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Thermal and structural evolution of Uranus

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Abstract

Understanding Uranus' low luminosity is a long-standing challenge in planetary science. Simple adiabatic evolution and structure models are inconsistent with the measured low luminosity of Uranus. This implies that the planet is non-adiabatic due to the existence of thermal boundary layers and/or conductive regions. Gradual composition distribution, if stable, acts as a thermal boundary to suppress convection and slow the internal cooling.

We present new models of the thermal and structure evolution of Uranus. We assume different primordial composition distributions, and identify the models that fit Uranus measured properties (mass, radius, luminosity, and J2) at present time. We find several alternative non-adiabatic internal structures that fit the available measurements. It is found that Uranus' current structure cannot be very different from its primordial structure, since convective-mixing in the ice giants is limited, unlike in the case of the gas giants. Our models are consistent with a metal-rich outer envelope of Uranus and the predictions for its magnetic field location.