LA-SUB--95-69

IGPP Progress Report

Project Title: *The Role of Composition Gradients in the Evolution of Uranus and Neptune*

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Laboratory Co-Principal Investigator: Dr. Gary Glatzmaier

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Reporting Period

Begin: 1 January 1994

End: 1 September 1994

Grant Period

Begin: 1 January 1994

End: 1 October 1994

Preceding Grant Period: None

Amount: \$13,500

Summary of Objectives, Approach, Results, Conclusions, & Importance

Thermal evolution models of Uranus and Neptune constructed over the last two decades overestimate the current luminosities of both planets (Stevenson 1982; Podolak, Hubbard, and Stevenson, 1992 (hereafter PHS)). These models have also failed to explain the disparity between the relatively large excess luminosity of Neptune and the virtually undetectable one of Uranus (an unexpected dissimilarity given the comparable size, mass, and composition of the two planets). A proposed solution (Stevenson, 1985; PHS) for both puzzles is that previous models have neglected the important role played by gradual variations in the composition of these planets with radius. Such composition gradients may exist at both Uranus and Neptune (Hubbard and Marley, 1989; Hubbard *et al.* 1991) and even slight such variations can have a stifling influence on heat transport and convection (PHS). Yet all Jovian planet evolution models have assumed an adiabatic, fully convective, envelope. The objective of this program was to conduct new evolutionary calculations for Uranus and Neptune in order to explain their current luminosities and help constrain planetary formation models in the outer solar system.

Our approach is to combine planetary evolution models with numerical simulations of convection in the presence of a stabilizing composition gradient. As of this report date, we have begun to adapt the global convection model of the laboratory PI Dr. Gary Glatzmaier (Glatzmaier and Schubert 1992) to the conditions found in the interiors of Uranus and Neptune. When complete this model will calculate the mass and energy fluxes across double-diffusive interfaces in the interior of each planet needed in the new evolutionary calculations. The new Jovian planet evolution model is also nearing completion and undergoing testing. This model includes both the usual convective energy transport as well as conductive transport at diffusive interfaces. Since, after the first semester of support, both numerical models are still under development, no modeling results or conclusions are yet available.

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Additional Information

IIC. Equipment Obtained and Facilities Used

No new equipment was obtained for this program.

IID. Tangible Results

One test of the evolutionary code constructed for this research resulted in a journal article in preparation:

Marley, M.S., P. Gomez, M. Podolak, Monte Carlo models of the interiors of Uranus and Neptune, *Geophys. Res. Let.*

III. Future of Project

A renewal proposal was submitted to the IGPP in March of 1994. The project was not renewed by the IGPP.

IV. Funds Received as a Result of IGPP-Sponsored Research

To support the atmospheric modeling required by this project, the PI was awarded a NASA/Ames Research Center Consortium grant of \$13,002. This grant supports construction of models of the past atmospheres of Uranus and Neptune to be used as boundary conditions in the Uranus and Neptune evolution models.

V. Los Alamos Facilities Used for this Project

No Los Alamos facilities have been used.

REFERENCES

- Glatzmaier, G. and Schubert, G. 3D spherical models of layered and whole mantle convection. *J. Geophys. Res.* submitted, 1992.
- Hubbard, W. and M. Marley, M. Optimized Jupiter, Saturn, and Uranus Interior Models. *Icarus* **78**, 102-118, 1989.
- Hubbard, W.B., Nellis, W.J., Mitchell, A.C., Holmes, N.C., Limaye, S.S., and McCandless, P.C. (1991) Interior structure of Neptune: Comparison with Uranus, *Science* **253**, 648-651, 1991.
- Podolak, M., Hubbard, W., and Stevenson, D. Models and Uranus' Interior and Magnetic Field. In Uranus (eds. Bergstralh, J., Miner, E., and Matthews, M.) Univ. of Arizona Press, 1992.
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