On the Edge of Fire

WD1032+011: An eclipsing white dwarf–brown dwarf binary with a highly irradiated secondary

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Introduction

- Only **0.1-0.5%** of white dwarfs have a brown dwarf companion[1].
- Brown dwarfs have **degenerate physical parameters** (age, mass, luminosity)[2].
- Brown dwarfs in binaries can have their ages determined from the age of the primary.
- Close white dwarf–brown binaries are post-common envelope systems.
- Brown dwarfs are **tidally locked** and **irradiated** by the white dwarf.
- WD1032+011 is the only close, **eclipsing** white dwarf–brown dwarf binary with an **inflated** brown dwarf[3].

Data

- Hubble WFC3 spectroscopy spanning 1.1-1.7 μm.

Hubble WFC3 Spectra → Derive Lightcurve → Isolate Brown Dwarf → Compare Dayside to Nightside

- Observations in primary eclipse show the **non-irradiated nightside** of the brown dwarf only.

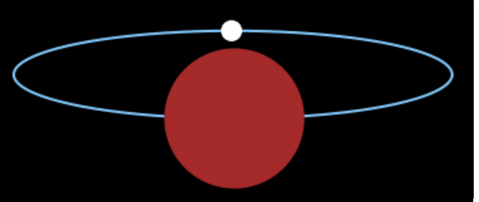
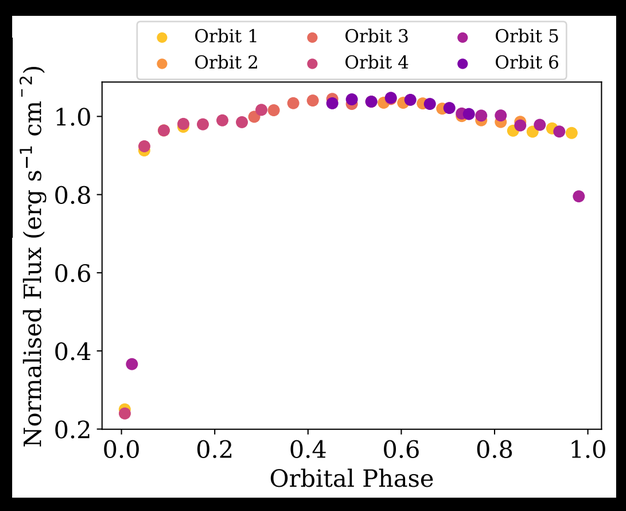


Figure 1: Left: Schematic of the brown dwarf fully occulting the white dwarf during the primary eclipse.

Right: Phasefolded lightcurve of WD1032+011 with the primary eclipse at a phase of 0.



Results

- Irradiated dayside and non-irradiated nightside show a **210 K difference** in brightness temperature[4].
- Spectral type of the brown dwarf is **L1 pec**.

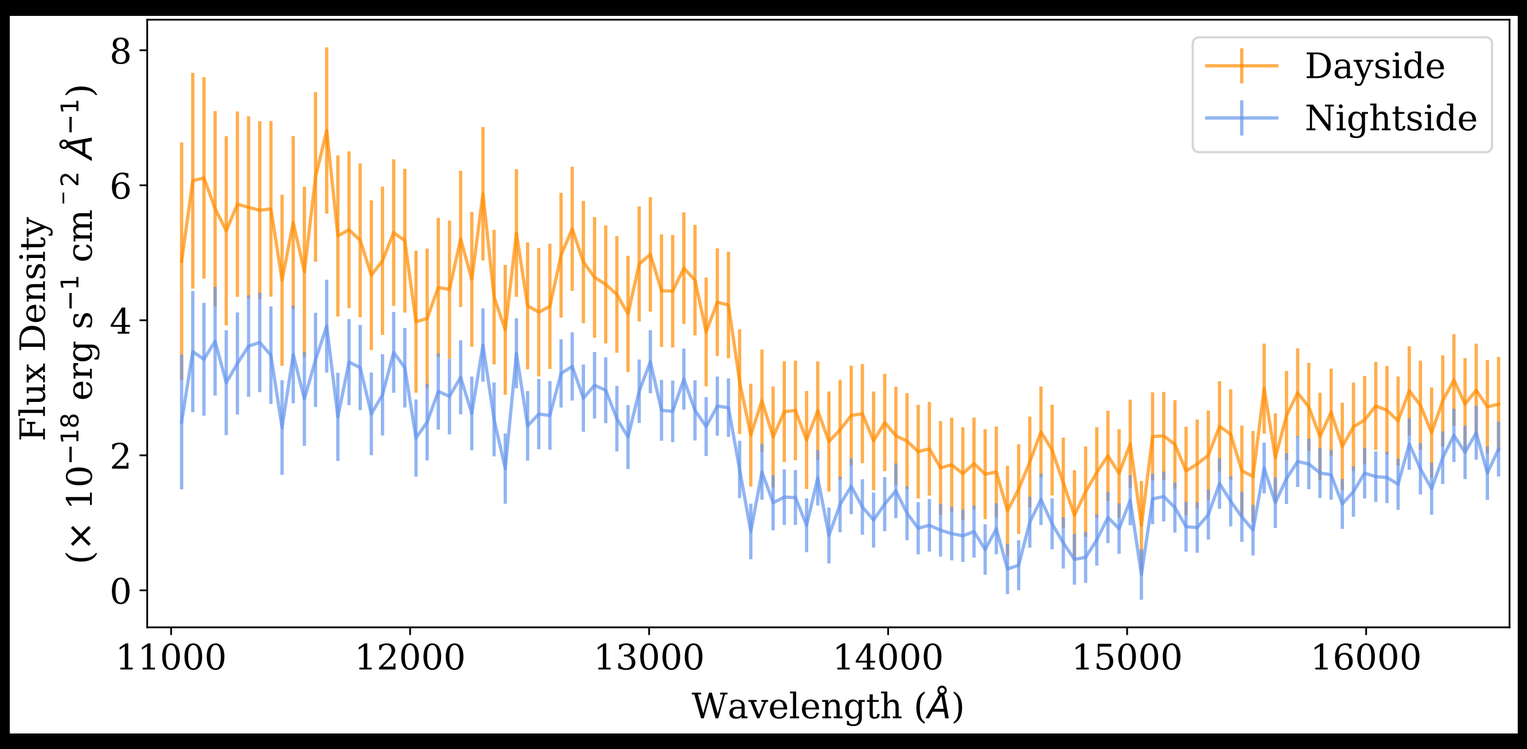


Figure 2: Spectra of the brown dwarf in WD1032+011. The irradiated dayside is shown in orange and the non-irradiated nightside is shown in blue. The decrease in flux around 13500Å is due to water absorption in the atmosphere of the brown dwarf.

- Sub-band lightcurves show **irradiation equally penetrates** the entire brown dwarf **atmosphere**.
- High-resolution ULTRACAM lightcurve and evolutionary models[5] show the brown dwarf is **inflated**.
- Atmospheric retrievals are consistent with calculated **log g = 5.22**.
- Retrieved internal temperature is **1748 K** for the dayside and **1555 K** for the nightside.
- Temperature difference is **consistent** with **WD0137** and **NLTT5306**[6,7].

Conclusions

- Difference in temperature due to **high irradiation** and **poor heat redistribution**, as in other such binaries.
- To fit the **inflated radius**, models require an unusually **high internal temperature** for this spectral type.
- Dayside atmosphere has an irradiation-driven **temperature inversion**.

[1]French et al., (2023), MNRAS, **519**
[2]Dupuy & Liu, (2017), ApJS, **231**
[3]Casewell et al., (2020), MNRAS, **497**
[4]French et al., *in prep*
[5]Marley et al., (2021), Zenodo
[6]Amaro et al., (2023), ApJ, **948**
[7]Zhou et al., (2022), AJ, **163**