Master's Thesis

Envisioning Distant Worlds: Fine-Tuning a Latent Diffusion Model with NASA's Exoplanet Data
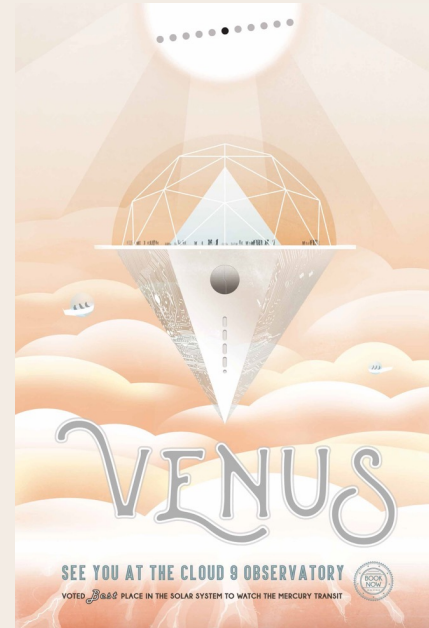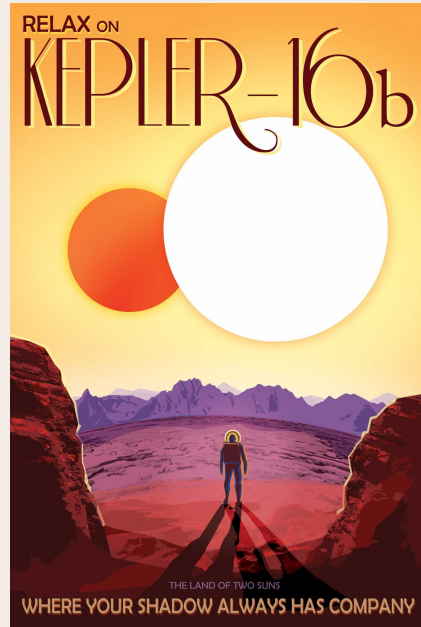
University of Arts London

James Webb Photograph, 2022

By Marissa Beaty

Where it began...
JPL- Caltech & Visual Artists

JPL-Caltech, Space Tourism Posters (2018)

NASA's Exoplanet Data

NASA Exoplanet Archive
NASA Exoplanet Science Institute

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Planetary Systems

Planet Name	Host Name	Default Parameter Set	Number of Stars	Number of Planets	Orbital Period [days]	Orbit Semi-Major Axis [au]	Planet Radius [Earth Radius]	Planet Radius [Jupiter Radius]	Planet Mass or Mass*sin(i) [Earth Mass]	Planet Mass or Mass*sin(i) [Jupiter Mass]	
11 Com b	11 Com	0	2	1		$1.21^{+0.06}_{-0.05}$			$5434.7^{+540.3}_{-413.2}$	$17.1^{+1.7}_{-1.3}$	Ms
11 Com b	11 Com	1	2	1	326.03±0.32	1.29±0.05			6165.6±476.7	19.4±1.5	Ms
11 UMi b	11 UMi	0	1	1		$1.51^{+0.06}_{-0.05}$			$3432.4^{+381.4}_{-413.2}$	$10.8^{+1.2}_{-1.3}$	Ms
11 UMi b	11 UMi	1	1	1	516.21997±3.20000	1.53±0.07			4685±795	14.74±2.50	Ms
11 UMi b	11 UMi	0	1	1	516.22±3.25	1.54±0.07			3337.07±785.01	10.50±2.47	Ms
14 And b	14 And	0	1	1		$0.68^{+0.03}_{-0.06}$			$1017.0^{+127.1}_{-190.7}$	$3.20^{+0.4}_{-0.6}$	Ms
14 And b	14 And	1	1	1	185.84±0.23	0.83			1525.5	4.8	Ms
14 Her b	14 Her	1	1	2	$1765.03890^{+1.67709}_{-1.87256}$	$2.774^{+0.109}_{-0.120}$			2559^{+519}_{-281}	$8.053^{+1.632}_{-0.883}$	Ma
14 Her b	14 Her	0	1	2		2.730			1440.663	4.533	Ms
14 Her b	14 Her	0	1	2	1773.4±2.5	2.77±0.05			1474.67±60.39	4.64±0.19	Ms
14 Her b	14 Her	0	1	2	1796.4±8.3	2.80			1506.45±19.07	4.74±0.06	Ms
14 Her b	14 Her	0	1	2	$1766.41^{+0.67}_{-0.68}$	2.830±0.041			1541±48	4.85±0.15	Ms
14 Her b	14 Her	0	1	2	1724±50	2.82			1554.12	4.89	Ms
14 Her b	14 Her	0	1	2	1773.40002±2.50000	2.93±0.08			1481±48	4.66±0.15	Ms
14 Her b	14 Her	0	1	2	1766	2.864			1581.138	4.975	Ms
16 Cyg B b	16 Cyg B	0	3	1	800.8±11.7	1.6			476.7	1.5	Ms
16 Cyg B b	16 Cyg B	0	3	1	799.5±0.6	1.68±0.03			533.93±22.25	1.68±0.07	Ms
16 Cyg B b	16 Cyg B	0	3	1	798.50000±1.00000	1.66±0.03			566±25	1.78±0.08	Ms

NASA Confirmed Exoplanet Dataset, 2023

Data Used

Exoplanets

- Define planet_category using pl_bmass

- Define planet_color using chemical composition

- Define planet_spin using orbital period

- Define tidal_locked using roche limit and impact parameter

- Define planet_size using:

  - pl_bmass

  - Ratio between planet and its star

  - Textual description

Stars

- Define stellar_color using st_spectype

- Define stellar_size using:

  - st_mass

  - Ratio between planet and its star

  - Textual description

NASA's Image and Video Library
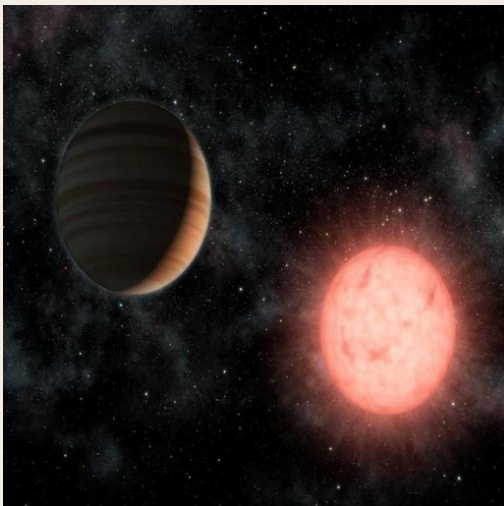
Artist Illustration of Exoplanet Kepler-1520 b

Photograph of Neptune

Artists Illustration of Kepler-9 c

NASA Image and Video Archive

The Generated Prompts

75_token

A light orange, small star with a massive, gas-giant planet. The planet is mostly blue with traces of white coloring, has clear, sharp-edge stripes of thick clouds, and only has one side of the planet facing the sun. The side facing the sun is extremely hot and the side that faces away from the sun is dark and cold.

Exoplanet 18 Del b

mass_prompt

A solar system made up of 1 planet(s), 1 star(s), and 0 moon(s). This gas-giant planet is 1373 times the size of earth, likely has water vapor producing a blue color as well as helium and hydrogen, which both produce shades of white and has stripes of thick clouds of various coloring defined by clear, sharp edges. This planet only has one side of the planet facing the sun. The side facing the sun is extremely hot and the side that faces away from the sun is dark and cold. The planet's star is light orange and 1 times the size of the sun.

Exoplanet 18 Del b

ratio_prompt

A solar system made up of 1 planet(s), 1 star(s), and 0 moon(s). This gas-giant planet is 1373 times the size of earth, likely has water vapor producing a blue color as well as helium and hydrogen, which both produce shades of white and has stripes of thick clouds of various coloring defined by clear, sharp edges. This planet only has one side of the planet facing the sun. The side facing the sun is extremely hot and the side that faces away from the sun is dark and cold. The planet's star is light orange and 0.0888553119678667 the size of its planet.

Exoplanet 18 Del b

size_text_prompt

A solar system made up of 1 planet(s), 1 star(s), and 0 moon(s). This massive gas-giant planet likely has water vapor producing a blue color as well as helium and hydrogen, which both produce shades of white. This planet has stripes of thick clouds of various coloring defined by clear, sharp edges. The planet's star is only having one side of the planet facing the sun. The side facing the sun is extremely hot and the side that faces away from the sun is dark and cold and light orange.
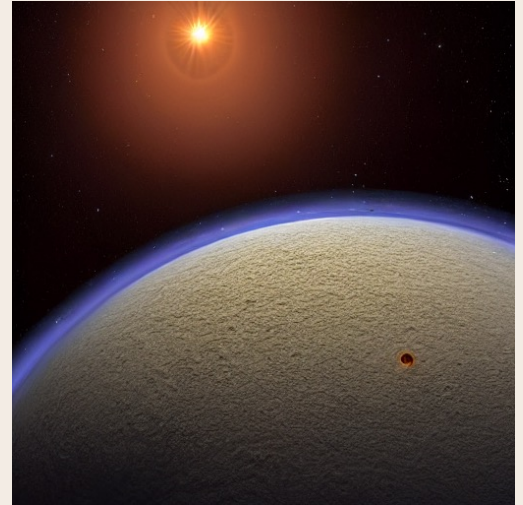
Exoplanet 18 Del b

The Generated Images
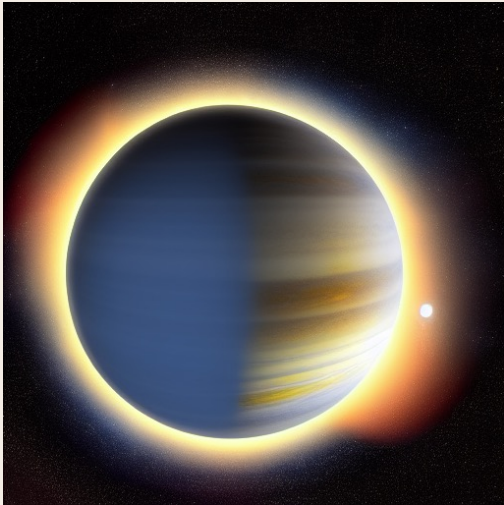
"75_token" Fine-Tuned Stable Diffusion
Model: Exoplanet HD 106270 b
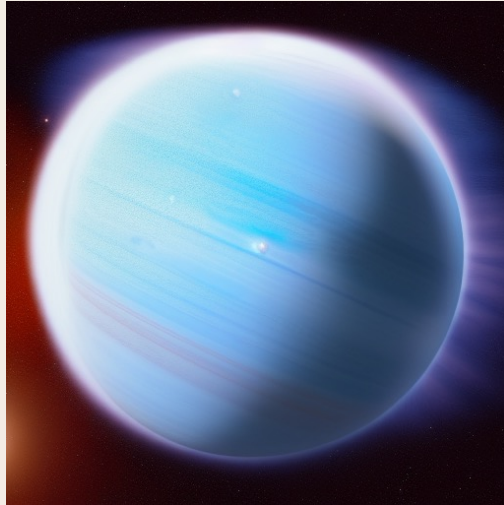
"75_token" Fine-Tuned Stable Diffusion
Model: Exoplanet HD 56957 b

"75_token" Fine-Tuned Stable Diffusion
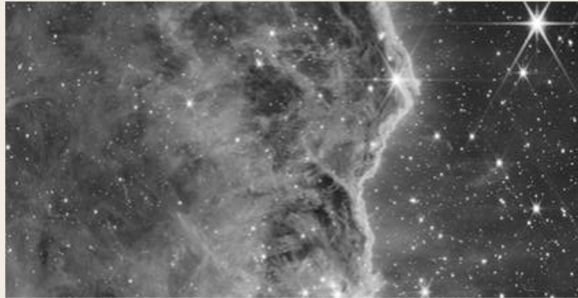Model: Exoplanet Kepler-226 d

Validation with James Webb

James Webb Predicted Visualization of
K2-18b

My Model's Prediction of K2-18b

FINAL
conclusions

The goal of this project was to develop a foundation for further research. Developing a scientifically backed fine-tuned Stable Diffusion model is possible and an interesting area of research for those interested in visualizing scientific research, or developing research supported art.