

COSMIC RAY CHEMISTRY IN THE ATMOSPHERES OF IRRADIATED AND NON-IRRADIATED PLANETS



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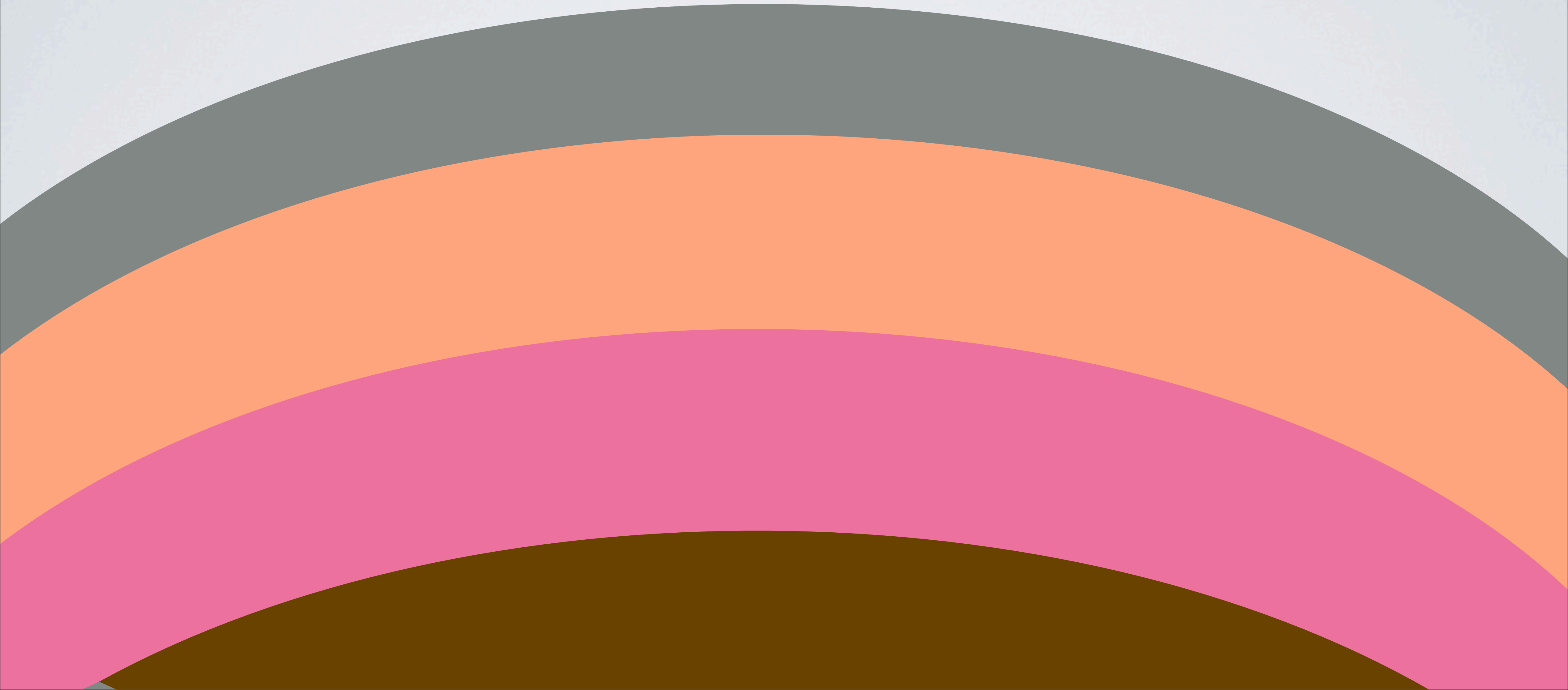


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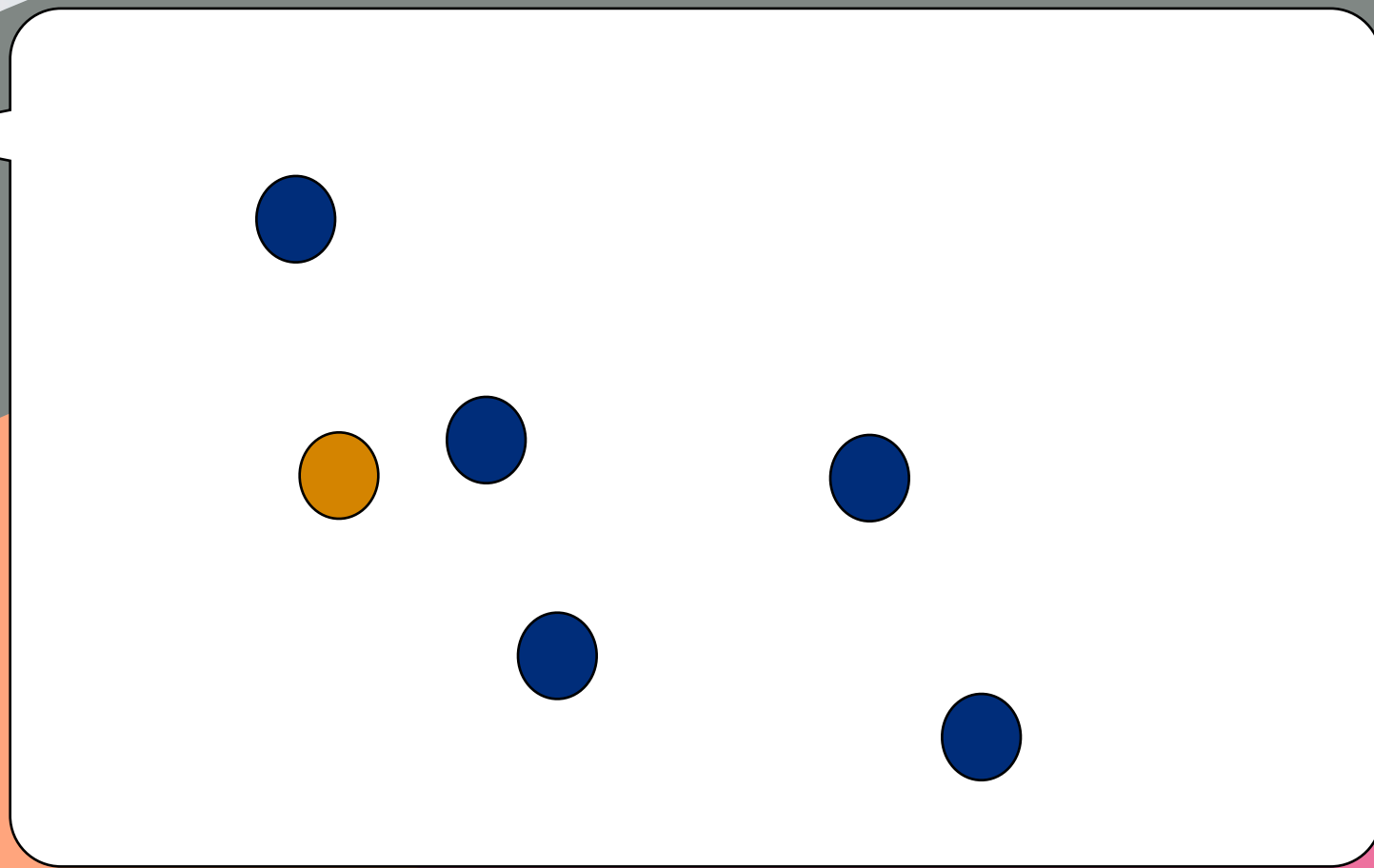


68th Ohio State University International Symposium on Molecular Spectroscopy

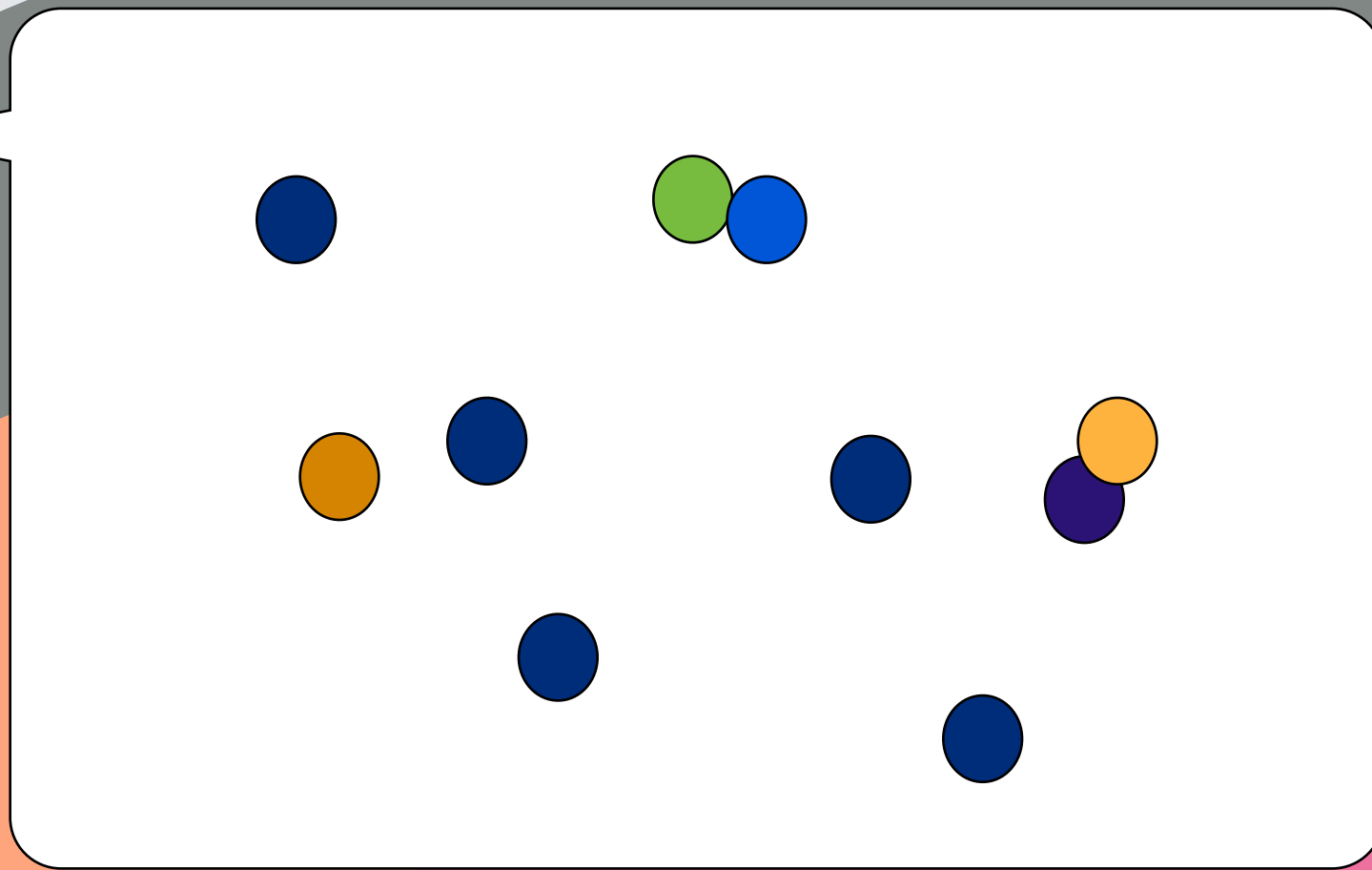
HOW TO MODEL GIANT GAS PLANETS



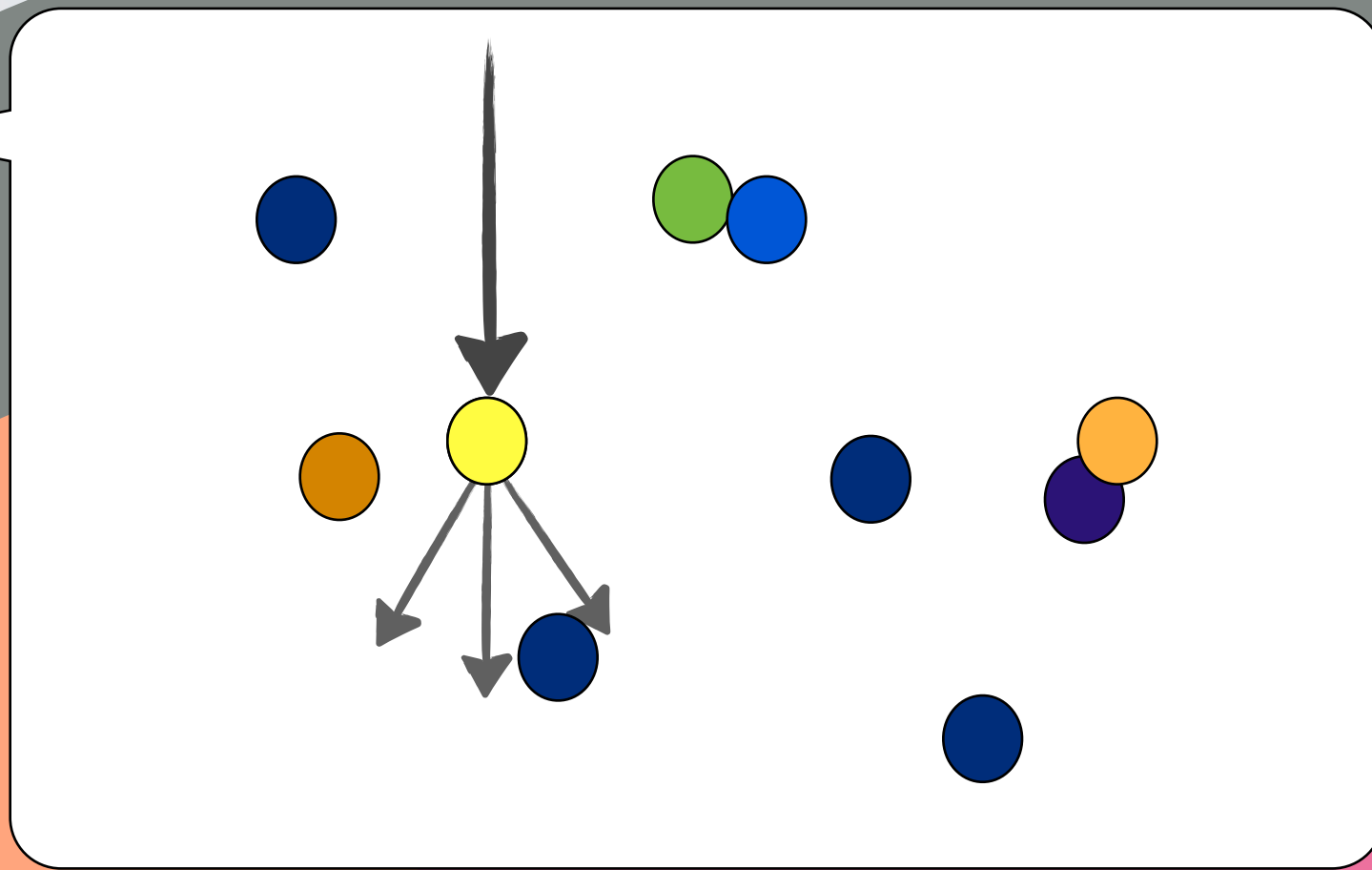
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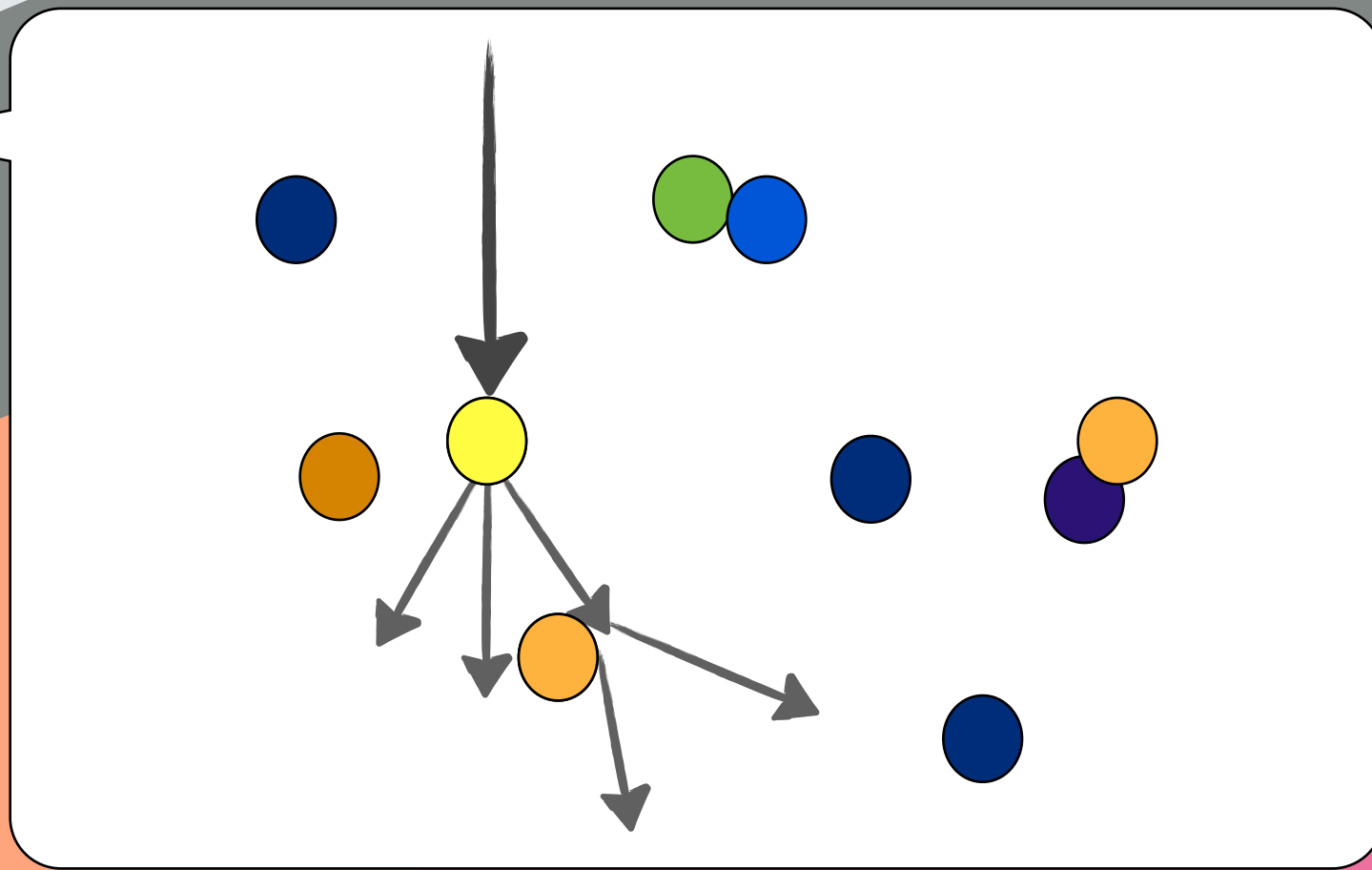
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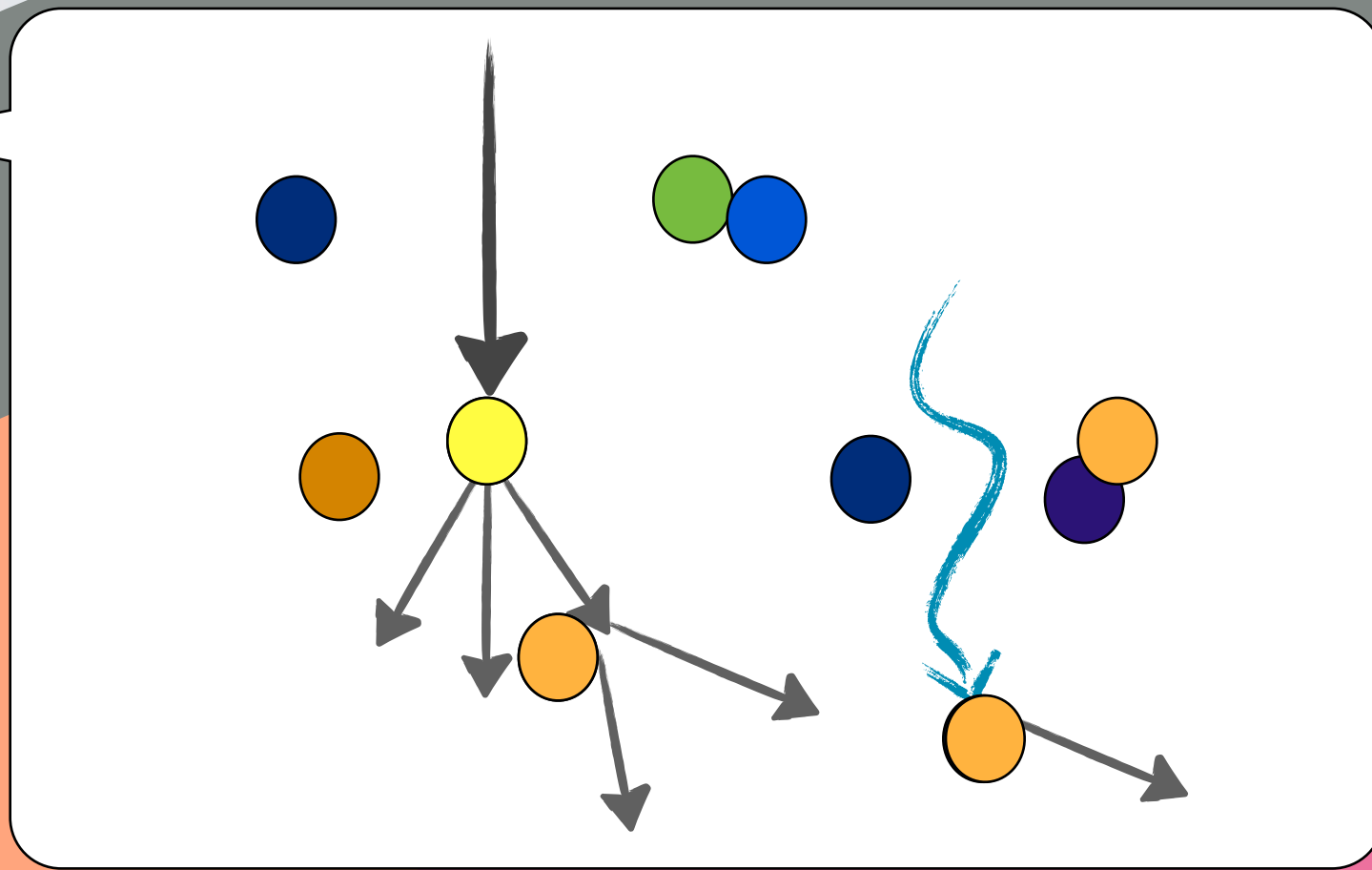
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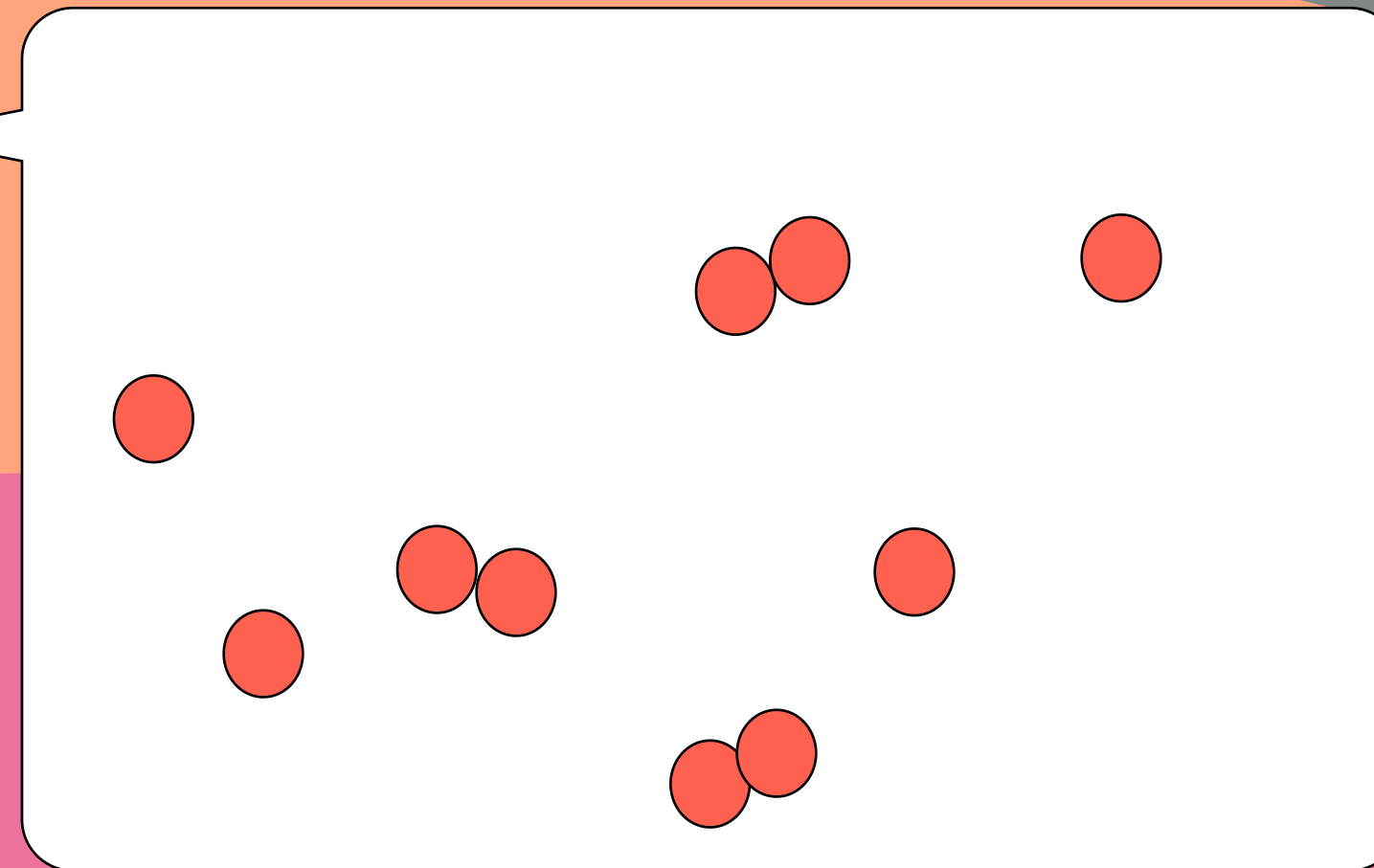
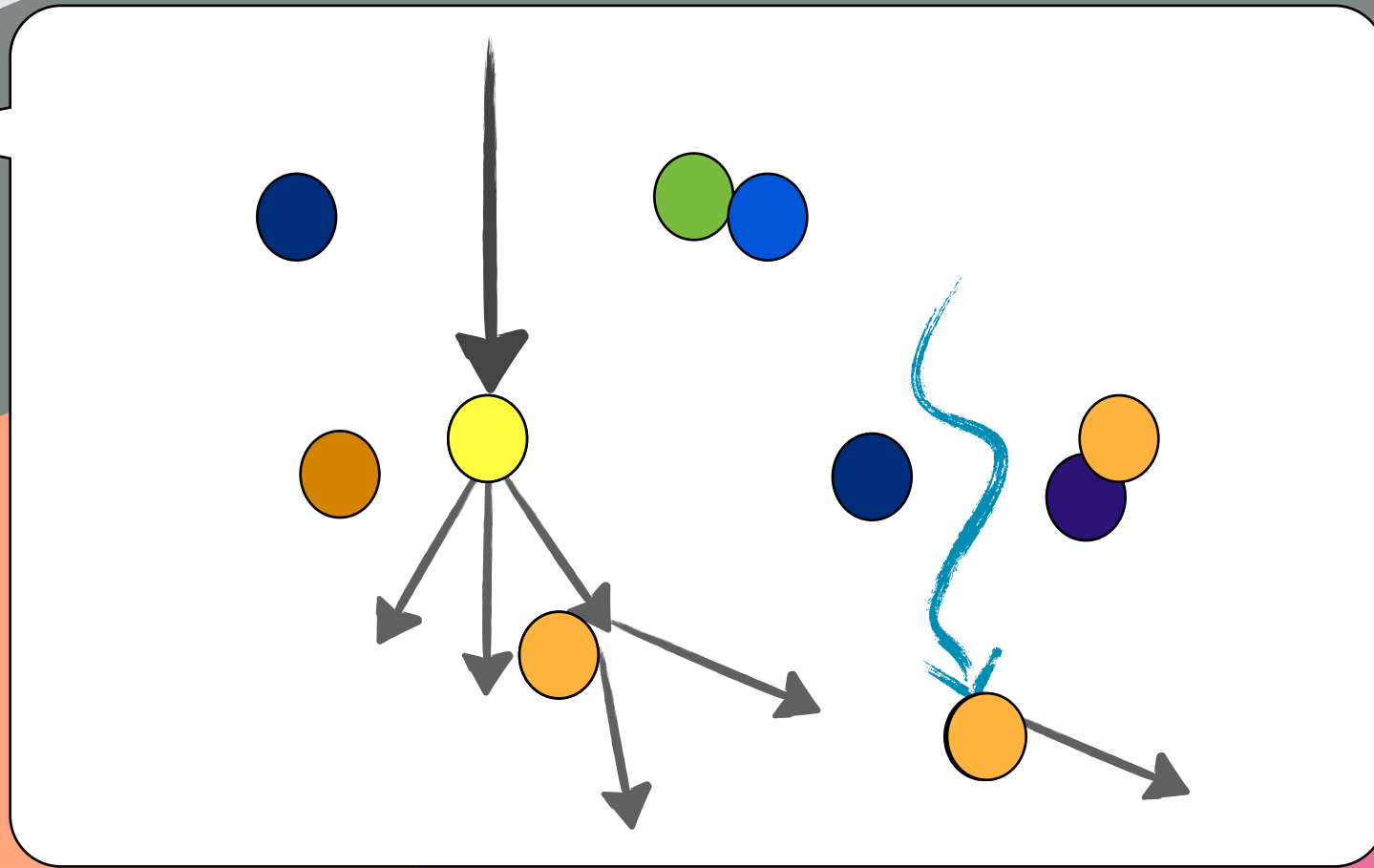
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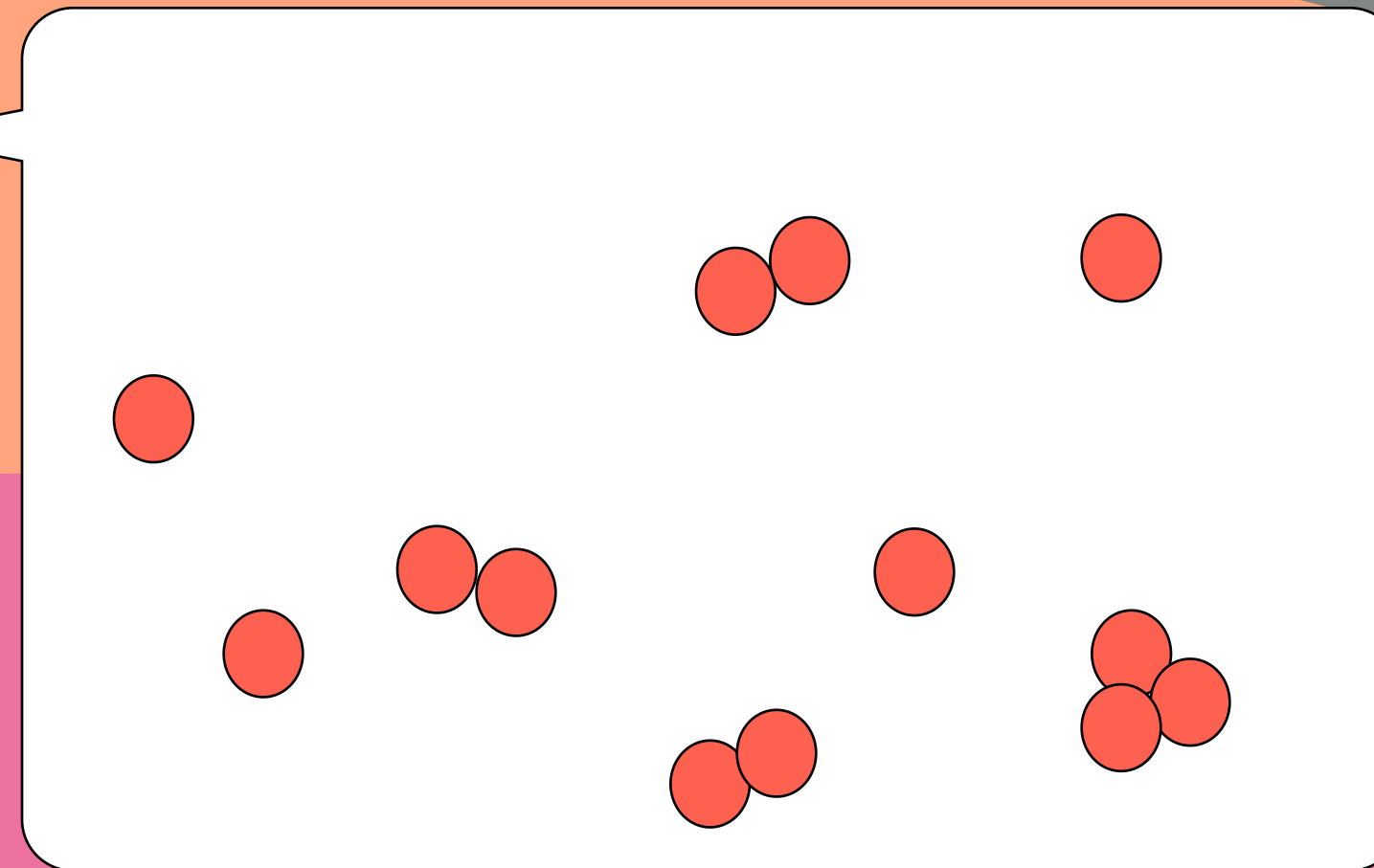
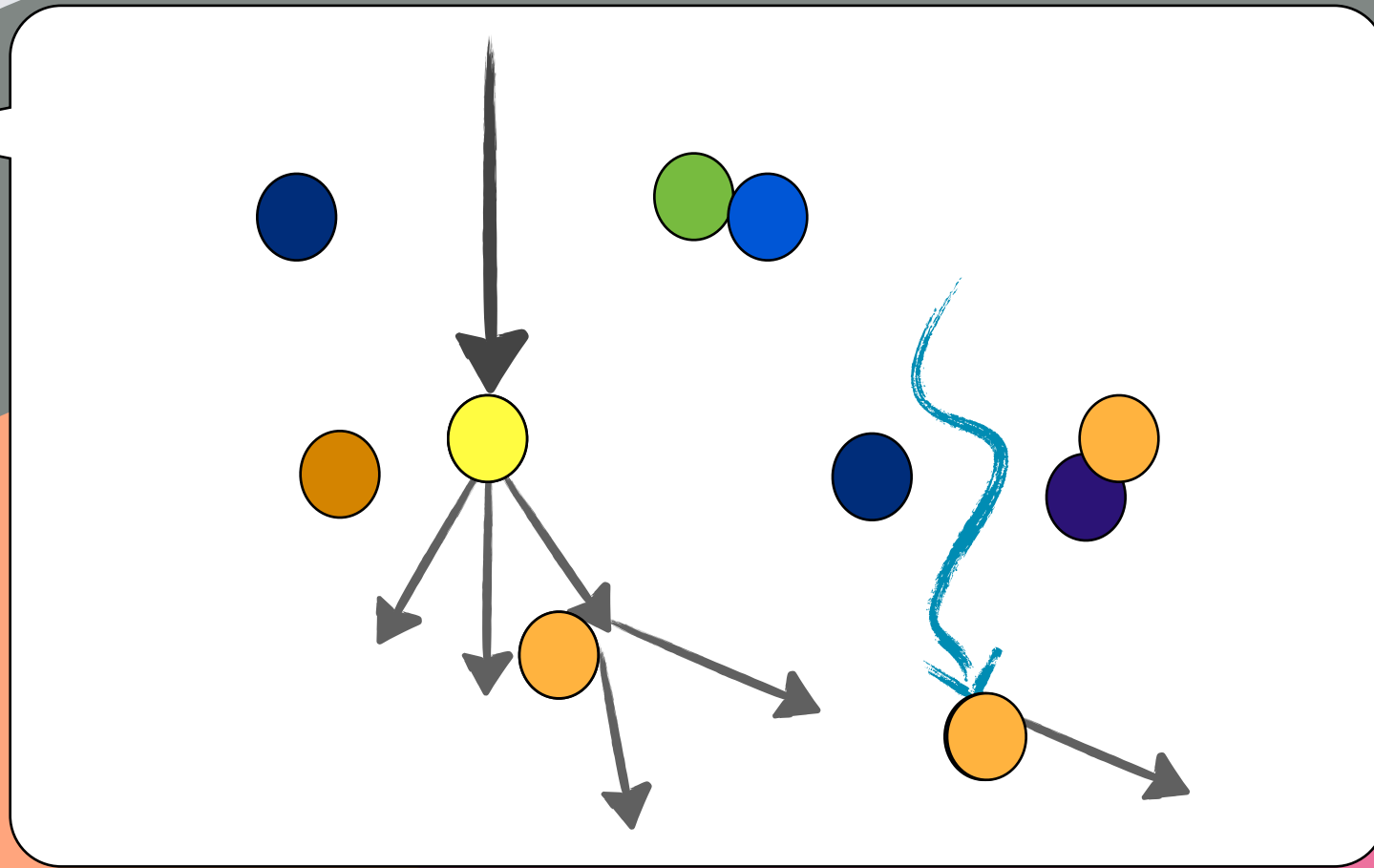
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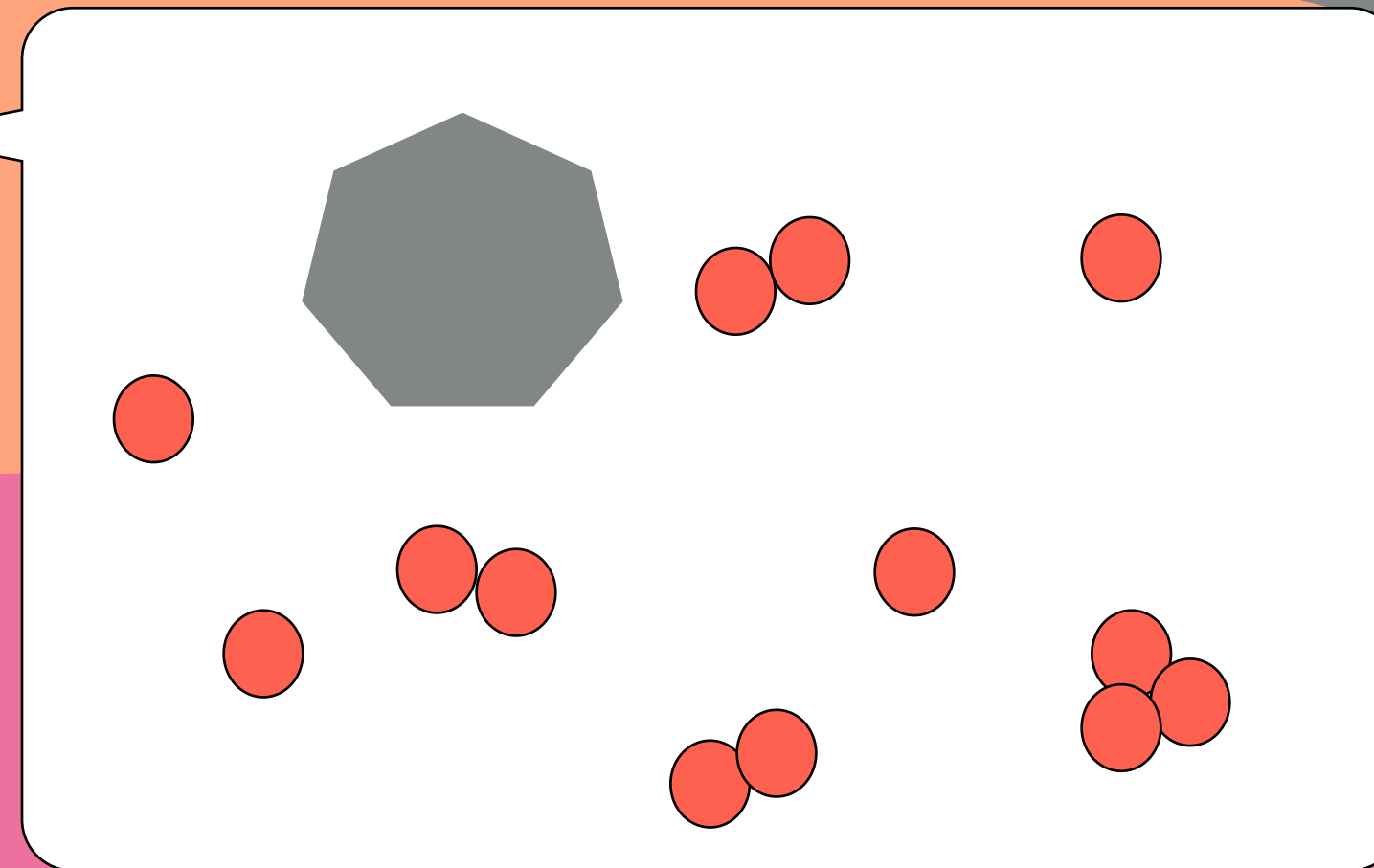
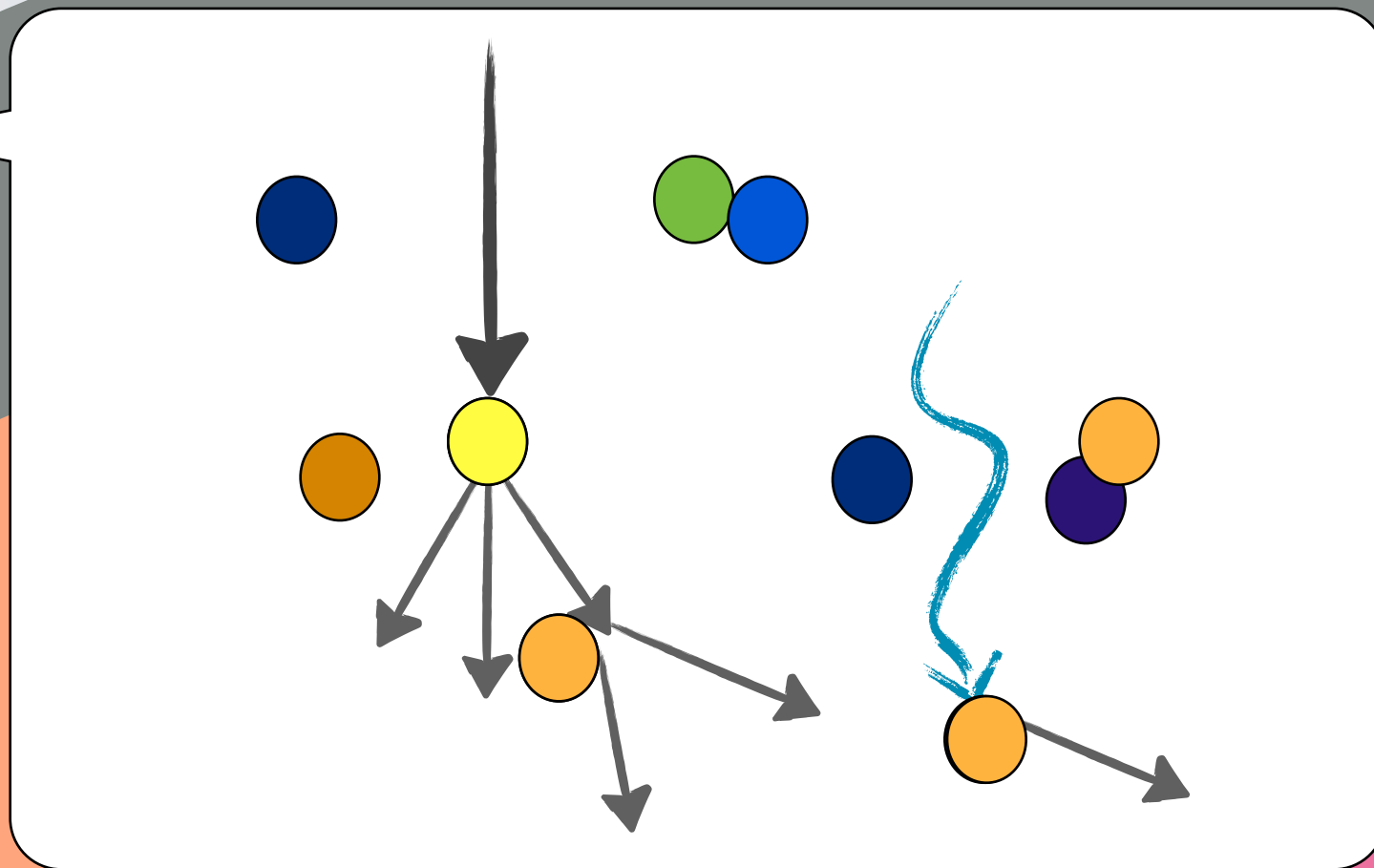
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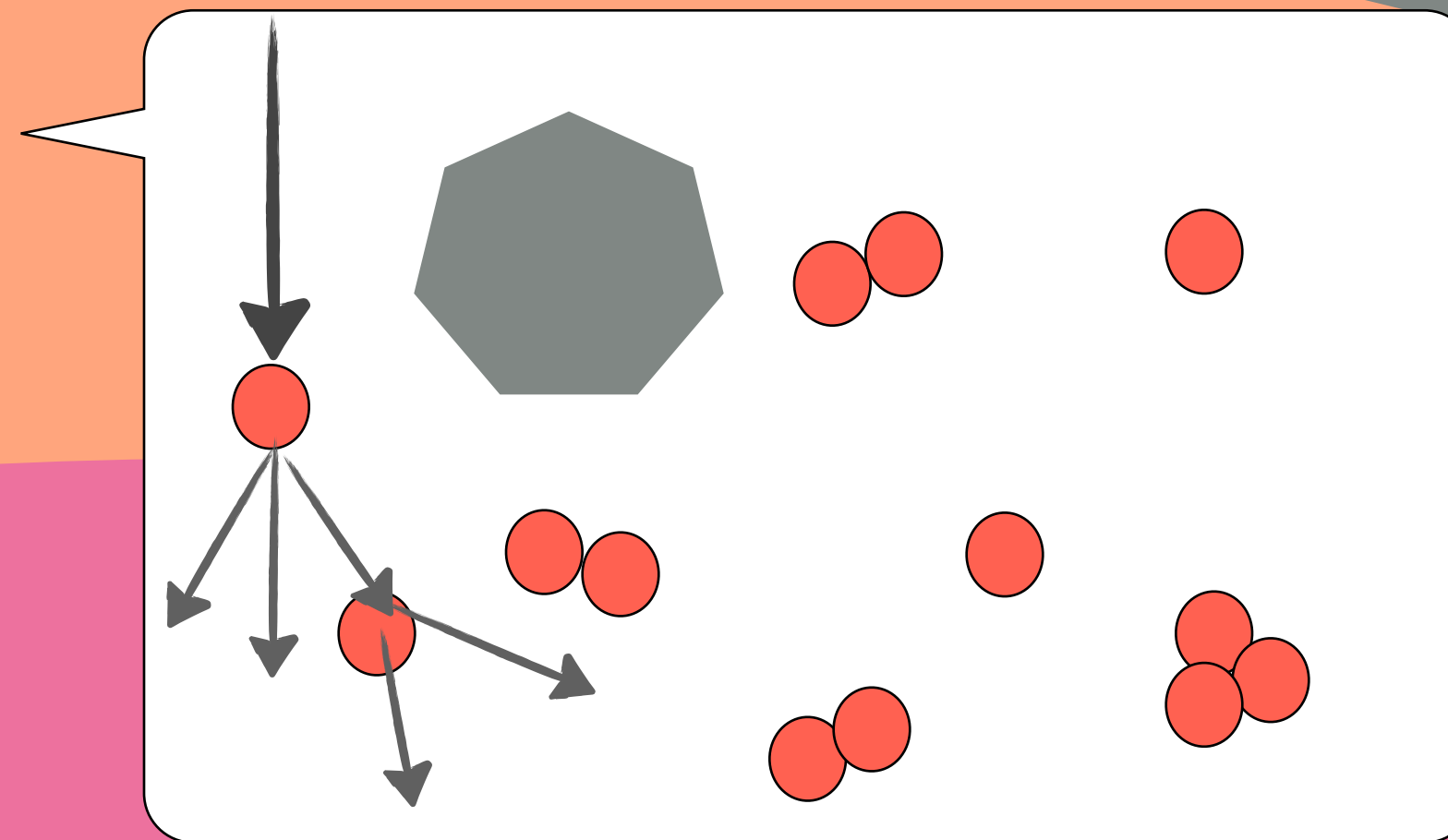
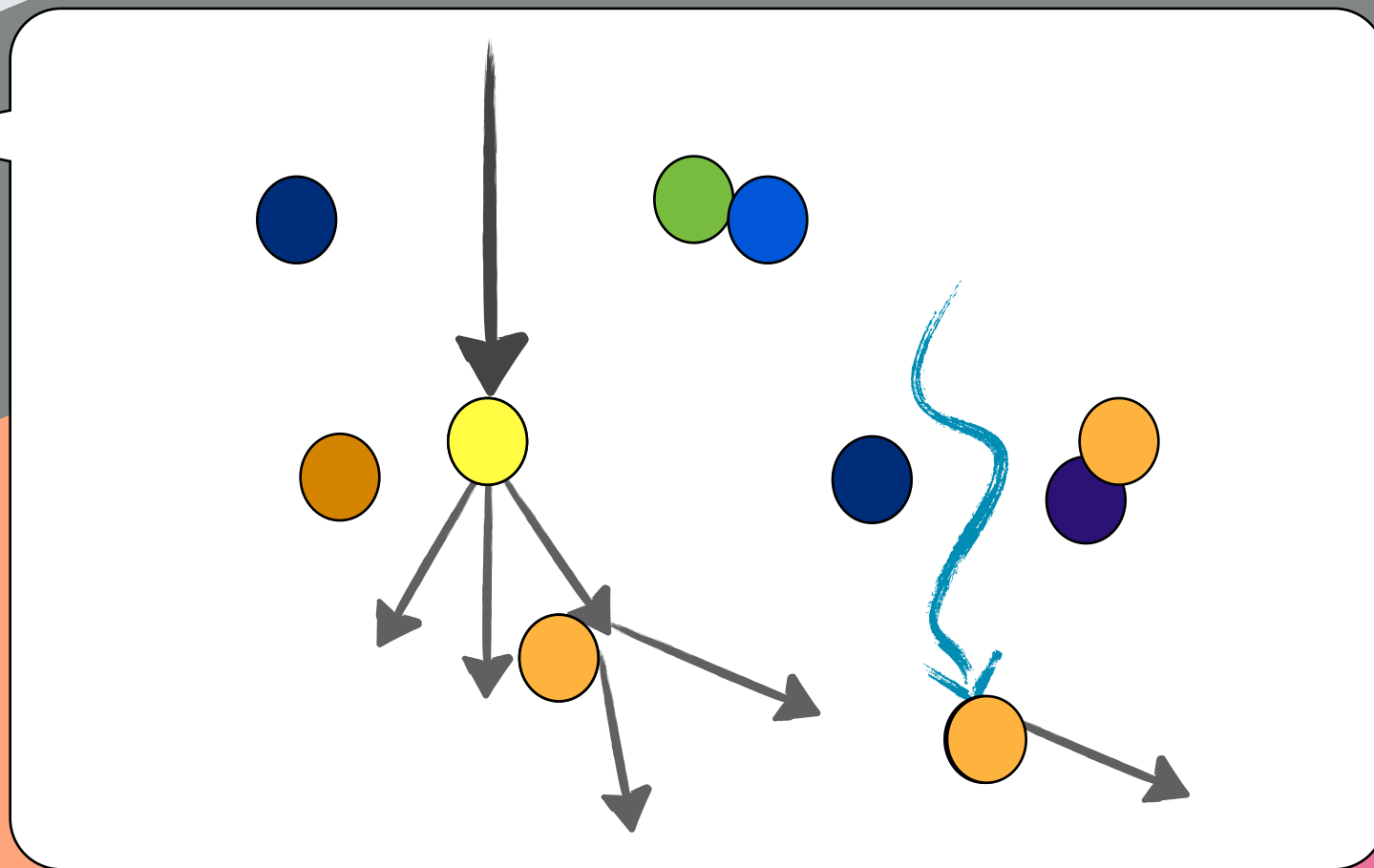
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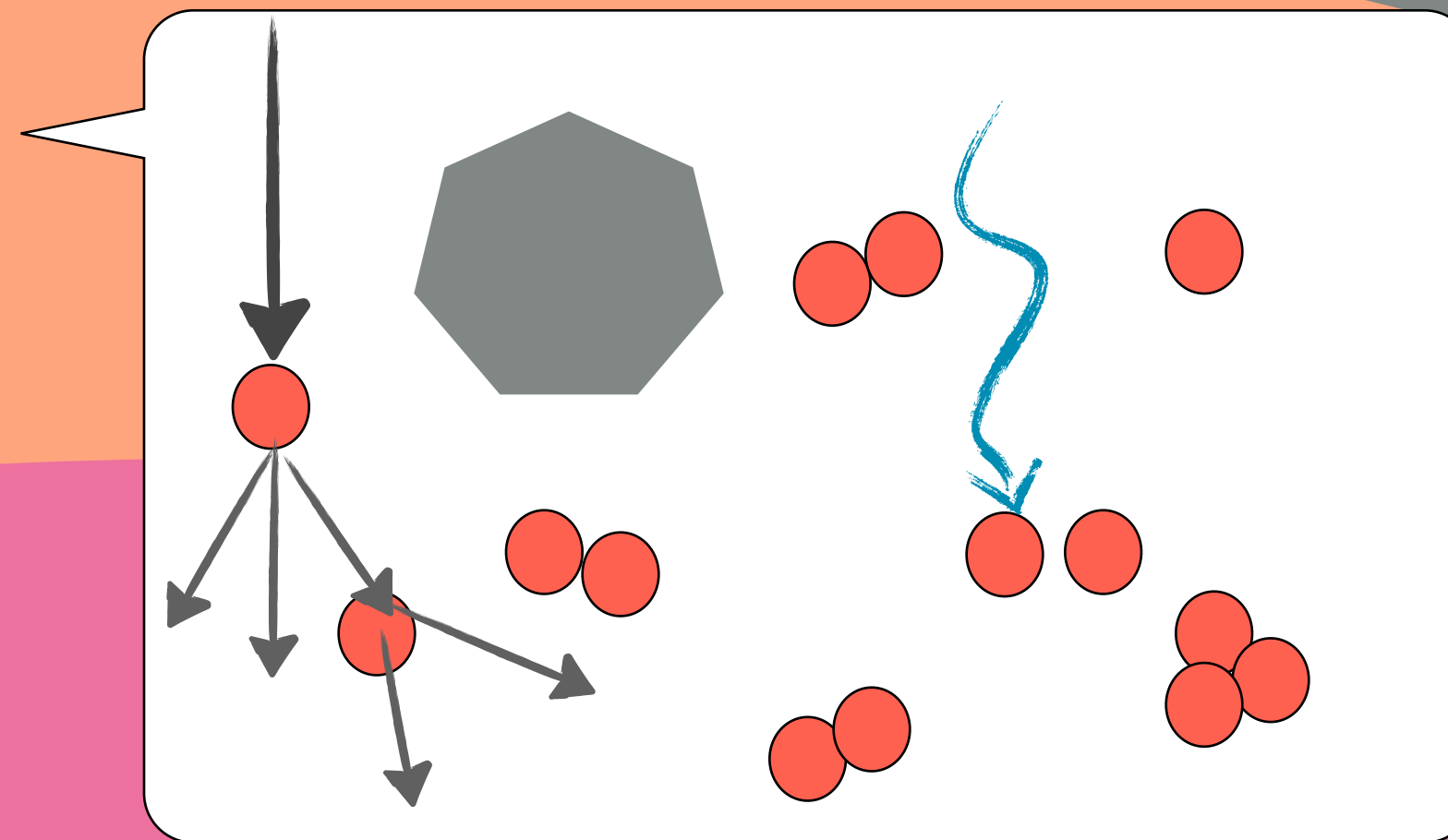
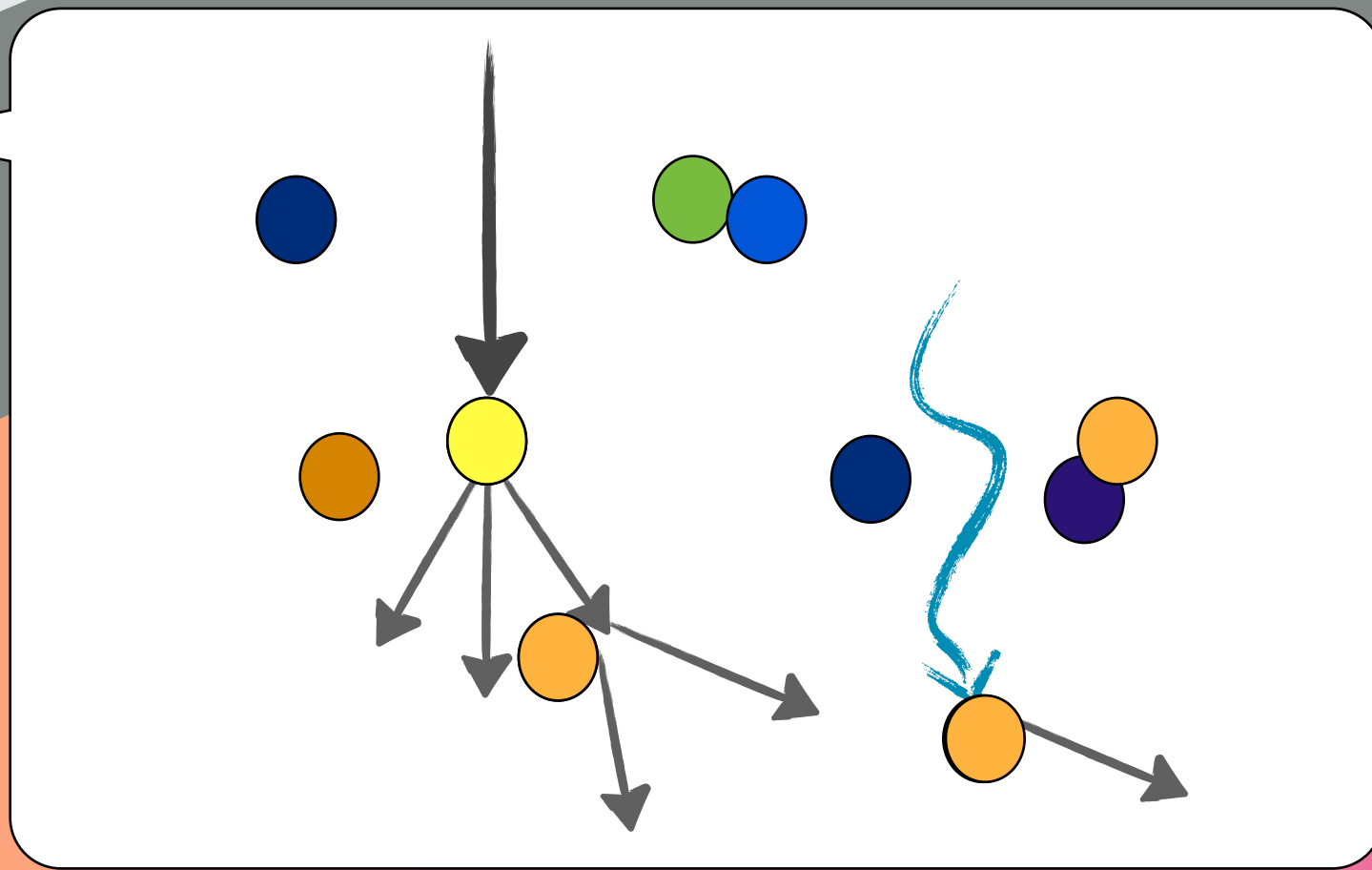
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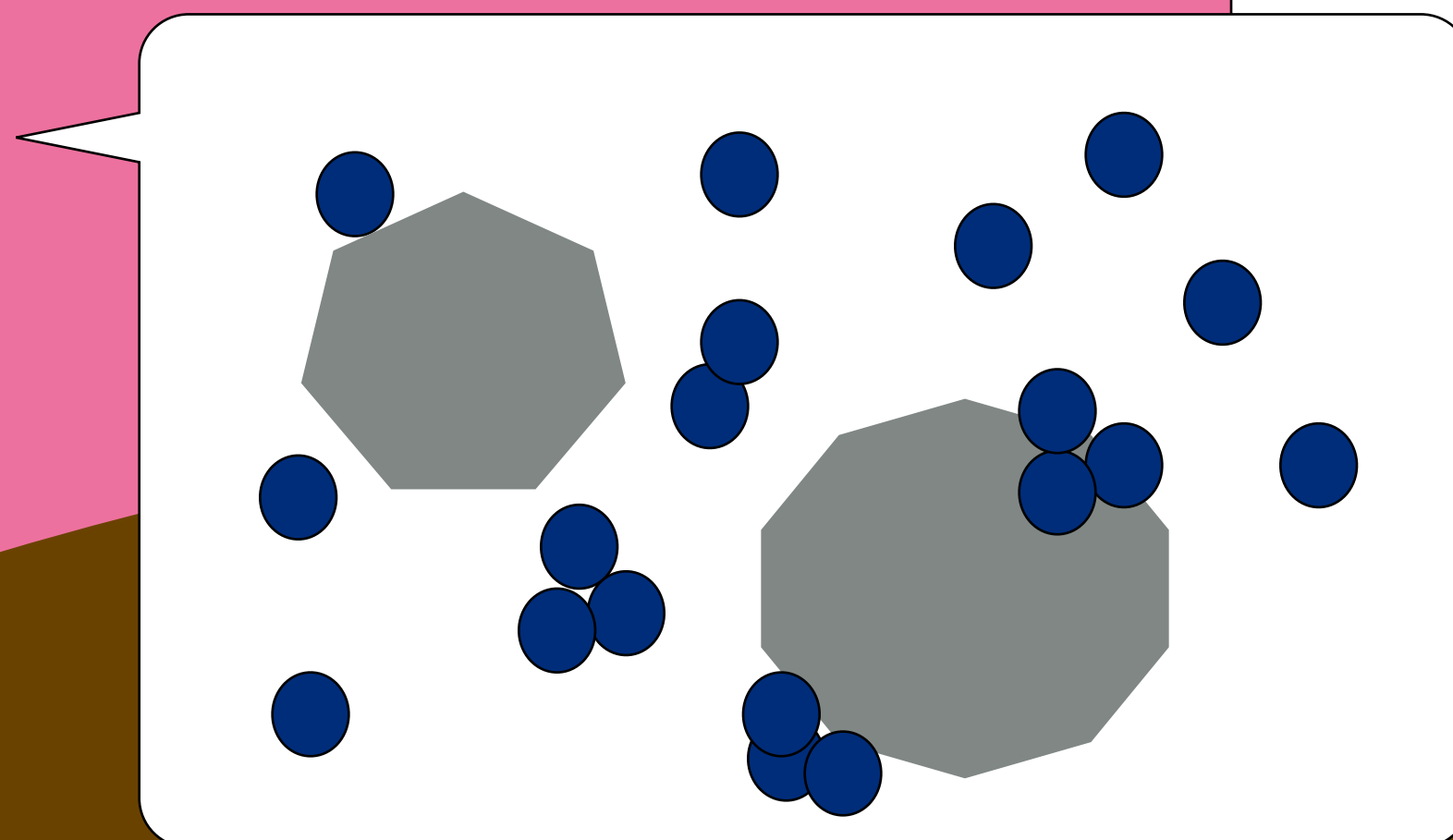
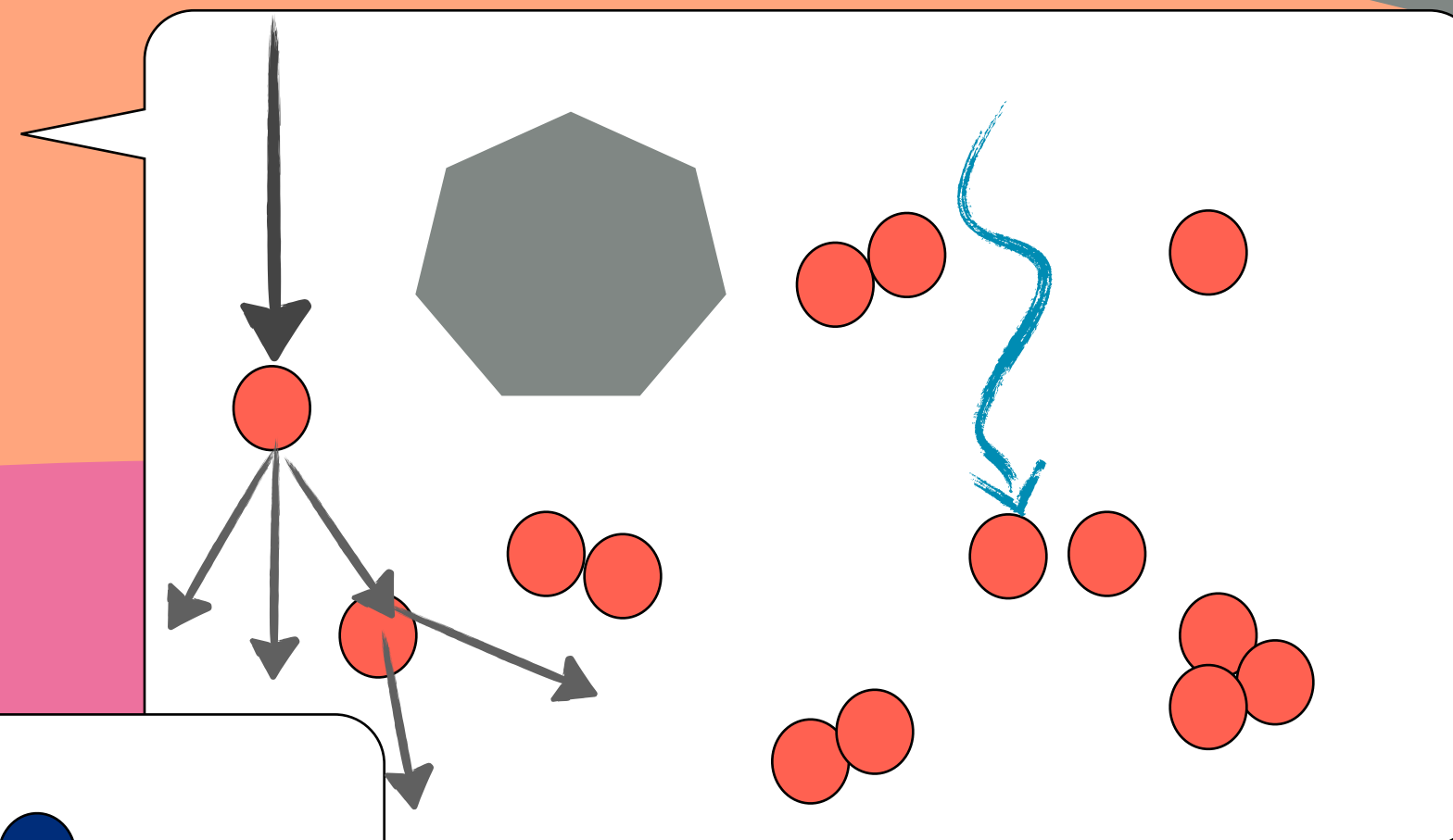
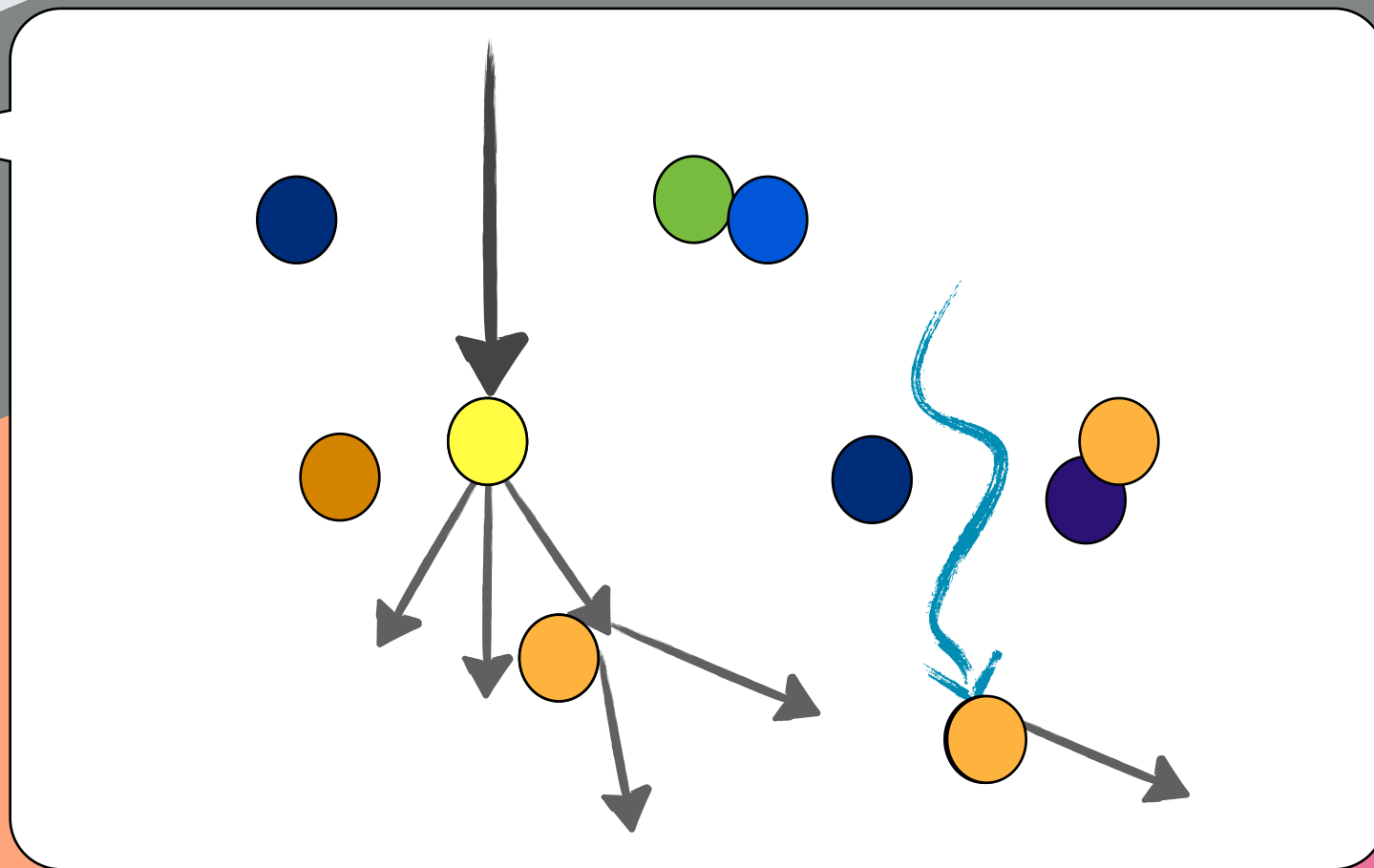
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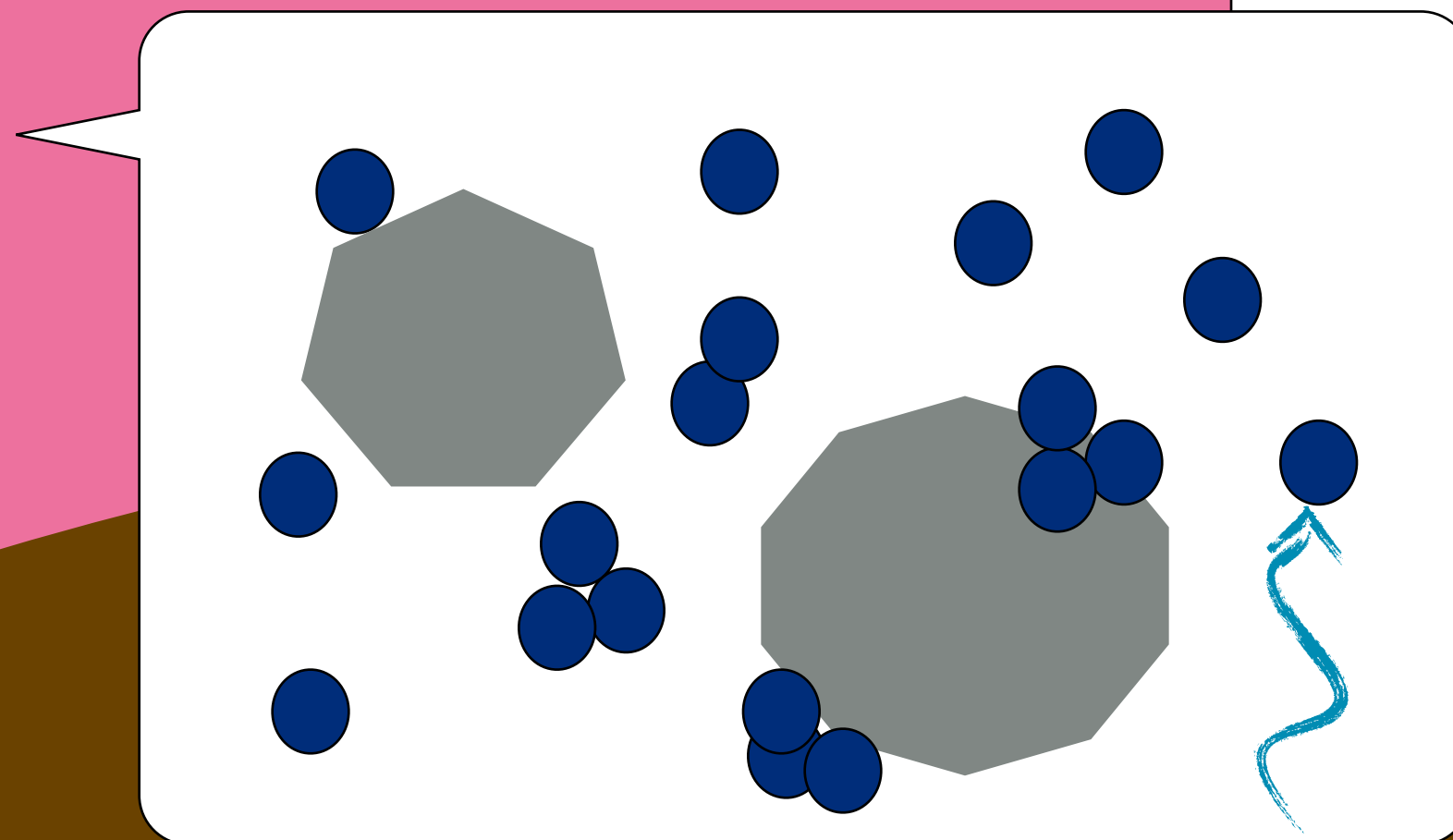
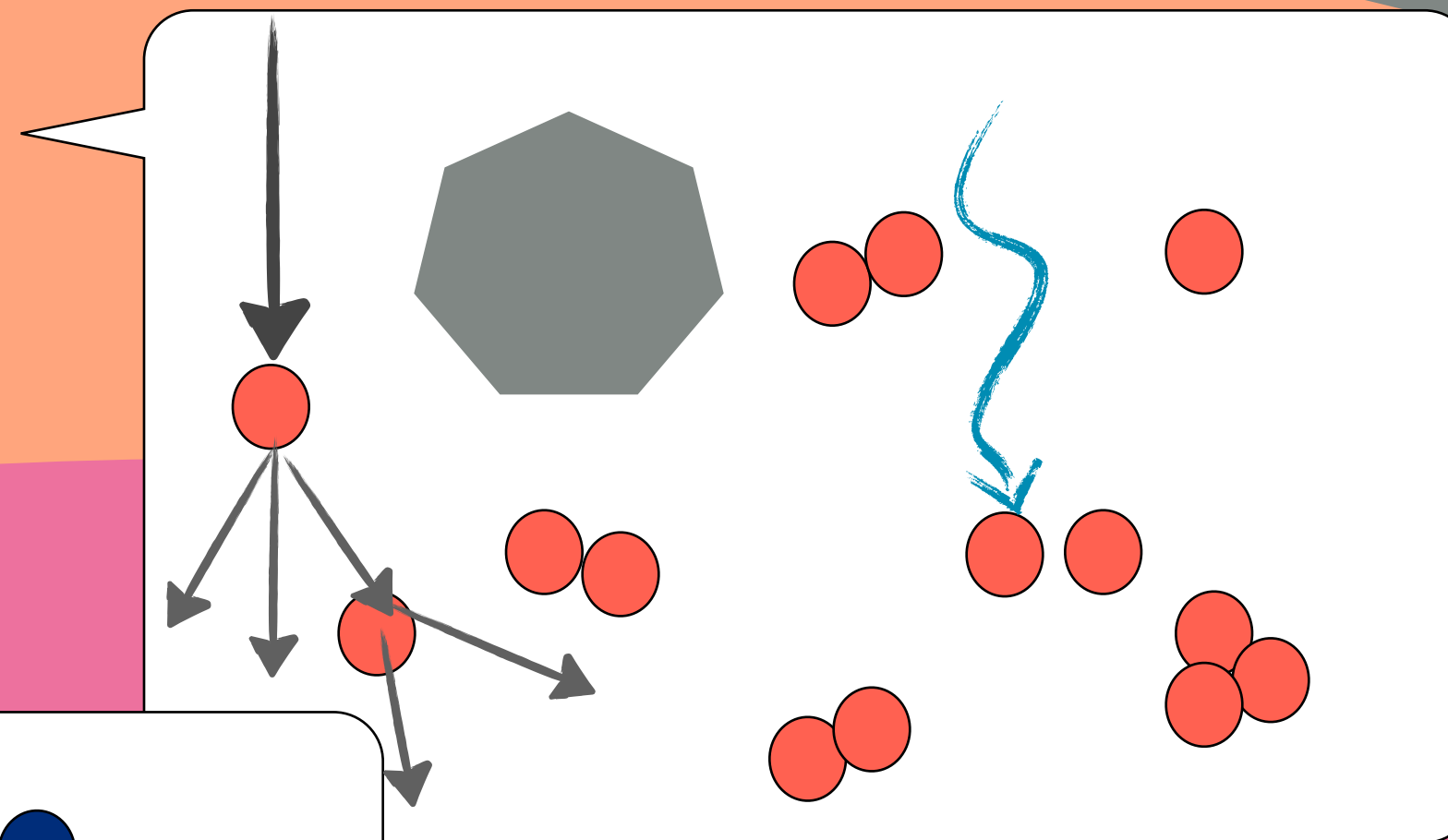
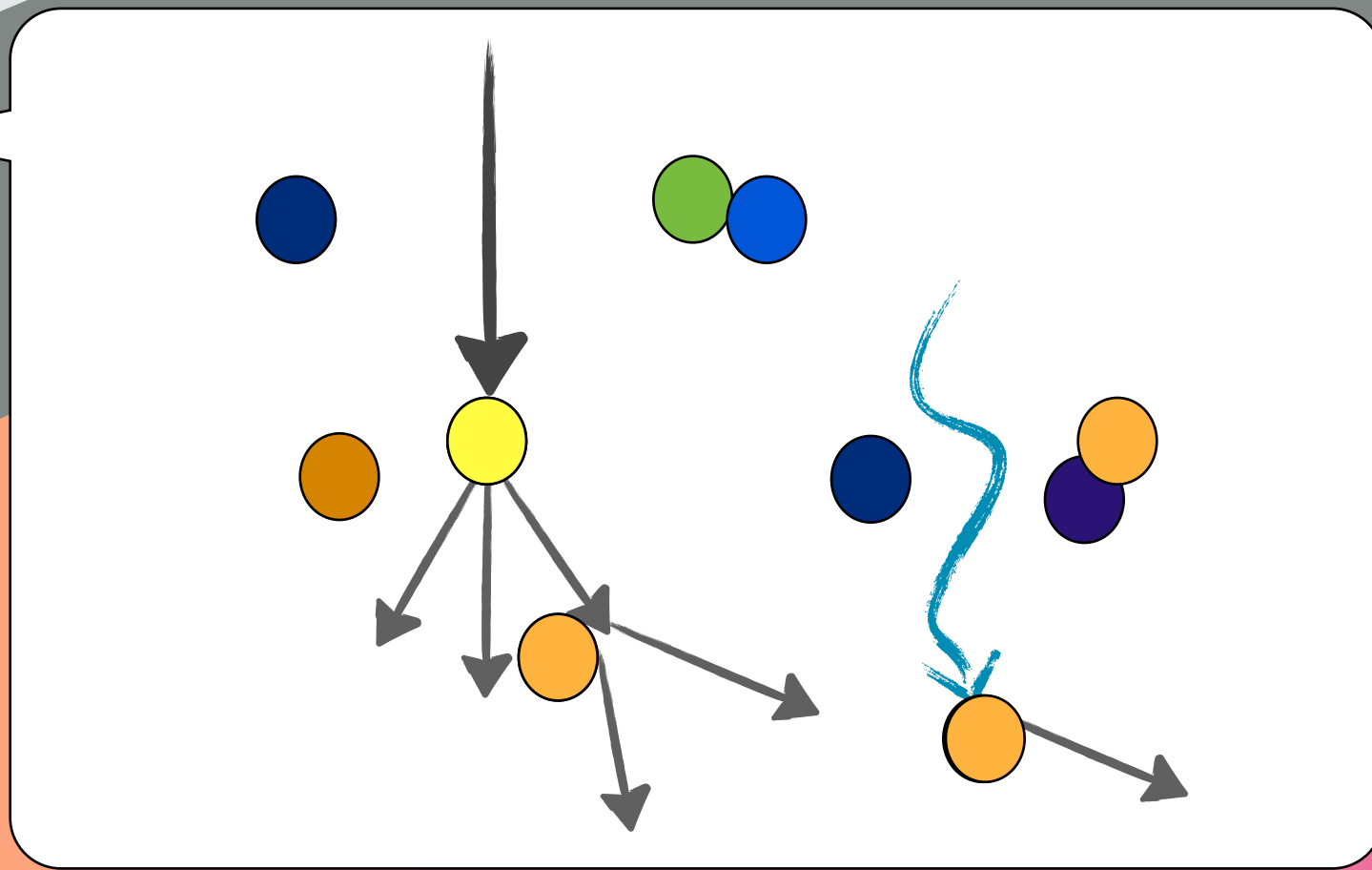
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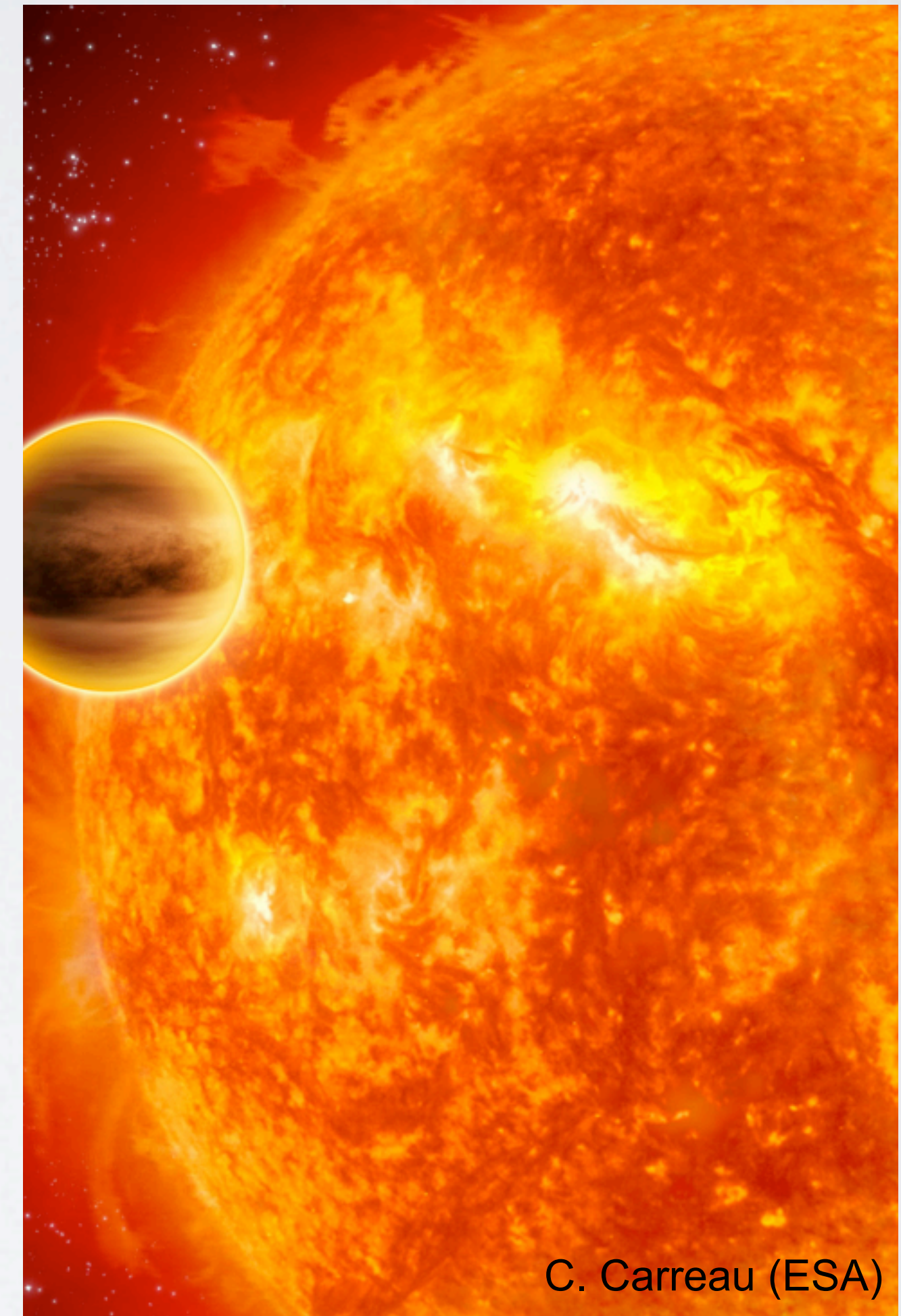
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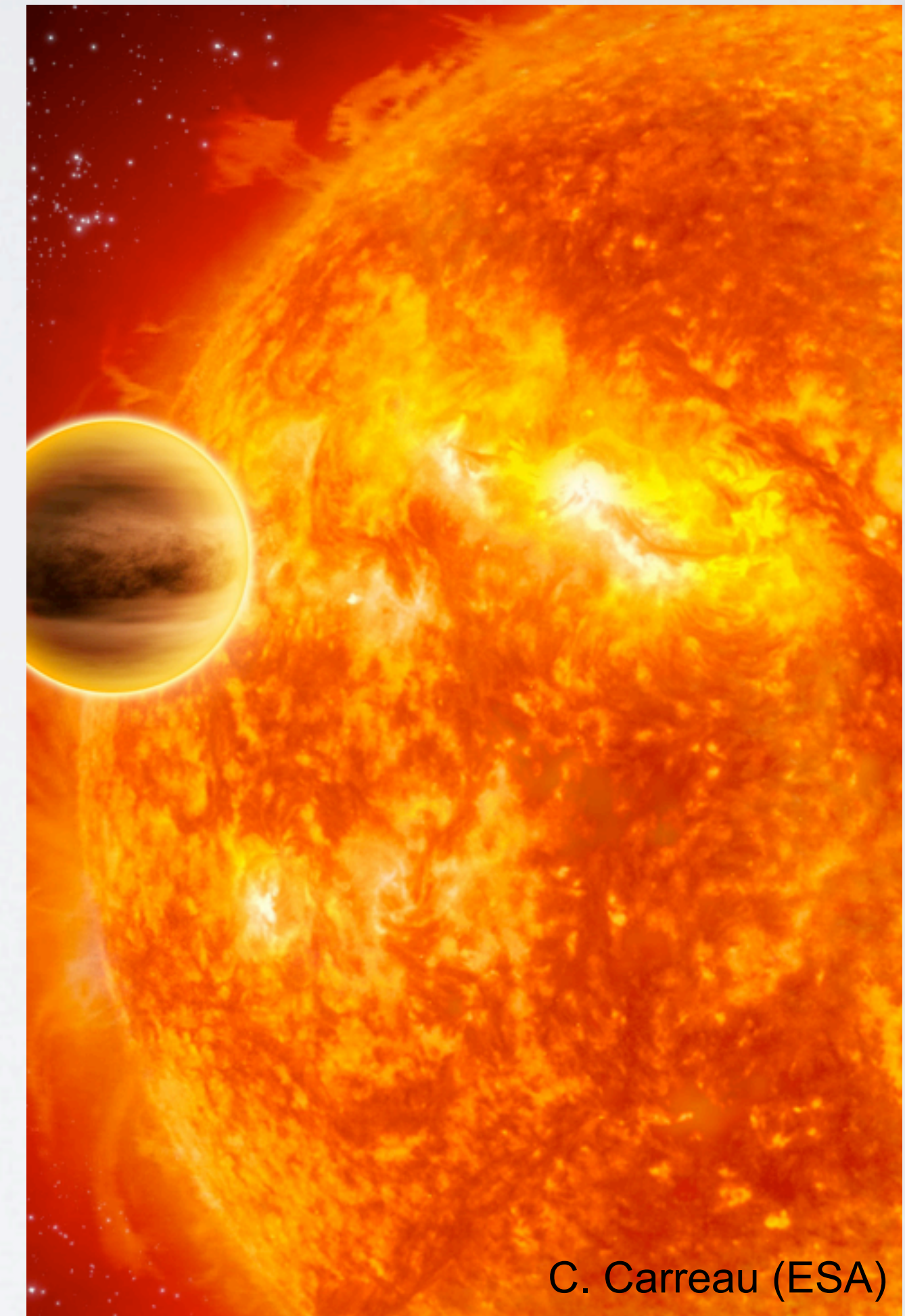
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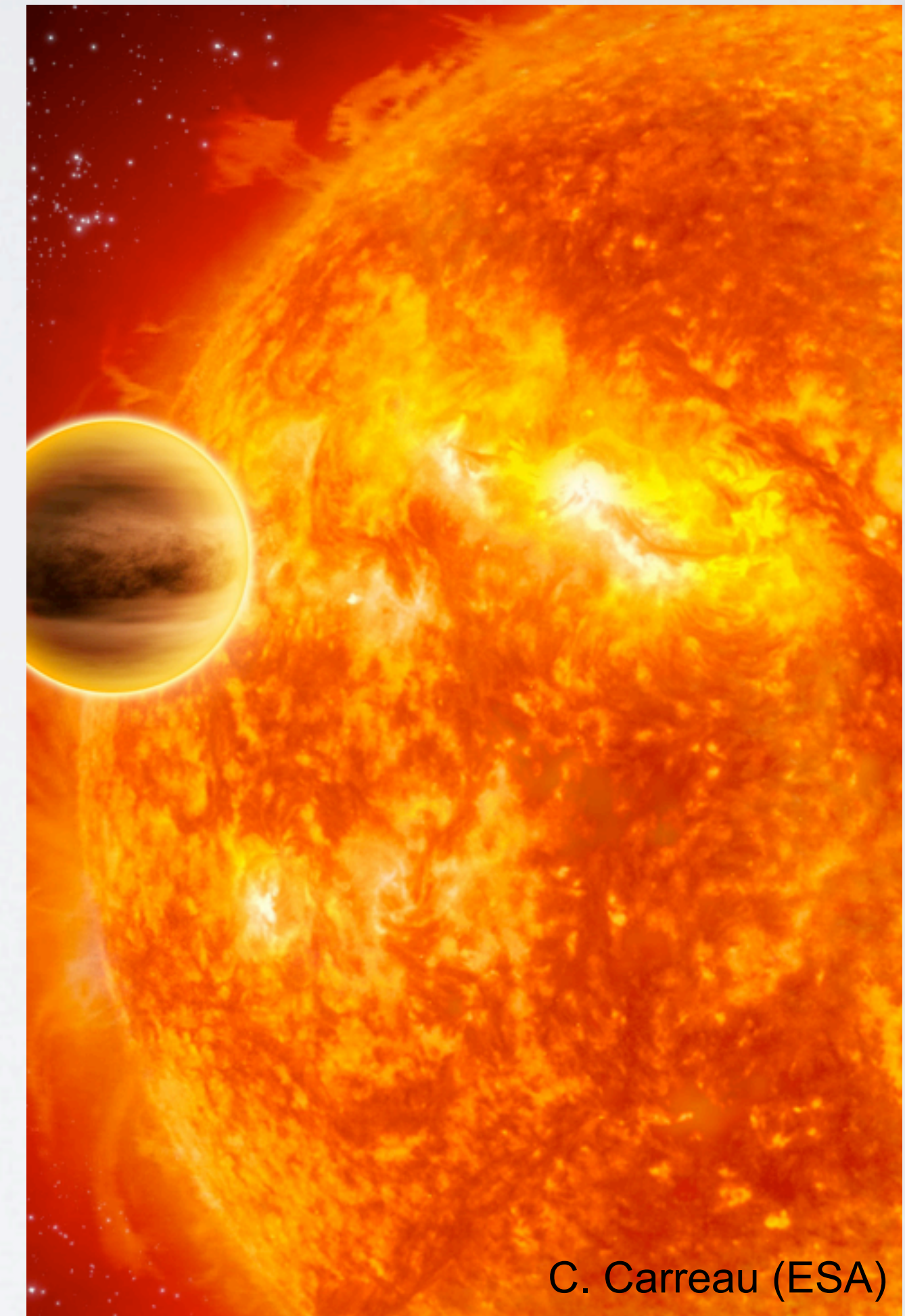
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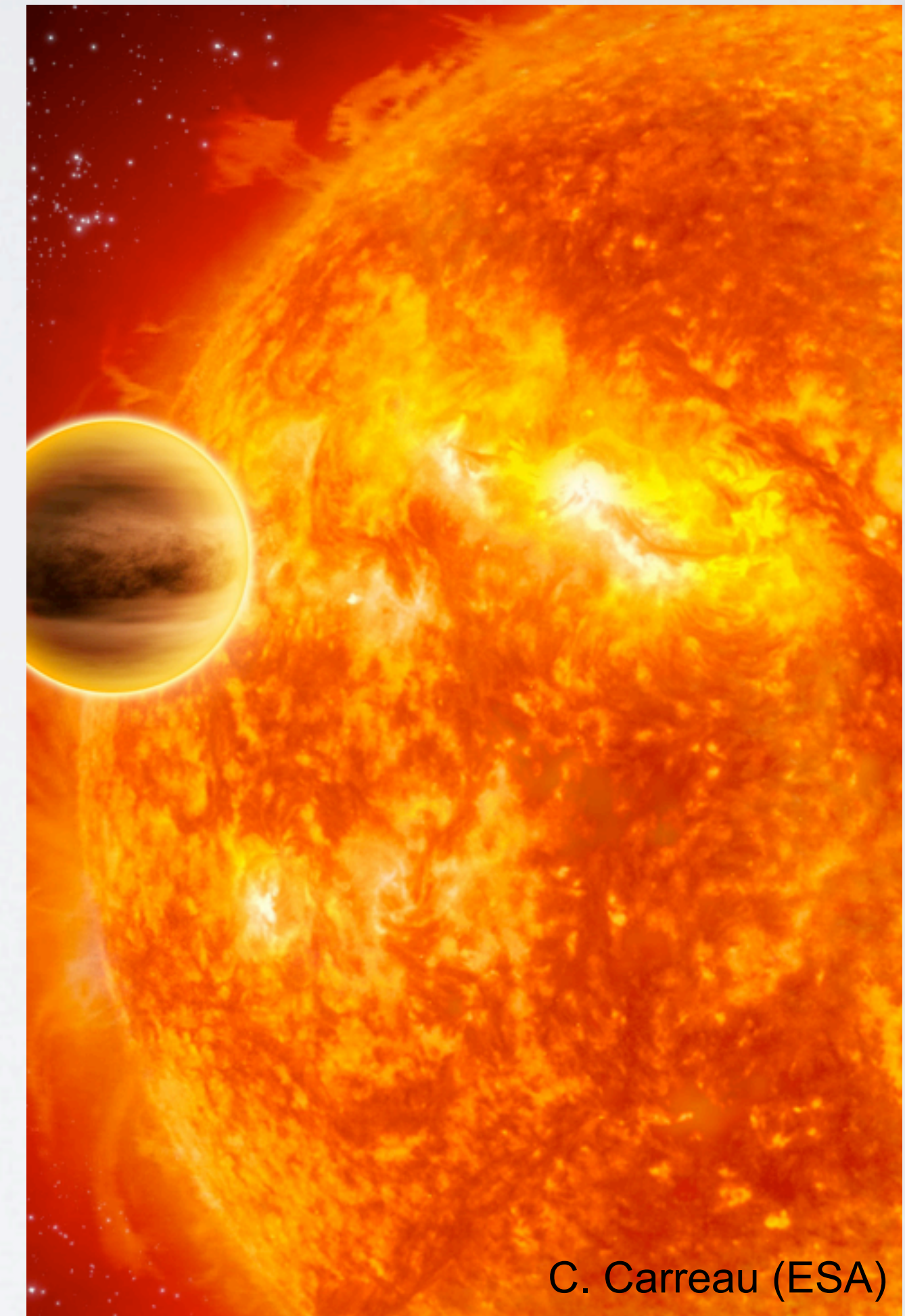
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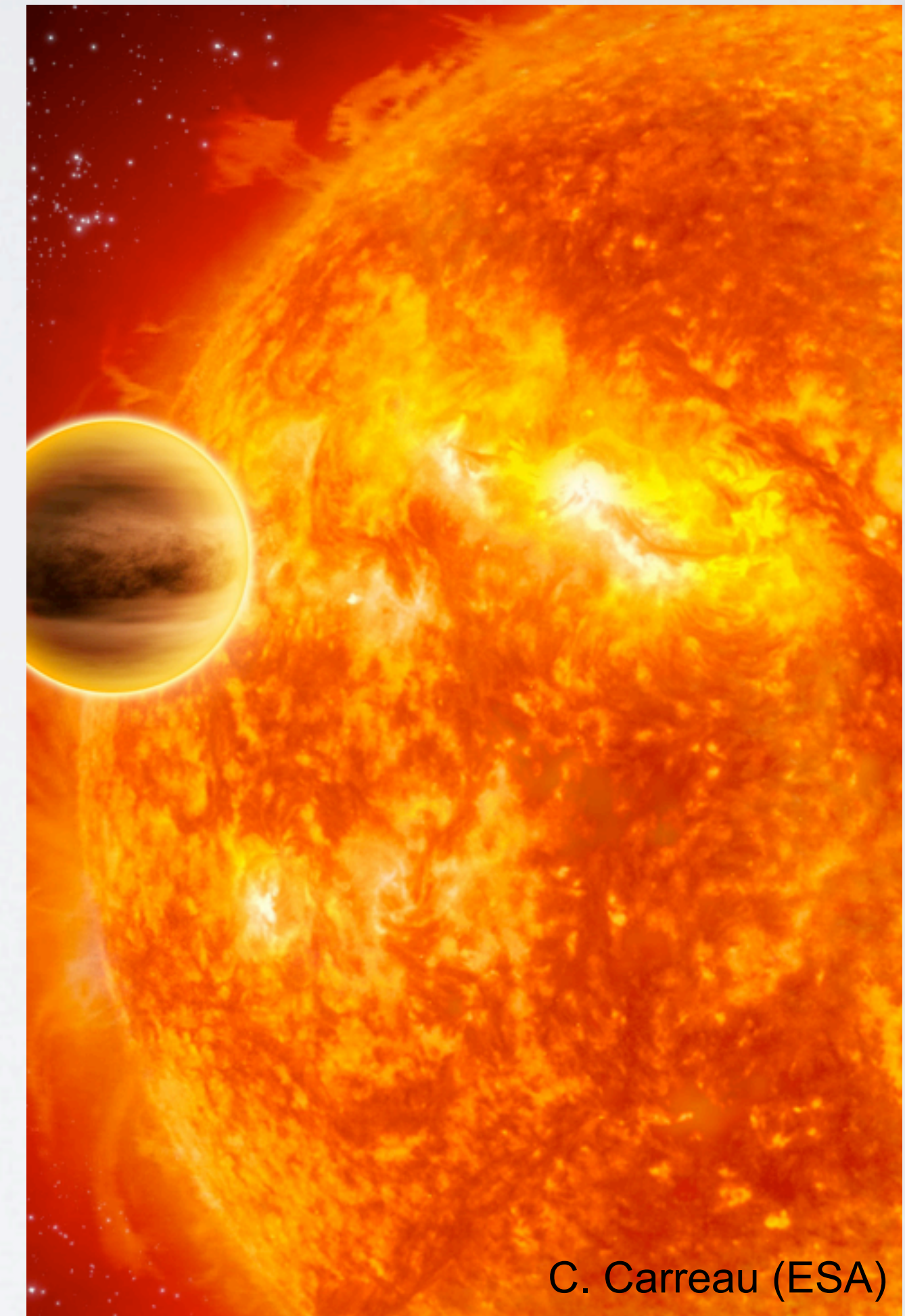
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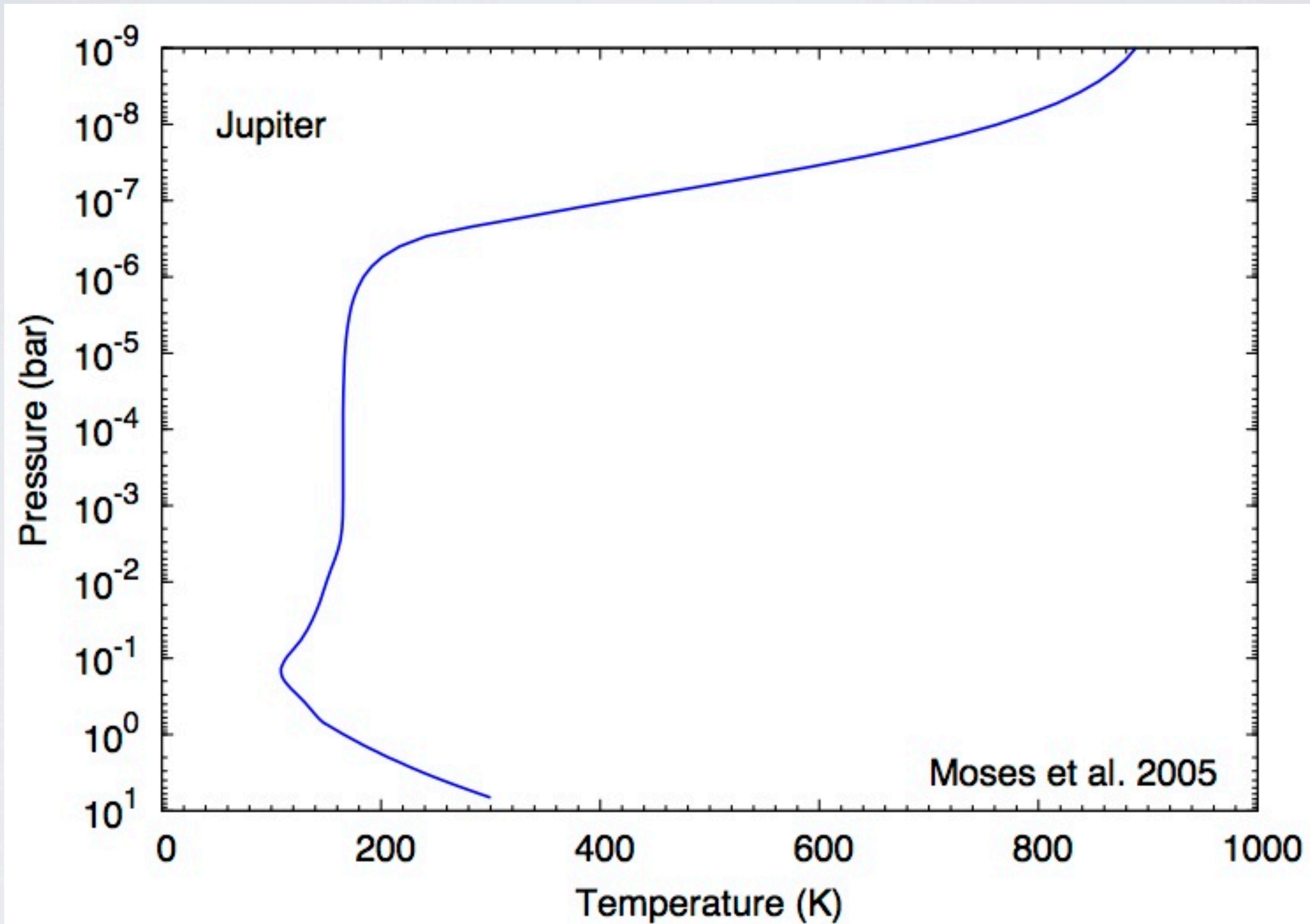
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- Where is the haze coming from, and what is it made of?

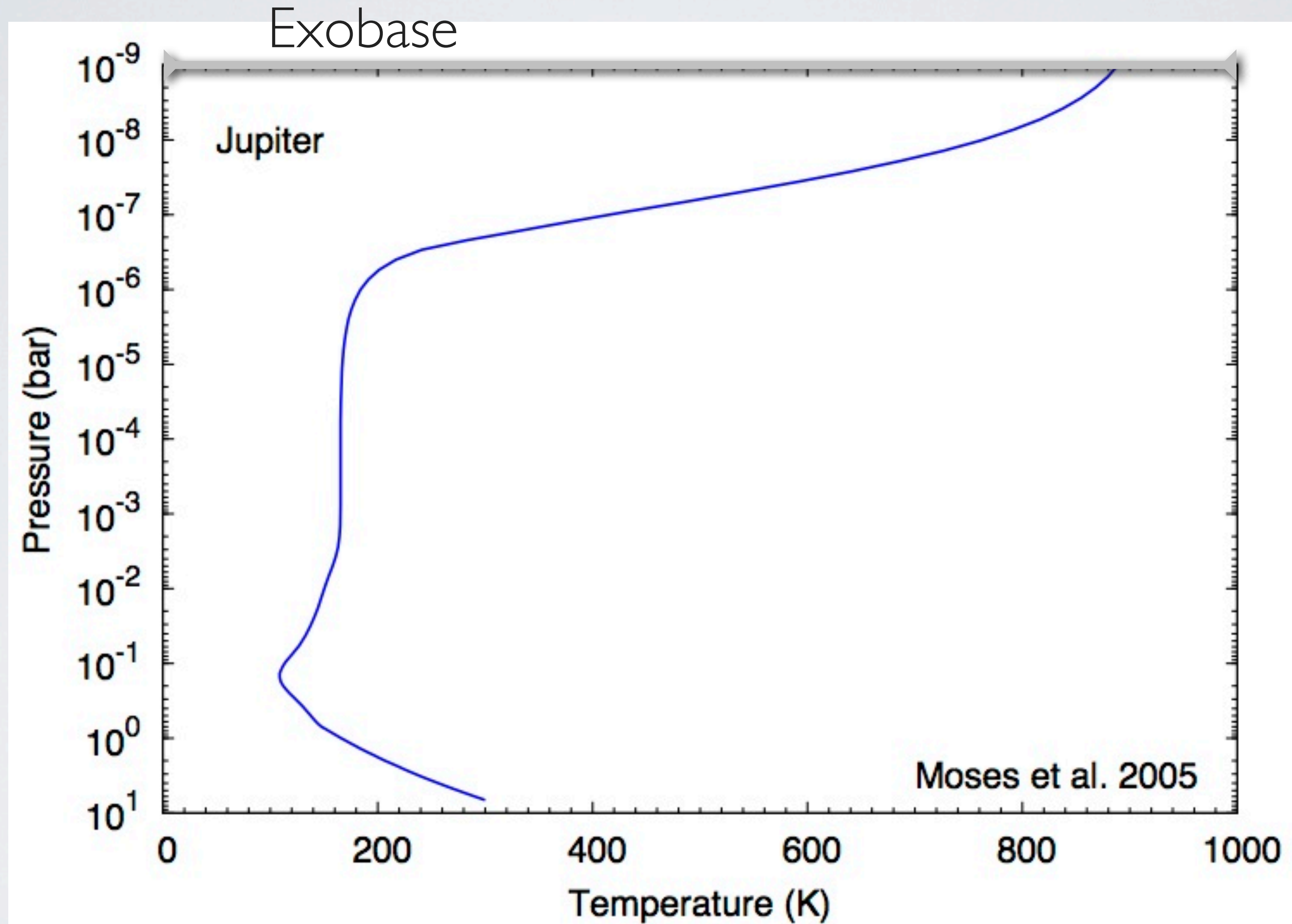


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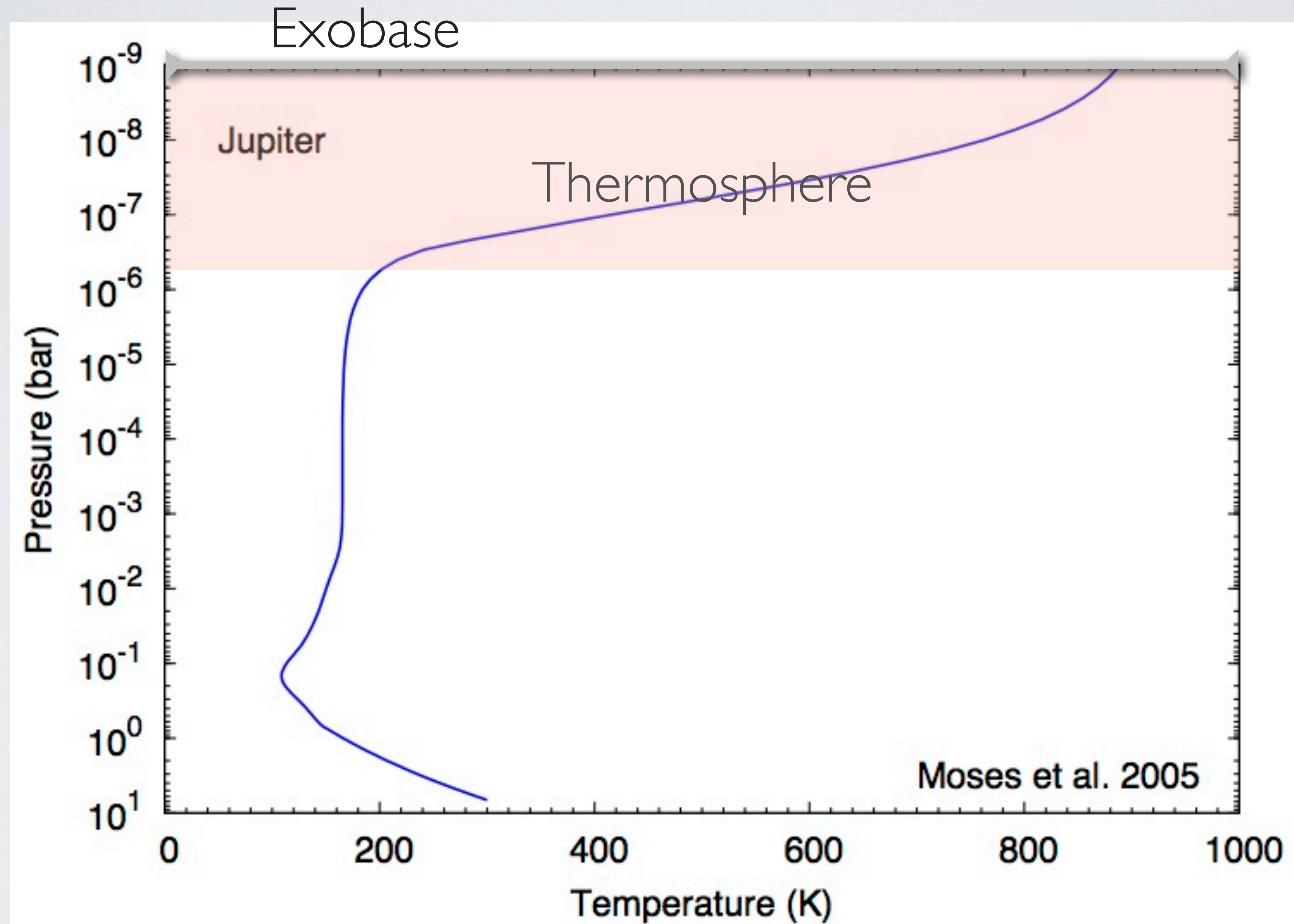
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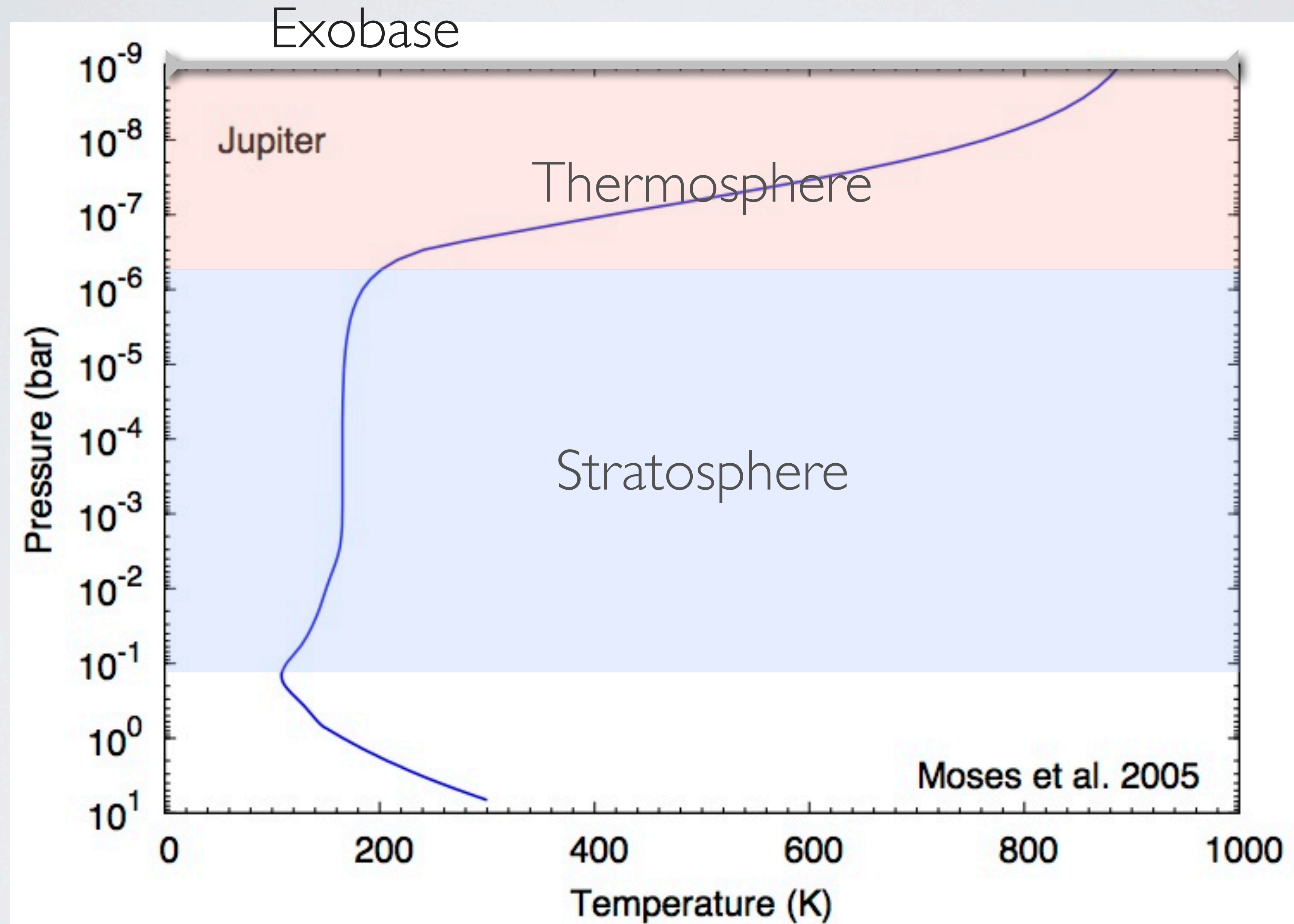
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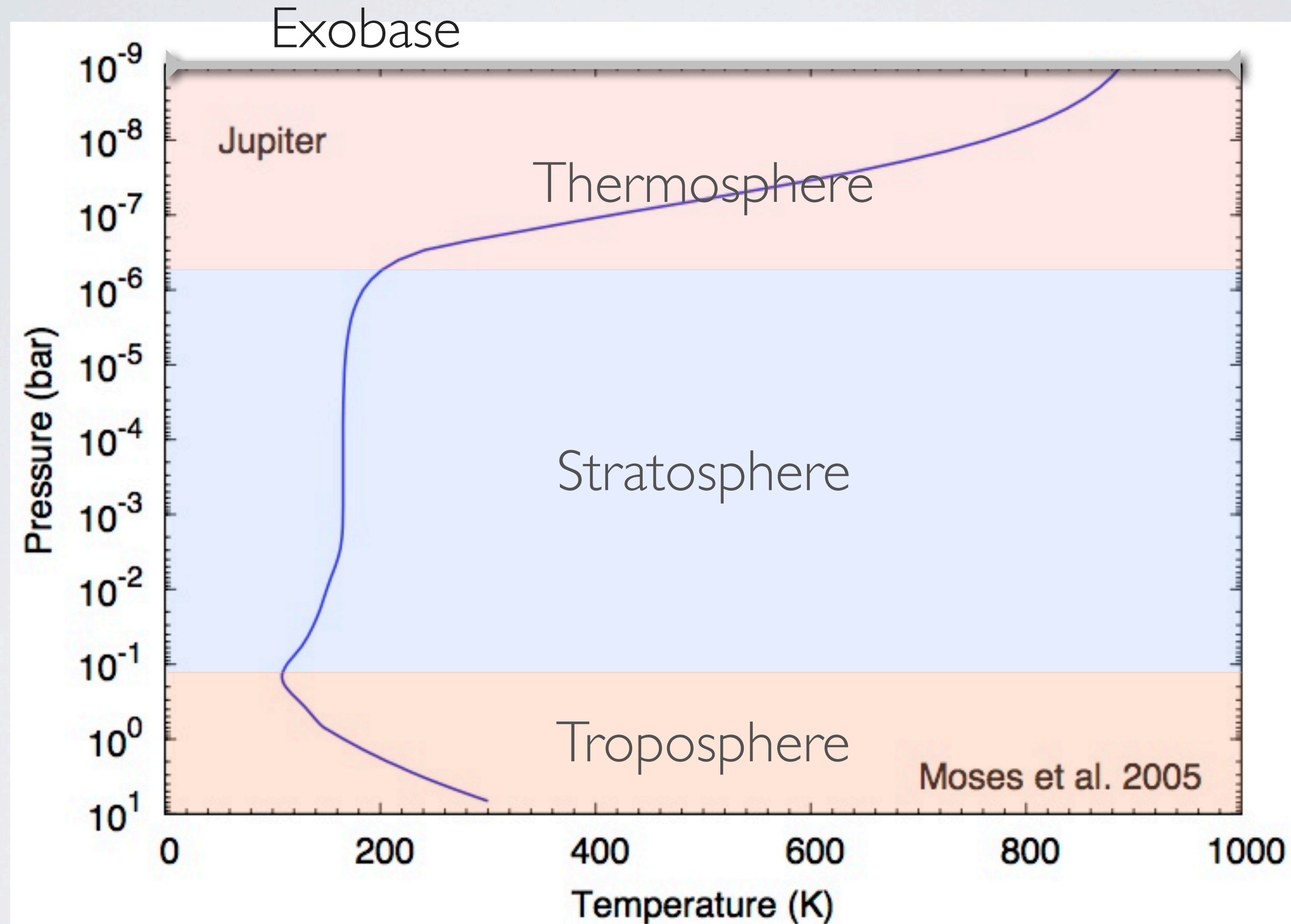
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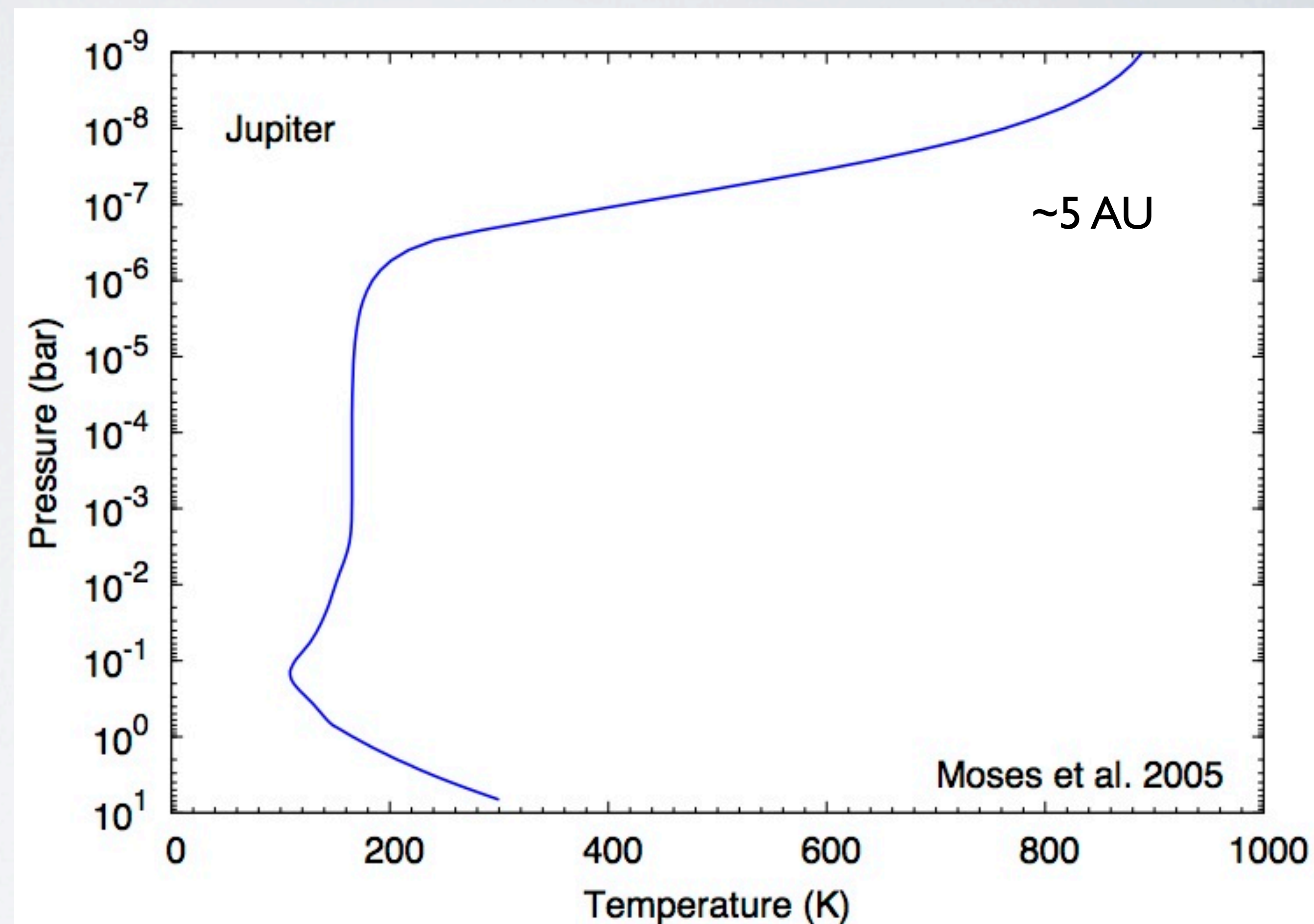
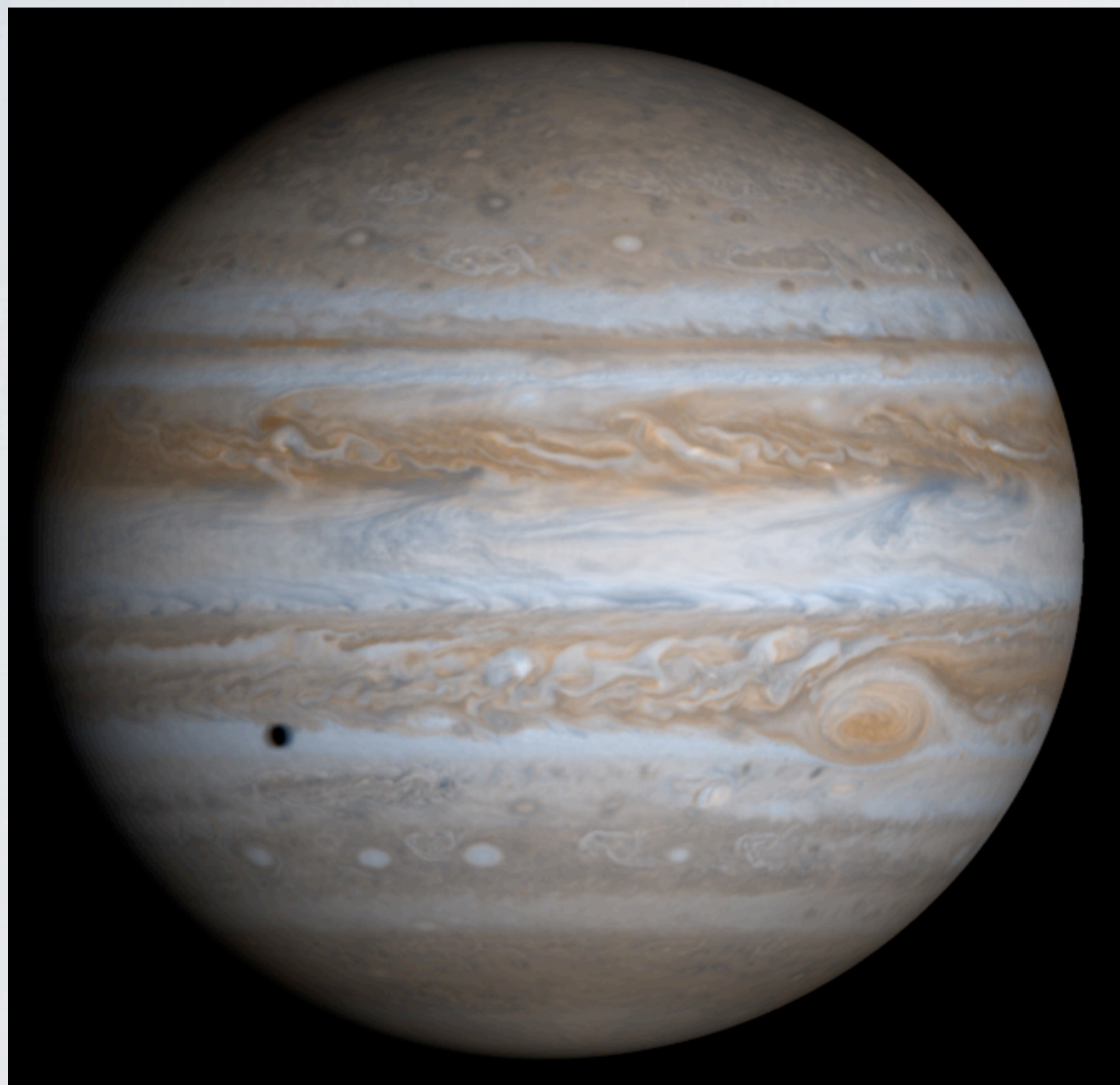
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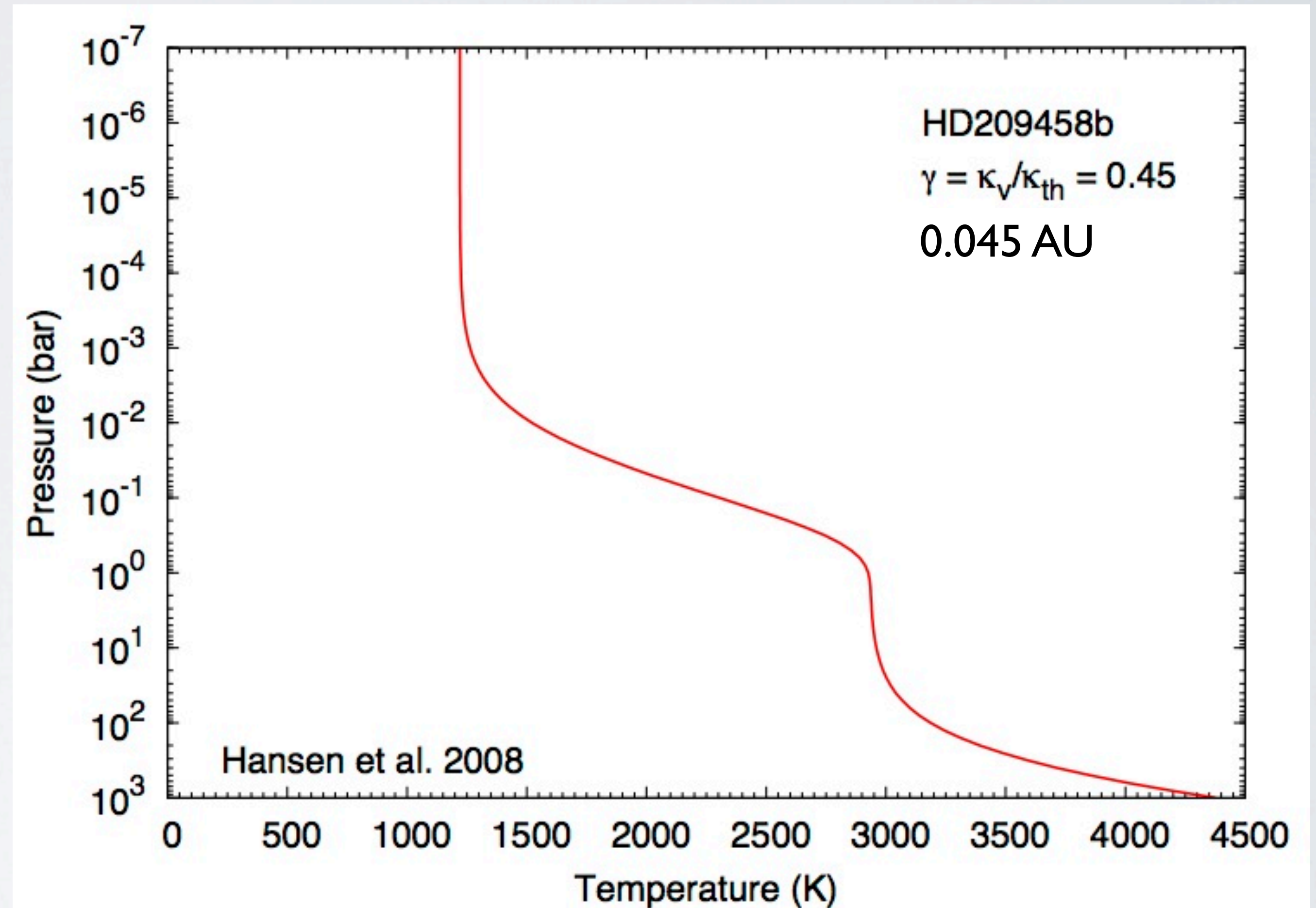
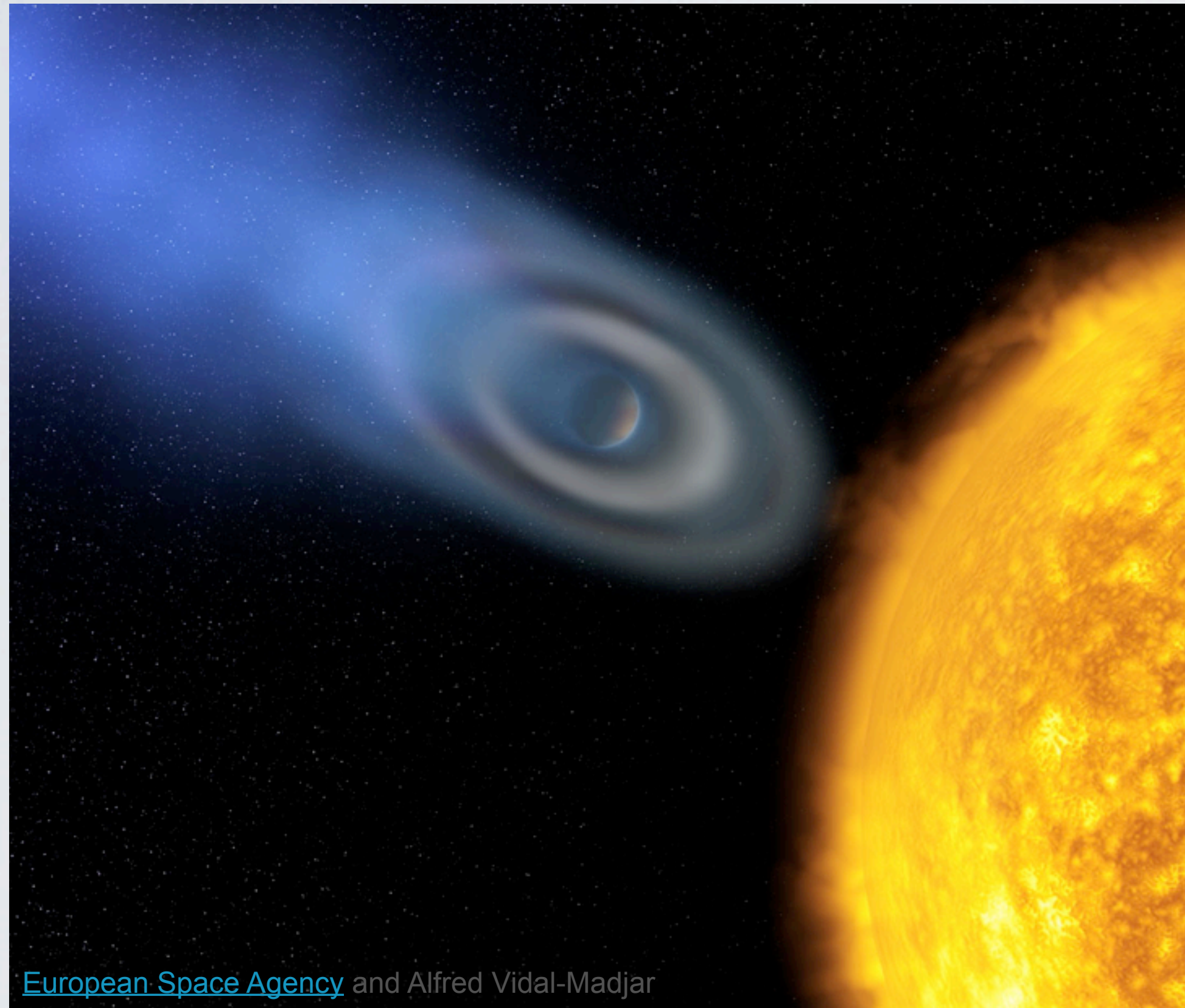
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JUPITER-LIKE PLANET “BESPIN”



HD 209458 b-LIKE PLANET “OSIRIS”



NON-EQUILIBRIUM CHEMISTRY: WHAT CAUSES IT?

- **Effects within the Atmosphere**

- Large-scale motion (Convection)
- Small-scale motion (Turbulence)
[Helling & Woitke (2006), Helling et al. (2008)]
- Dust nucleation and growth
[Helling & Woitke (2006), Helling et al. (2008)]
- Alfvén ionization, grain discharges, lightning,
[Helling et al. (2012), Stark et al. submitted]

- **Effects outside the Atmosphere**

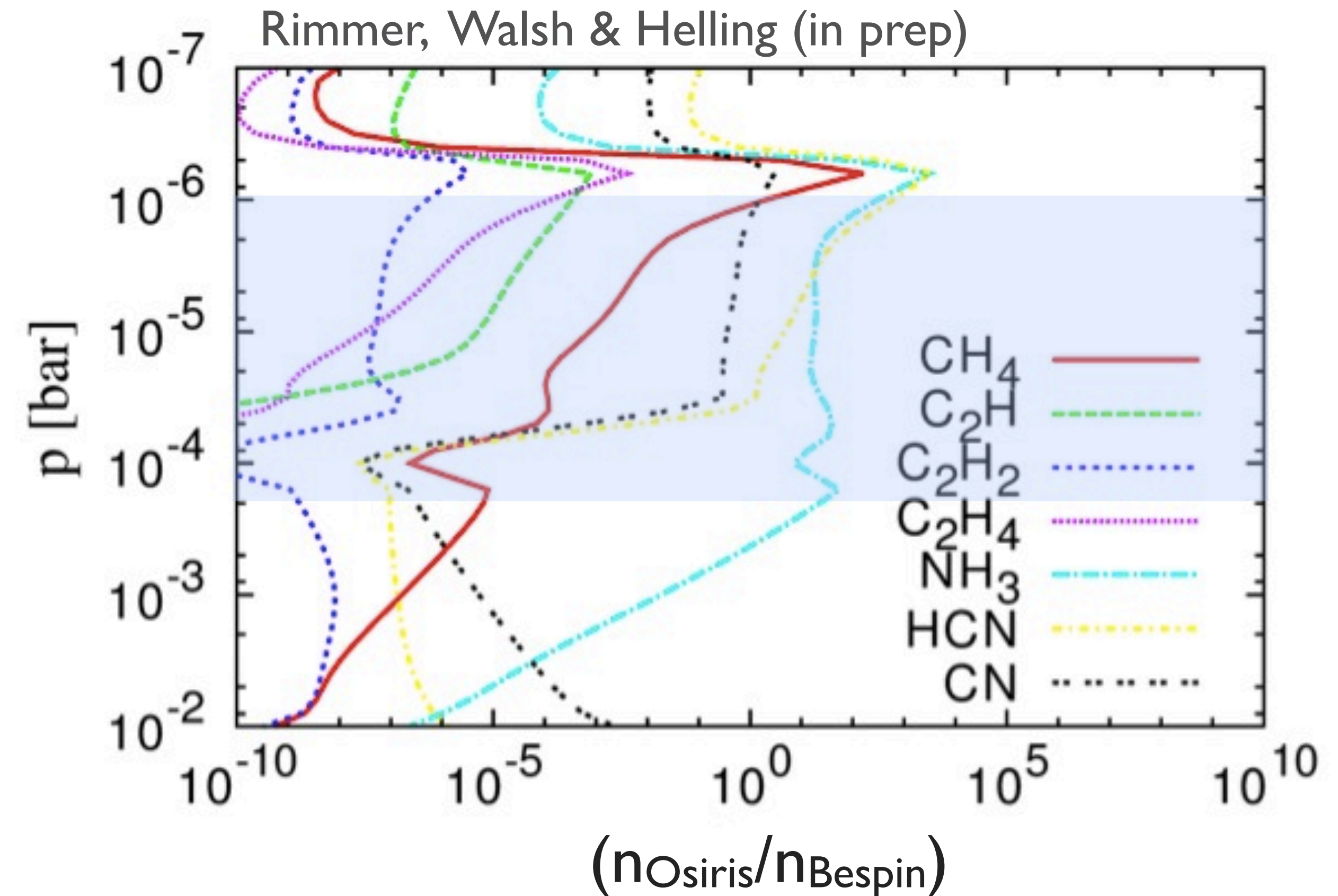
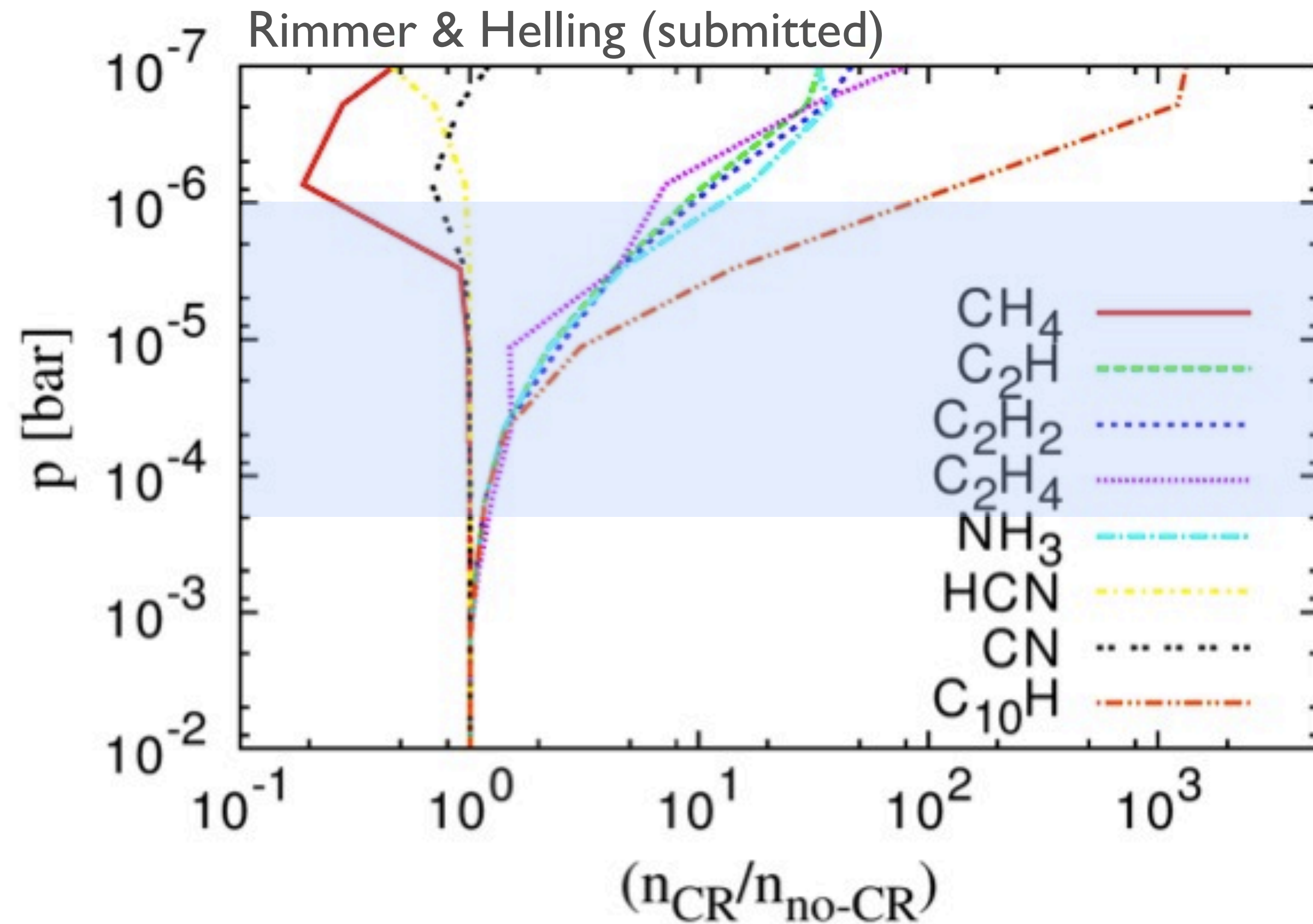
- Cosmic Rays [Rimmer & Helling, Accepted]
- UV Photons [Rimmer et al, in prep]
- IR Photons, X-Rays, Gamma Rays
- Meteorites, infalling dust, etc.

OUR ION-NEUTRAL NON-EQUILIBRIUM NETWORK

- Over 100 species
- Up to C₂H₆
- Includes Cations, some Anions
- Treats atmospheric mixing
- Cosmic rays via atmospheric transport model
- Analytic radiative transfer
- Over 2000 Reactions
- Reversible: Neutral-Neutral, Three Body, Ion-Neutral
- Combustion Reactions and Capture Reactions
- Non-Reversible: Photodissociation, Photoionization, Cosmic Ray Ionization

UK Astrobiology - Molecules and Life in Extremes

RESULTS



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- ... but have we really addressed the question at all?

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- Maybe cosmic rays and UV photons conspire to produce a PAH haze in hot Jupiters?

QUESTIONS

