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3-D Visualizations of Terrestial Exoplanet Interiors Generated with MAGRATHEA in Blender

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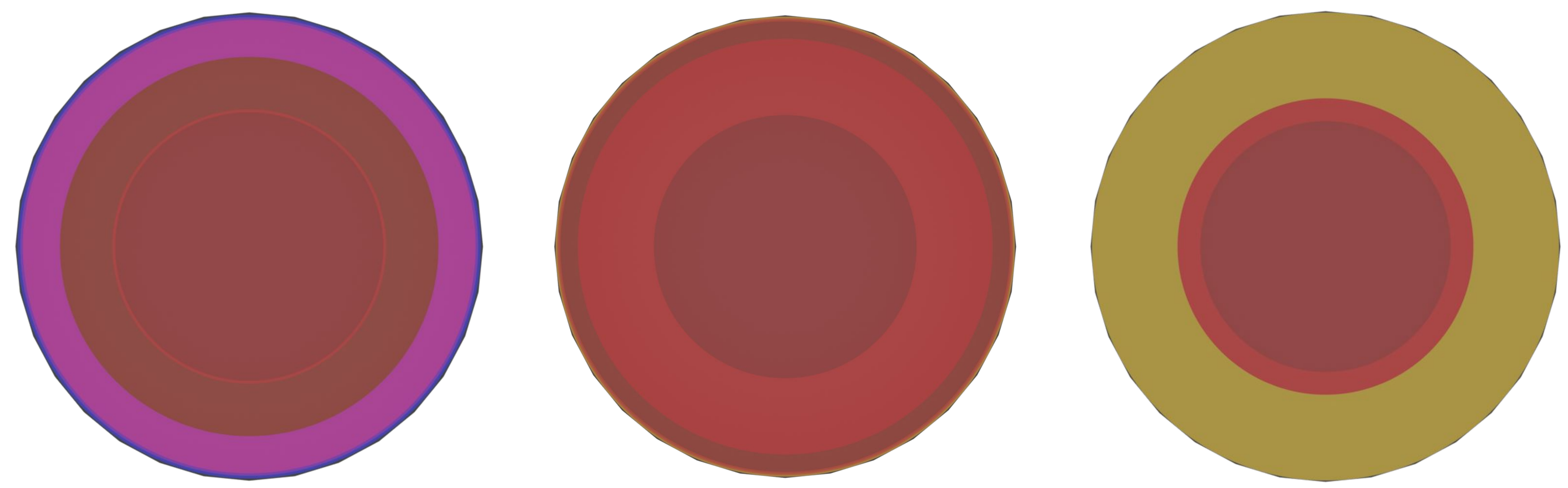
Abstract

There has been significant progress in simulating exoplanet interiors in the past decade. With the discovery of the TRAPPIST-1 system in the last few years, there have been many publications presenting models to best characterize specific aspects of exoplanets in study. However, with more parameters and considerations for different characteristics of an exoplanet there will be a need to represent many findings into a comprehensive model in the future. We extend the capabilities of MAGRATHEA from a planet interior solver to start incorporating multi-faceted functions starting with generating 3-D terrestrial planetary visualizations using a 3-D open-source computer graphic software called Blender.

Results



Legend: red-like colors indicate denser materials like hcp iron, yellow-like colors indicate medium dense materials like silicates, purple-like colors indicate high-pressure ices , and a blue color indicating water. Schematic: 3-D Visualizations of (Left) Trappist-1f, (Middle) K2-106b, and (Right) Earth.

The Trappist-1f exoplanet was simulated with a 50% core, 34% mantle, and a 16% H_2O hydrosphere in MAGRATHEA with a calculated 1.041 $R_\oplus$, 1.039 $M_\oplus$, 0.92 $\rho_\oplus$ which is consistent with calculated values of 1.045 $R_\oplus$, 1.039 $M_\oplus$, 0.911 $\rho_\oplus$in (Agol et al.2021) as well as a similar WMF from (Acuña et al. 2021).

The K2-106b exoplanet was simulated in MAGRATHEA with a calculated 1.708 $R_\oplus$, 8.53 $M_\oplus$, 2.68 $\rho_\oplus$ which is consistent with the calculated values of 1.7 $R_\oplus$, 8.36 $M_\oplus$, 2.40 $\rho_\oplus$ from (Guenther et al. 2017).

The Earth planet was simulated with a 33% core and a 66% mantle in MAGRATHEA with a calculated 0.97 $R_\oplus$ which is a little smaller than the rercorded radii.

MAGRATHEA/Blender

MAGRATHEA is a user-oriented, open source, planet interior solver which solves for a four fully differentiated, spherically symmetric layers predominately, a iron core, a silicate mantle, a water hydrosphere, and a ideal gas atmosphere (Huang et al. 2022). At each iteration the code can solve for pressure, density, and temperature at each radii until the radii matches the targeted radii. To which the code can also determine the radii where phase transitions occurs with an integrative library of EOSs. All of which are stored in a tabulated file. We used Blender to generate 3-D visualizations of exoplanets by first sorting out the data from the tabulated file to only record and store the radii which phase transition occurs, then we did the same for the EOS name at each radii. Then we generated a primitive sphere with radii size of largest radii recorded. We then applied some modifiers to add thickness and make a cross-section using a cylinder. We then applied nodes to represent these radii values to to be projected as indices in making planetary shells to visualize. We then made some conditionals to indicate based on name of the EOS to give the radii value a particular color.

Conclusions

We have shown a few capabilities of Blender to visualize the data from MAGRATHEA. We conclude that Blender is a useful tool for providing visualizations of exoplanet interiors with different materials. Blender has more capabilities that yet remained unexplored.

We have future work not only improve our visualizations but as well as to incorporate new features such as planet textures and magnetic dynamo starting with the presence of liquid iron in the interior.

Literature cited

Acuña et al. 2021. Characterisation of the hydrospheres of TRAPPIST-1 planets. *Astronomy and Astrophysics (Berlin), 647*(March), A53

Agol et al. 2021. Refining the Transit-timing and Photometric Analysis of TRAPPIST-1: Masses, Radii, Densities, Dynamics, and Ephemerides. *The Planetary Science Journal, 2*(1).

Guenther et al. 2017. K2-106, a system containing a metal-rich planet and a planet of lower density. Astronomy and Astrophysics (Berlin), 608, A93

Huang et al. 2022. MAGRATHEA: an open-source spherical symmetric planet interior structure code. Monthly Notices of the Royal Astronomical Society, 513(4), 5256–5269.

Acknowledgments

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Further information

To become a Magrathean scan top QR code to github and for blender code scan bottom QR code to github.