UNIVERSITY of CALIFORNIA
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CONDENSATION-INHIBITED CONVECTION IN THE ATMOSPHERE OF URANUS AND ITS IMPACT ON THERMAL EVOLUTION

A thesis submitted in partial satisfaction of the
requirements for the degree of

BACHELOR OF SCIENCE

in

ASTROPHYSICS

by

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Abstract

Condensation-inhibited convection in the atmosphere of uranus and its impact on thermal evolution

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This will be the last section written, once we have finished our analysis.

Contents

List of Figures

List of Tables

To my wife,

Stinkers

Acknowledgements

1

Introduction

When planets form from their protoplanetary disk, they heat due to the release of gravitational potential energy as they collapse upon themselves. The collapse eventually stops as they reach hydrostatic equilibrium, and they finally begin to cool as they release this latent heat of formation through the top of their atmosphere. There are deviations from this evolutionary track, as when terrestrial planets undergo a greenhouse effect, or warm due to the formation of a secondary atmosphere created by outgassing of cooling molten material. Planets may migrate closer to their parent star, increasing the amount of stellar radiation absorbed by the planet's atmosphere. In our solar system, the giant planets are far from the Sun and primarily of solar composition. We are not concerned with those warming scenarios here. In this paper, we examine the thermal evolution of the planet Uranus. Uranus is closer to the Sun than its neighbor, Neptune, with which it shares similarities in mass and chemical composition. Strikingly, Uranus is cooler than its more distant counterpart. Much work has been done with model Uranus atmospheres (Fortney et al., 2011). These models assume a thoroughly convective atmosphere along a dry adiabat and have been consistently at odds with observation of Uranus. They do not predict the under-luminous Uranus that we now observe. In this paper, we explore the impact of condensation-inhibited convection on the planet's thermal evolution to see if it offers a possible explanation for current observations. In section 1.1, we review prior work done on model atmospheres of solar system giant planets. In section 1.2, we review prior work done on the formation of water condensation zones in these hydrogen rich atmospheres. In chapter 2, we describe our model and present our results. In chapter 3, we discuss the ramifications of condensation inhibited convection for the thermal evolution of Uranus. Finally, in chapter 4, we summarize our findings.(Friedson & Gonzales, 2017) (Leconte et al., 2017).

1.1 Model Atmospheres

Will review current understanding of solar system giant planet thermal evolution here, referencing work done by Fortney, et al., and others. Not sure how far back I want to go here, but will probably mention when, and by who, thermal evolution modeling began, and then quickly get into the thermal evolution background from fortney papers.

1.2 Condensation-inhibited Convection

This section will contain theory surrounding condensation in hydrogen rich atmospheres, citing LeConte, Friedson, others.

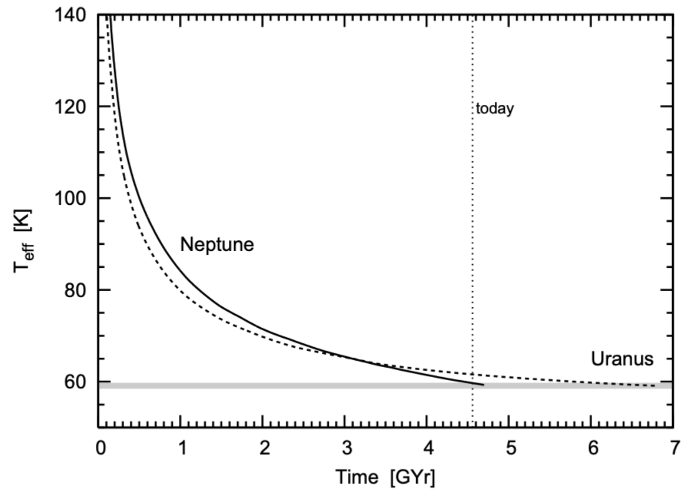

Fig. 6 Homogeneous evolutionary models of Uranus (dashed) and Neptune (solid). The underlying interior models are among those presented in Fig. 3. Notably, the real Uranus is underluminous as compared to the model. The solar system's age is shown (dotted line) and the grey bar indicates the present T_{eff}s.

Figure 1.1: bobloblaw

1.3 Open Questions

Describe where the current models fail (ex: uranus, neptune, saturn)

1.3.1 A subsection on tables

Not only do I give two examples on tables here, I show you how to force tables (or other "floating" environments like figures) to appear close to where you want them.

When I first compiled this, the tables meant for this section appeared during the following one. LaTeX is just trying to arrange things well and avoid blank space, but if you want to prioritize having something appear about where you put it in the LaTeX code, put the notation "`[!htb]`" as shown at the start of the tables here. The "h" stands for "put it here," The "h" stands for "here," the "t" for "top," the "b" for "bottom," and the "!" for something like, "really, darnit, override some rules if you have to. You can use "b" or "t" alone or with the ”!” if you like to see all your figures at the top of a page (common) or at the bottom (rare).

Note that if your placement choices end up generating a lot of whitespace, that whitespace will not count toward the minimum page count of your thesis.

Title	Author
War And Peace	Leo Tolstoy
The Great Gatsby	F. Scott Fitzgerald

Table 1.1: A normalsize table. This would be the normal size that you would make a table, so that it is most readable, unless it's hard to fit everything in. Some journals (like Physical Review) use captions at the bottom of tables that can be as wordy as the caption to a figure, like this one. If your thesis is in physics or applied physics, rather than astrophysics, you should use this convention.

Table 1.2: A small table.[a]

Title	Author
War And Peace	Leo Tolstoy
The Great Gatsby[b]	F. Scott Fitzgerald

[a]In astrophysics, the table title is usually short and always at the top, and other information is put into table footnotes like this.

[b] A much shorter read than War and Peace.

2

Previous Work

This section contains another figure, this one a .jpg file; it is Figure 2.1.

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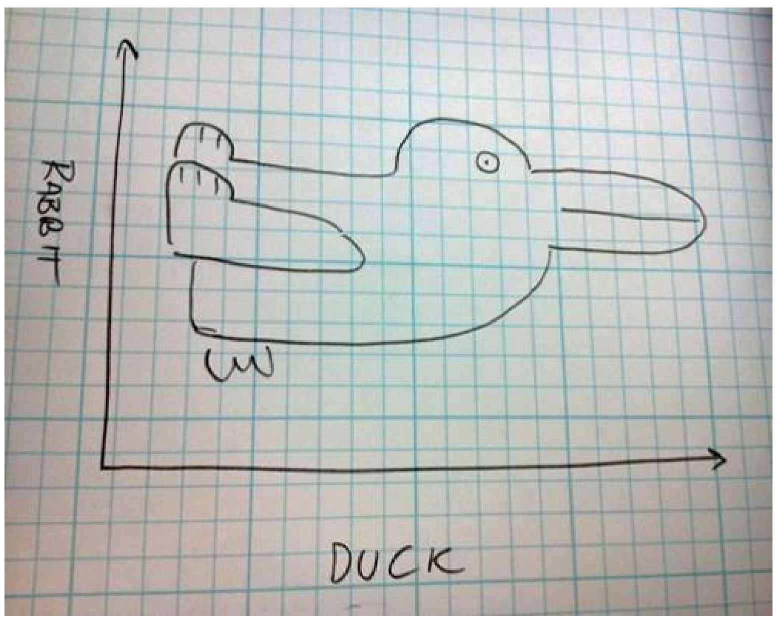

Figure 2.1: An image that looks like a rabbit one way, and a duck another. Your caption should describe everything that the reader sees looking at the figure, but *interpretation and significance* should be left for the main text.

3

Conclusion

I actually don't like to use "conclusion" for the final section, as it's not clear on the purpose. I think it's better to have a "discussion" and a "summary". In the discussion, you bring up new information by *interpreting* your result in the context of theory and other peoples' work; this can include new ideas and new citations. In the summary, which will be very much like the abstract, you simply sum up your main conclusions (although the abstract, unlike the summary, has to briefly define the problem and methods).

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Appendix A

Some Ancillary Stuff

Ancillary material should be put in appendices. The guidelines are not clear whether bibliography comes before or after the appendices, but they *suggest* appendices come first. Ancillary material should be put in appendices. The guidelines are not clear whether bibliography comes before or after the appendices, but they *suggest* appendices come first. Ancillary material should be put in appendices. The guidelines are not clear whether bibliography comes before or after the appendices, but they *suggest* appendices come first. Ancillary material should be put in appendices. The guidelines are not clear whether bibliography comes before or after the appendices, but they *suggest* appendices come first.

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