(NASA-CR-142163) [PHYSICAL PROPERTIES OF GIANT PLANETS] Final Technical Report, period ending 30 Sep. 1973 (Yale Univ.) 3 p HC $3.25 CSCL 03B

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27 March 1974

Ms Beverly Hungerford
Grant Administrator
NASA
Washington, D.C. 20546

In Re: NASA Grant NGR 07-004-010

Dear Ms Hungerford:

Enclosed are two copies of a Final Technical REport for the NASA Grant NGR 07-004-010 which terminated on 30 September 1973. I regret the report has been delayed in reaching you.

Sincerely yours,

Mary S. Albee for
Rupert Wildt

cc: J. S. Warner, Director
Grant and Contract Administration

NASA Grant NGR 07-004-010
Final Technical Report
Prepared by R. Wildt
Principal Investigator
27 March 1974

FINAL (Submitted by letter dtd. 1-23-75 - addressed to Dr. Willaim E. Brunk)

YALE UNVERSITY

On reaching retirement age in 1973, the principal investigator could look back on more than forty years of effort to elucidate the physical nature of the giant planets. It began with the chemical identification of the prominent absorption bands in their spectra as due to hydrogen compounds (methane and ammonia) and the recognition of hydrogen and helium as the principal constituents of the bulk of Jupiter and Saturn. When the Lunar Science Institute in 1972 sponsored a conference on planetary interiors, at which the principal investigator delivered the keynote address entitled "Hydrogen Planets and High-Pressure Physics", he had the satisfaction to observe that the ideas he introduced decades ago are finally accepted and continue to bear fruit. The ongoing task is to refine the model computations of planetary interiors by ever more realistic input data. Initially the physical assumptions had to be quite schematic: the planets were supposed to be isothermal throughout, and in chemically non-homogeneous bulk material the molar volumes of the components were treated as additive. In either respect progress was made during the work performed under this grant.

The discovery of a substantial heat flow from Jupiter's interior, by Love and others, necessitated an appraisal of the possible modes of internal heat transfer and the relevant physical parameters. Dr. Wendell DeMarcus, Professor of Physics in the University of Kentucky, participated in this work from its beginning and served as visiting professor at Yale during the spring term of the 1966-67 academic year. Later Dr. Edwin V. Bishop joined the project, after completing his Ph.D. thesis at Yale, and

performed large-numerical computations (January 1966 - August 1969) with the computer at the Goddard Institute for Space Studies in New York City, whose support is gratefully acknowledged. The final result of the discussion was published in: Edwin V. Bishop and Wendell C. DeMarcus, Thermal Histories of Jupiter Models, Icarus 12, 317-330, 1970.

As early as 1938 the principal investigator called attention to the need for systematic exploration of the equations of state and phase equilibria of the presumptive constituents of Jupiter's and Saturn's deep atmospheres and interiors. Numerous attempts to persuade the scarce experimenters qualified to tackle these problems had no success until the middle 1960's when Dr. William B. Streett, Research Professor at the U.S. Military Academy (Westpoint, N.Y.) responded favorably to the suggestion that he apply his wide experience to the phase equilibria of mixtures of condensed gases found in the giant planets. After long planning, including Dr. DeMarcus, an ambitious experimental program got underway, but encountered persistent technological road-blocks it took years to overcome. The first definitive result was a study of the He-CH_4 phase equilibrium, on which Dr. Streett reported in the proceedings of the conference mentioned before (Lunar Science Institute Contributions No. 89, reprinted from Physics of the Earth and Planetary Interiors 1, 69-77, 1972). Of fundamental importance to the meteorology and internal circulation of the giant planets are the phase equilibria of H_2-He mixtures, which the principal investigator had long suspected of displaying immiscibility of coexistent fluid phases. This surmise has finally been proved by Dr. Streett up to pressures of 10 kbar and temperatures between 26° and 100° K. He is now trying to extend this work to the highest pressures safely attainable, because this

fluid-fluid phase separation may persist even to the limits of stability of the molecular phases. (William B. Streett, Phase Equilibria in Molecular Hydrogen-Helium Mixtures at High Pressures, Astrophysical Journal 186, 1107, 1973).

Papers published during the period of the grant by the principal investigator are listed below:

Planetary Interiors, The Solar System, G. P. Kuiper, Ed. Vol. III, chapter 5, 159-212, Univ. of Chicago Press, 1962

Planetary Interiors, Memoires de la Societe Royale des Sciences de Liege VII, 15-28, 1963.

The Planet Jupiter (with H. J. Smith, E. E. Salpeter and A. G. W. Cameron), Physics Today 16, 19-23, 1963.

Jupiter's Great Red Spot (with Wendell C. DeMarcus), Nature 209, 62, 1966.

Lectures on the Physics of the Planet Jupiter, Bonn Bundesministerius für Wissenschaftliche Forschung, No. FB W 67-40, 10-85, 1967.

The Outer Planets: Some Early History, Journal of Atmospheric Sciences 26, 795-797, 1969.

Hydrogen Planets and High-Pressure Physics, Physics of the Earth and Planetary Interiors 6, 1-4, 1972.