A T-Dwarf Candidate from JWST Early Release NIRCam Data

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INTRODUCTION

What are Brown dwarfs? Why searching for them?

Brown dwarfs are sub-stellar objects with a mass between Jupiter and the main sequence stars, which are insufficient to trigger hydrogen fusion.
It is important to understand the how stars bridges to planets. However, because of their low temperatures (≦2500K), they are faint and difficult to be found.

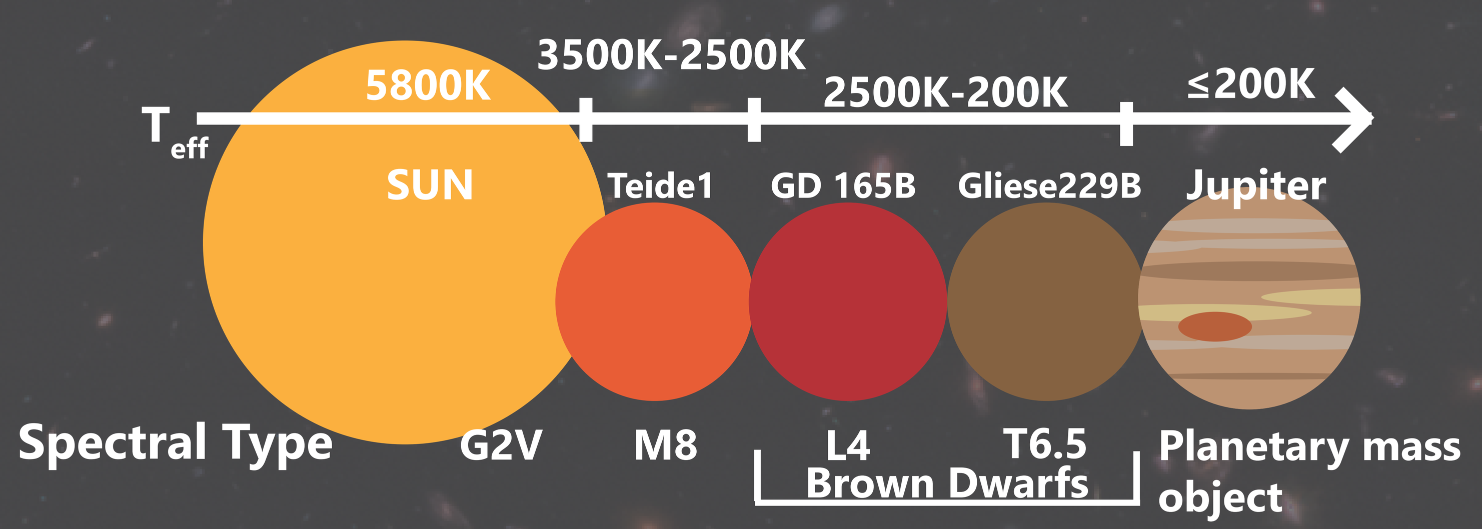

Fig 1. Cartoon of physical properties comparison of stars, brown dwarfs and Jupiter (not to Scale).

How can James Webb Space Telescope help us?

Previously both WISE/NEOWISE and Spitzer had only 4 filters in near-IR. In contrast, JWST NIRCam has 8 wide filters in the range of 0.6 to 5.0 μm.

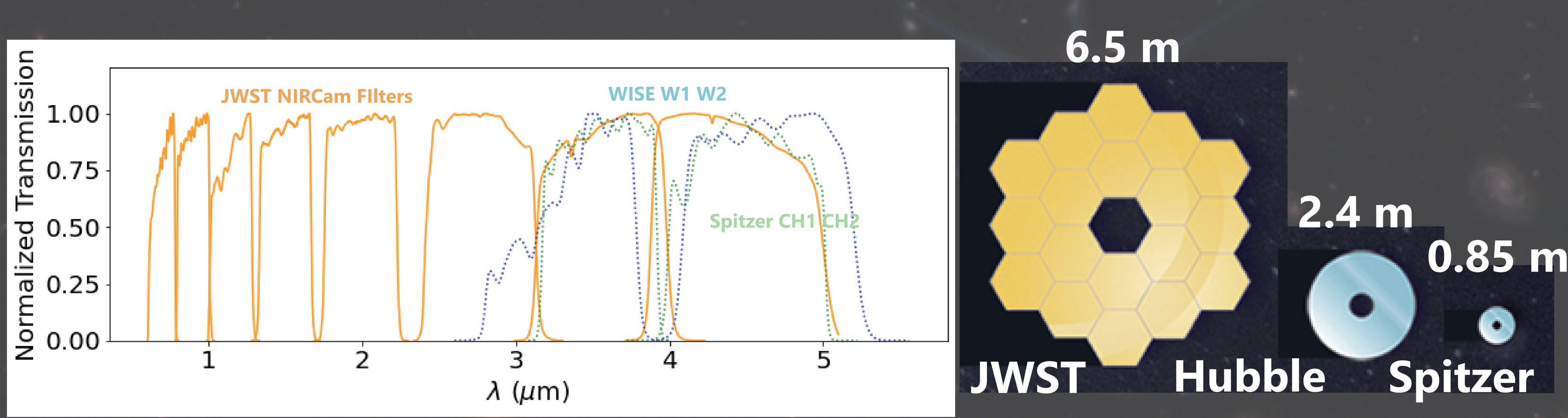

Fig 2. (a) Normalized NIRCam filter throughput of JWST, WISE and Spitzer.
(b) Comparison of space telescope mirror diameter.

The sensitivity of JWST is 3-4 magnitudes deeper than Spitzer which allow us to extend the search limit from thin disk (~20 pc) to thick disk/ galactic halo (~5kpc).

METHOD

1. Observations

We obtained 4 observations with NIRCam (total 26348 sources), summarized as below.

Table 1. Summary of JWST sample informations.

observation	number of point source	expected number of BD**
Stephan's Quintet (ERO-2732)	304	0.02
SMACS-J0723.3-7327 (ERO-2736)	408	0.01
Extended Groth Strip HST legacy field* (CEERS, ERS-1345)	83+127+120+142	0.05
A2744 Galaxy Cluster (GLASS, ERS-1324)	587	0.08

* 4 fields are obtained in this observation.
** expected number = FoV x detection limit x empirical space density

2. Model Spectra

We choose the chemical disequilibrium model, Sonora-Cholla (Karalidi et al. 2021), color selection criteria of F115W-F277W<-0.8 ∩ F277W-F444W>1.1 is decided by modeling spectra.

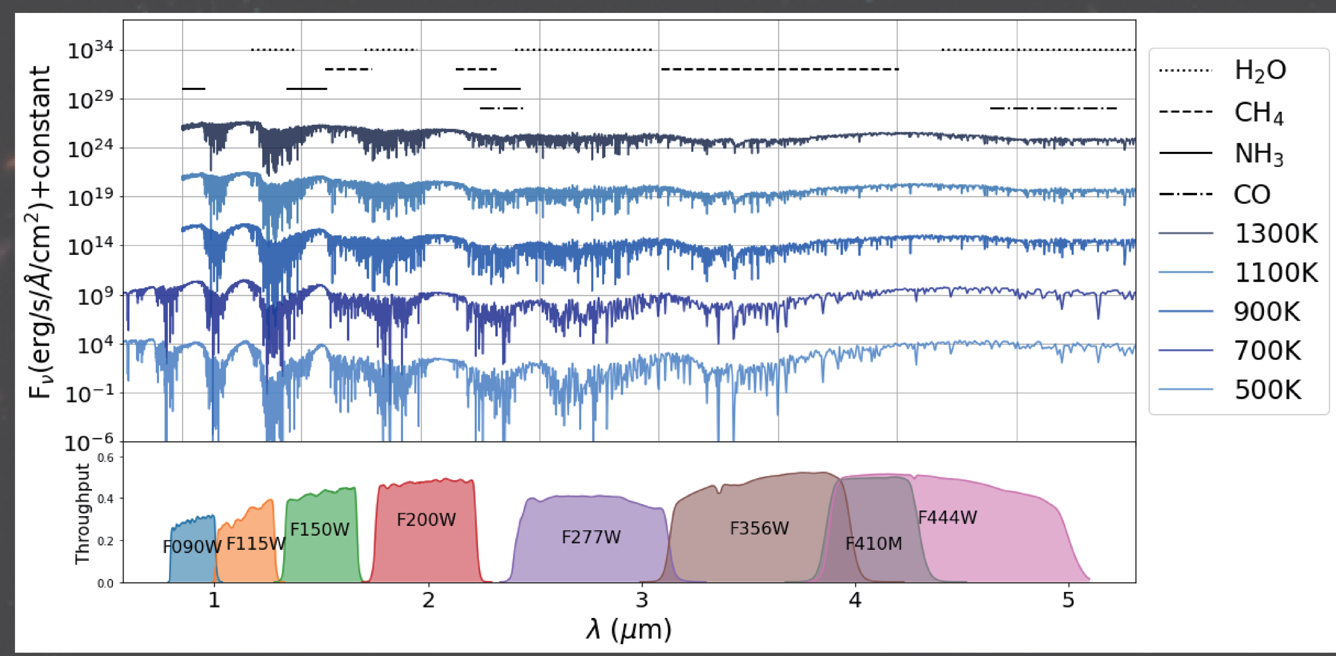

Fig 3. Model spectra with different temperature, fixed gravity (log g =3.16) and diffusion coefficient (log Kzz=2).

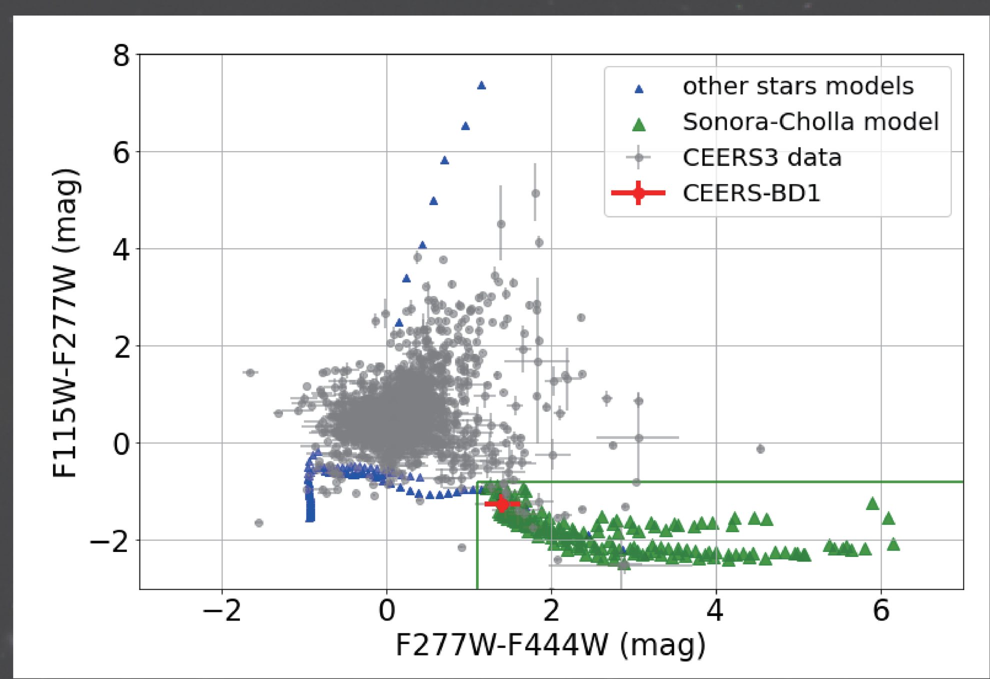

Fig 4. F115W-F277W-F444W color-color diagram from stellar models (blue and green) and JWST CEERS data (gray).

RESULT

After the filtering processes, we found one early T-type brown dwarf in CEERS field, CEERS-BD1.

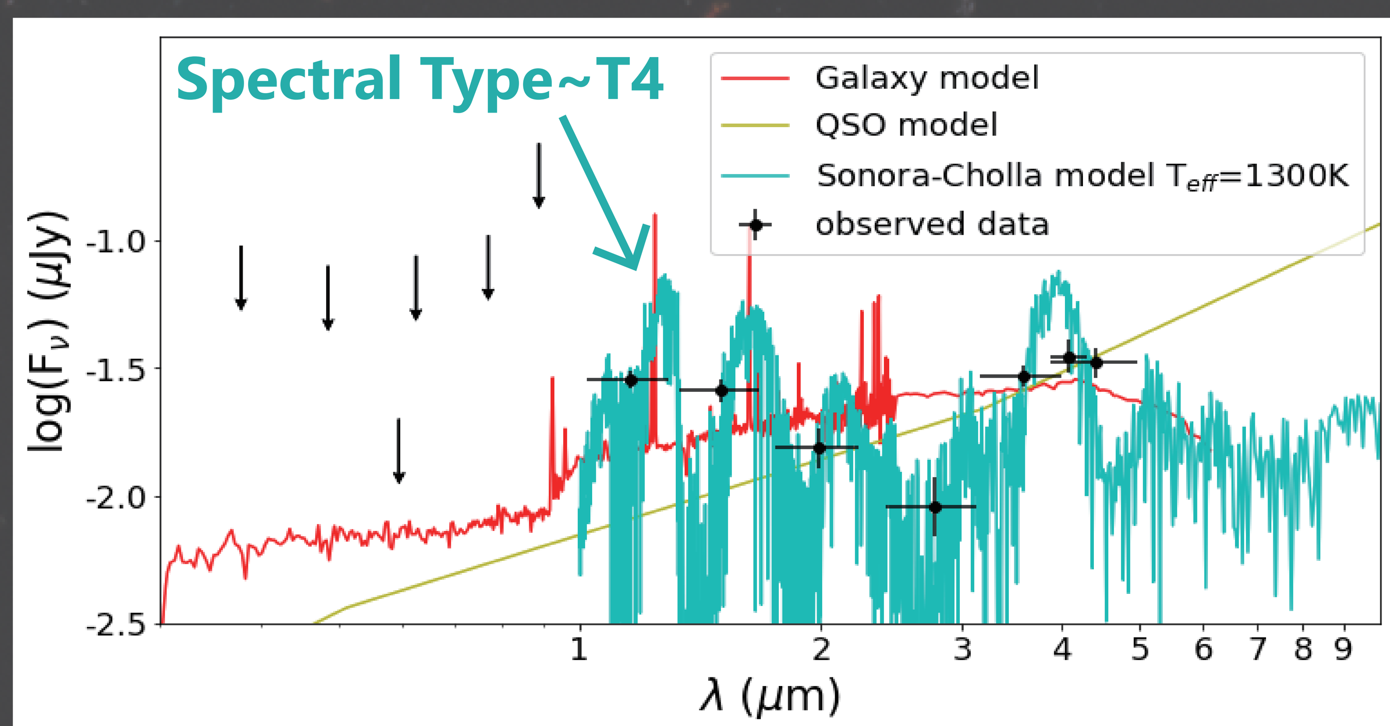

Fig 5. SED fitting result of CEERS-BD1.

Table 2. Properties of CEERS-BD1

T_{eff} (K)	1300
g (cm s^{-2})	$10^{4.25}$
K_{zz} ($cm^2 s^{-1}$)	10^7
d (kpc)	4.92 ± 0.32
mass ($M_\odot$)	0.01

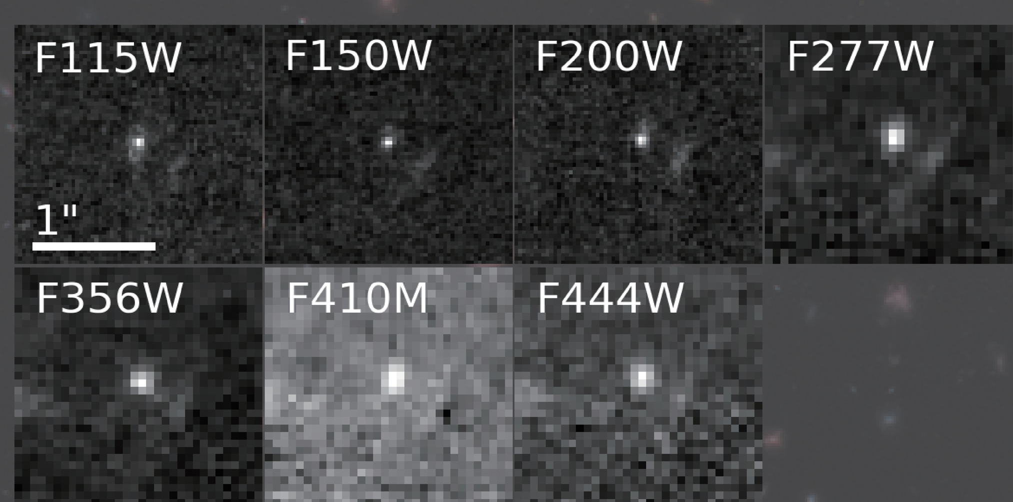

Fig 6. The image of CEERS-BD1 in each JWST NIRCam filter.

SUMMARY

We found an early T-dwarf, CEERS-BD1, with the effective temperature of T_{eff} ~1300K.
An estimated distance of 4.92±0.32kpc shows it could possibly be located in the thick disk or galactic halo.
Further spectroscopic observations such as JWST NIRSpec would be important to confirm the properties.