Fluid dynamics and the engulfment of planets by their stars

Ricardo Yarza

University of California, Santa Cruz
ryarza@ucsc.edu
ryarza.gitlab.io

Collaborators: Naela Razo-López, Ariadna Murguia-Berthier, Rosa Wallace Everson, Andrea Antoni, Morgan MacLeod, Melinda Soares-Furtado, Dongwook Lee, Enrico Ramirez-Ruiz

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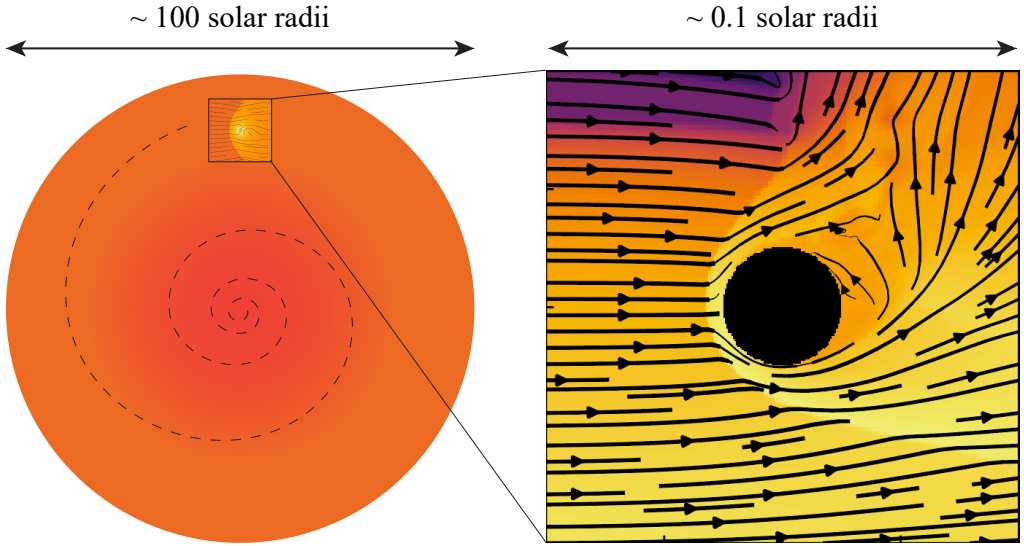
Introduction to planetary engulfment



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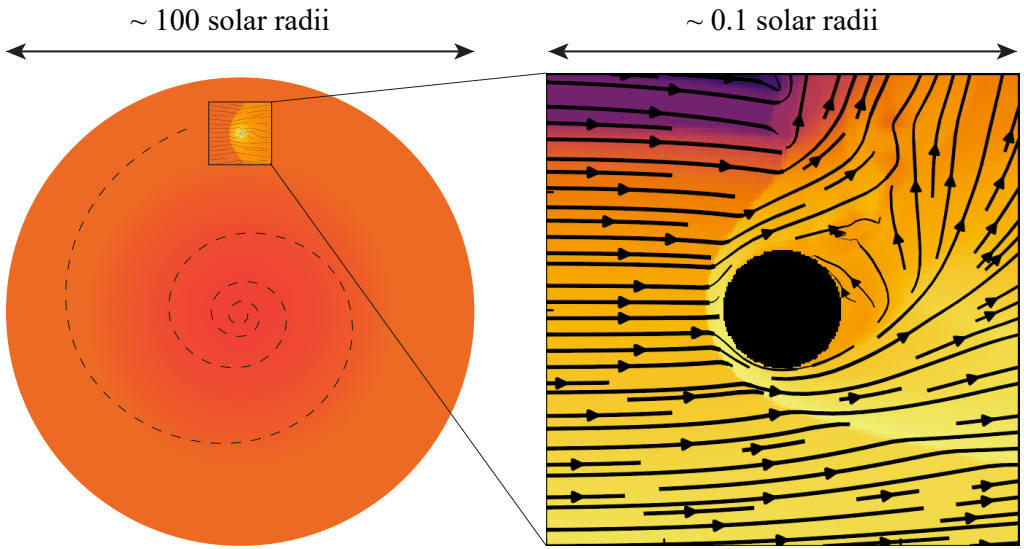

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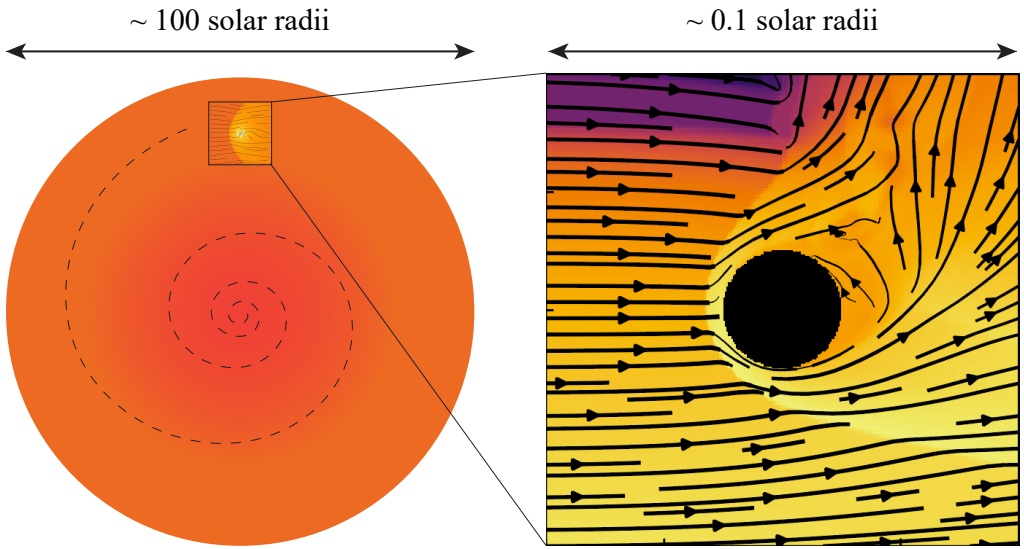

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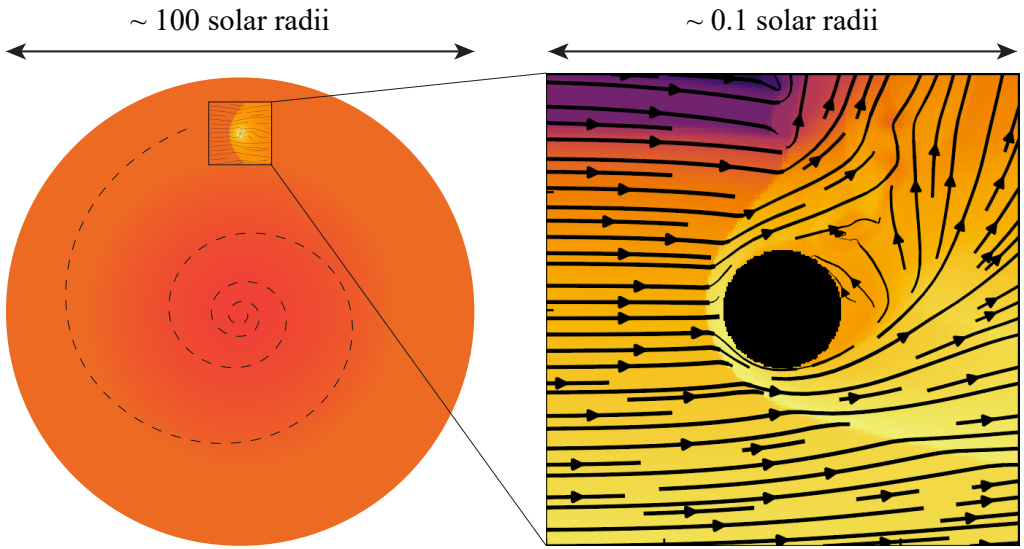

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- giant stars rich in lithium

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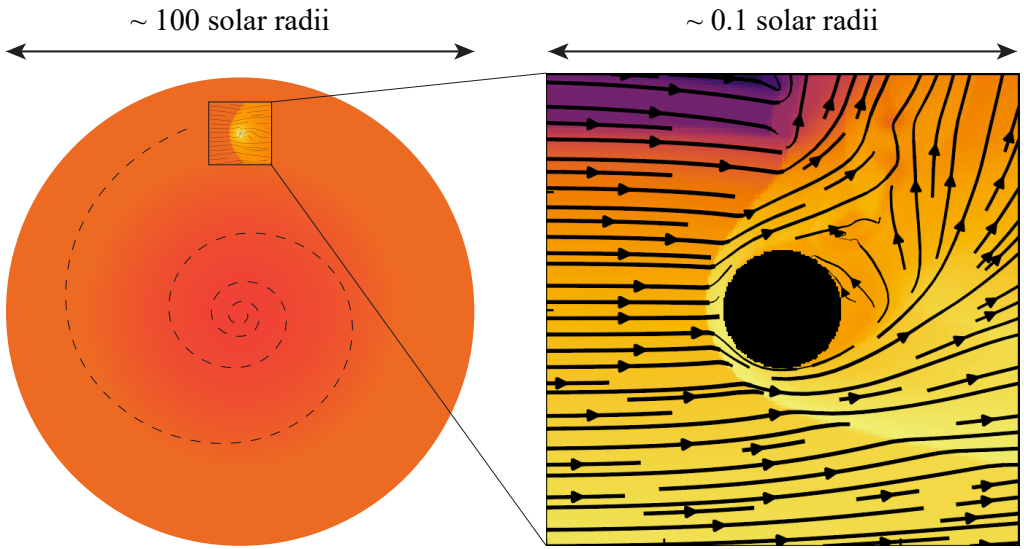

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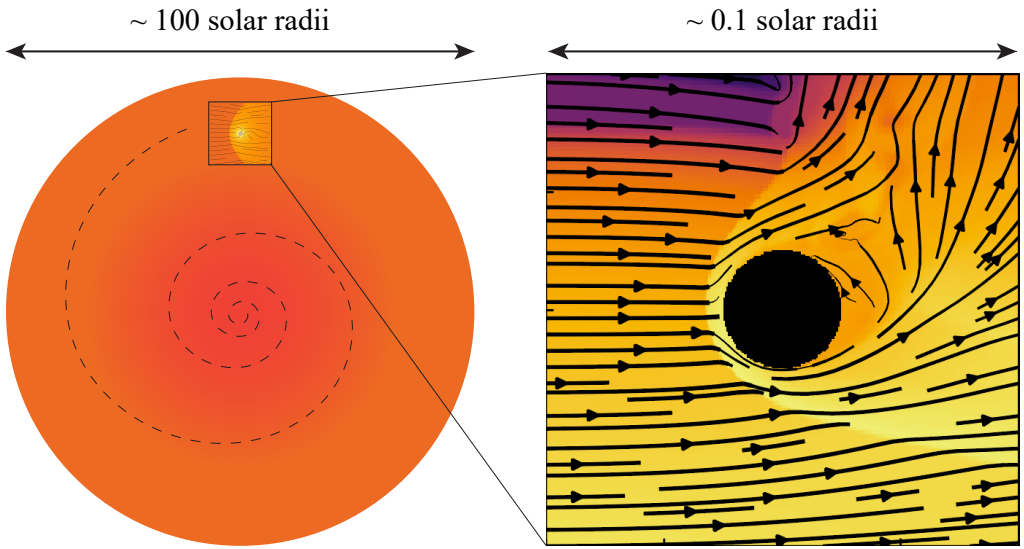
- giant stars rotating abnormally quickly
- giant stars rich in lithium
- planets and brown dwarfs found in close orbits around white dwarfs

Planets and giant stars have very different sizes



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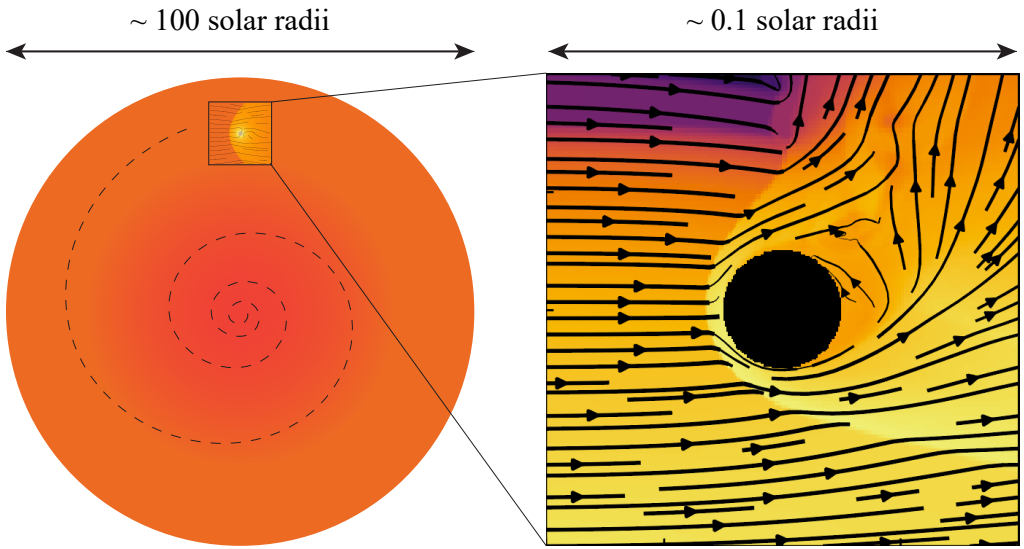

Our approach

Fluid dynamics simulations of the zoomed-in picture—the physical environment in the vicinity of the planet.

Steps in our numerical framework

1. Identify the physical properties of the environment around the planet: how fast is it moving? how dense is the surrounding material?

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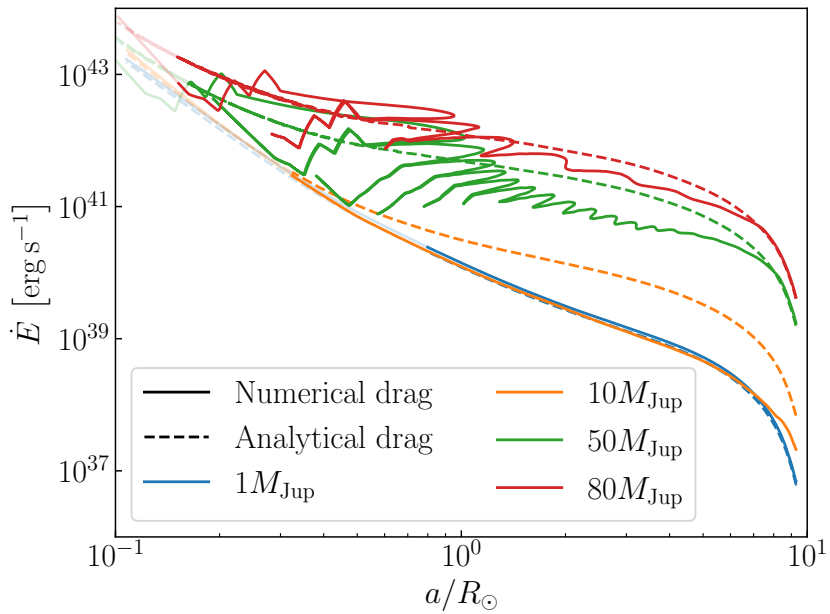
2. Simulate the vicinity of the planet using these parameters.
3. Measure the drag forces the planet experiences.
4. Use these drag forces to determine the trajectory of the planet inside the star.

Results

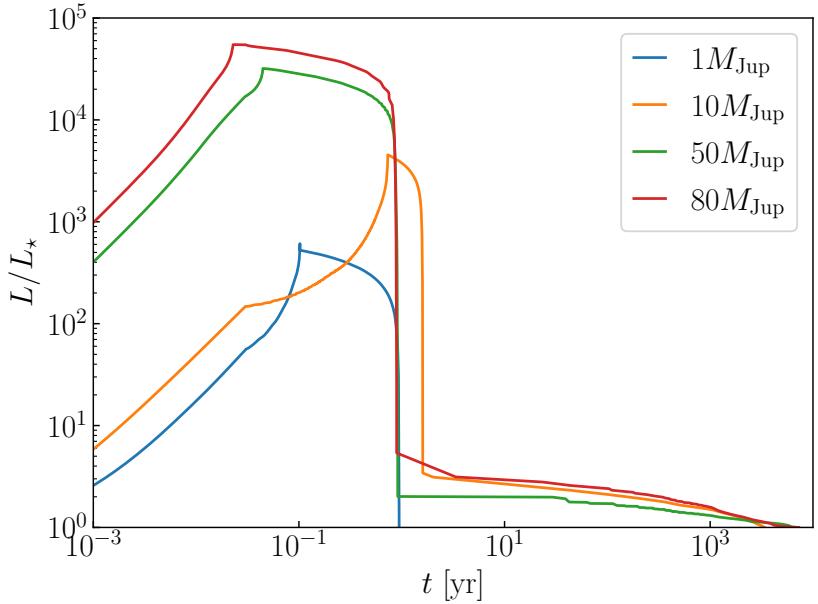
- The planet deposits energy into the star at a very different rate than expected.



Yarza et al. arXiv:2203.11227.

Results

- The planet deposits energy into the star at a very different rate than expected.
- Engulfment can significantly increase the luminosity of a star for up to a few thousand years.



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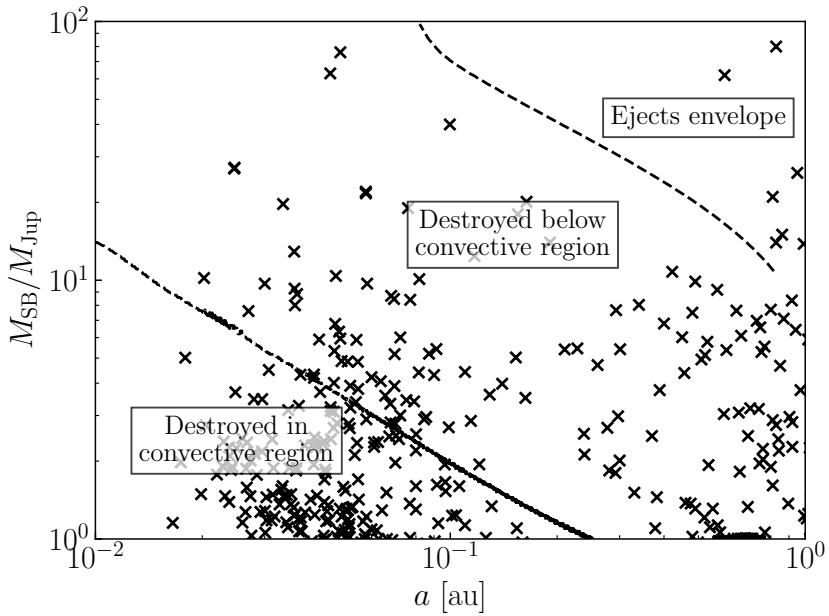
- Massive brown dwarfs can deposit enough energy to eject the outer layers of the star.



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Summary

We studied the fluid dynamics in the vicinity of a planet or brown dwarf engulfed by its star.

Our main results are:

- The planet deposits energy into the star at a very different rate than expected.
- Engulfment can significantly increase the luminosity of a star for up to a few thousand years.
- Massive brown dwarfs can deposit enough energy to eject the outer layers of the star.

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