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Conditions for stable layers in Jupiter and Saturn over time

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Interior models of giant planets in the Solar System traditionally assume convection as the dominant heat transport mechanism in the molecular hydrogen envelope. However, several observations of Jupiter are challenging to explain under this assumption, including the measured abundances of CO and water in the atmosphere, as well as the depth of the zonal winds. A stable layer located around the kilobar level has been proposed to reconcile these observations, an idea that has gained more support with recent Juno measurements of alkali metals, which suggest a depletion in the deep atmosphere. While the presence of a stable layer around the kilobar level appears promising, the degree of alkali depletion required to sustain it remains unclear.

In this work, we compute new opacity tables to determine the specific atmospheric compositions that can give rise to stable stratification in the outer envelopes of Jupiter and Saturn. Using evolution models, we investigate the long-term conditions that allow stable layers to persist, and how their depth changes over time. In addition, we investigate how stable layers influence key observables, such as the effective temperature and the atmospheric helium abundance.