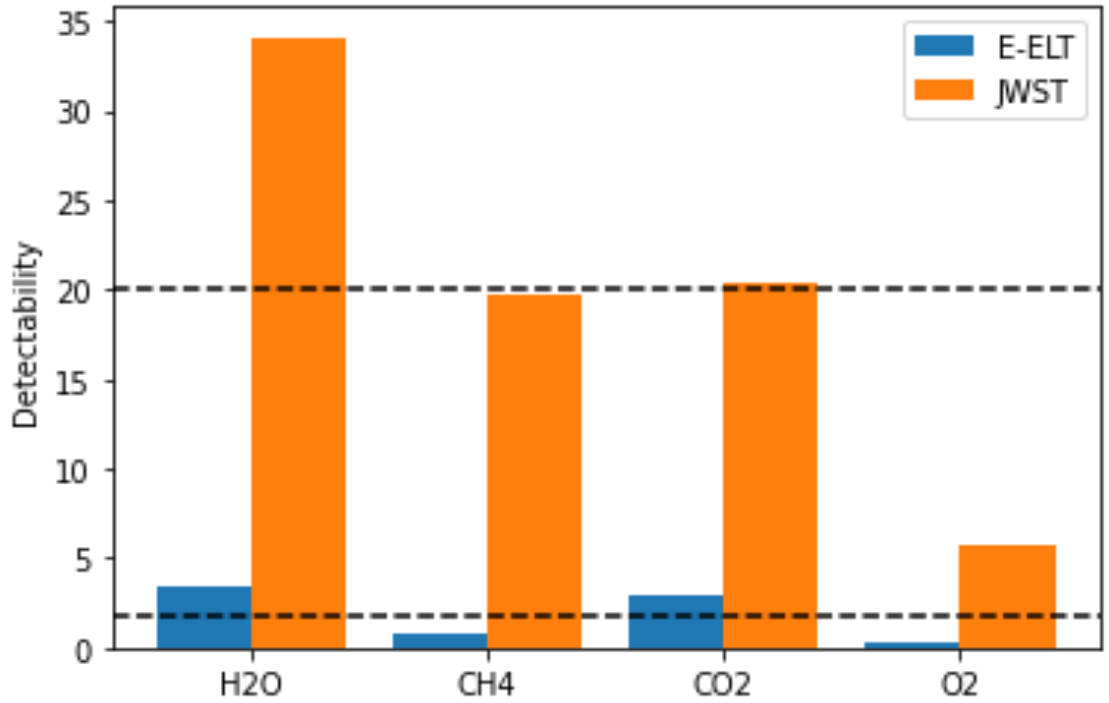
Using the method proposed by *Phillips, Caprice L., et al,*



Conclusion

For TRAPPIST-1 e, the detection capability of JWST is significantly higher than that of E-ELT.

This is because TRAPPIST-1 e has a very low brightness relative to TRAPPIST-1, which is not sufficient to overcome the noise from the observation.



This does not mean that ”generally” the detectability of E-ELT is less than JWST for the atmosphere of exoplanet

On the contrary, the detectability of E-ELT may much higher than JWST for some special exoplanets

Future

Find planets that fit the E-ELT observations according to some conditions

Simulate and quantify the detectability of E-ELT for the atmosphere of these planets

This will answer the question: whether we have a chance to solve the millennium problem in the next 20 years

Are we alone in the universe?

QUESTION?

Exoplanet data are from
https://exoplanetarchive.ipac.caltech.edu/

The open-source libraries used in the process

PICASO

PandExo

Thanks to the following teams for their support of this project

GFORSE
Group for Studies of Exoplanets

THE OHIO STATE UNIVERSITY
OFFICE OF UNDERGRADUATE EDUCATION

Undergraduate Research Apprenticeship Program (URAP)