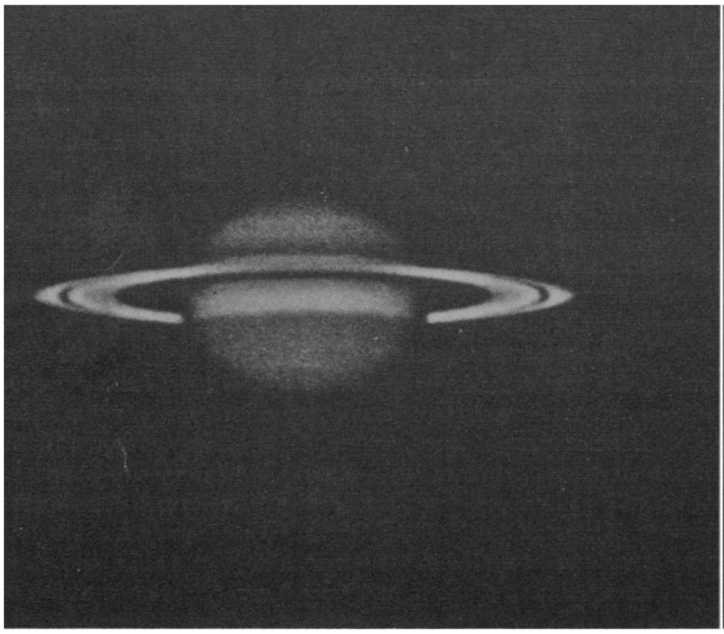
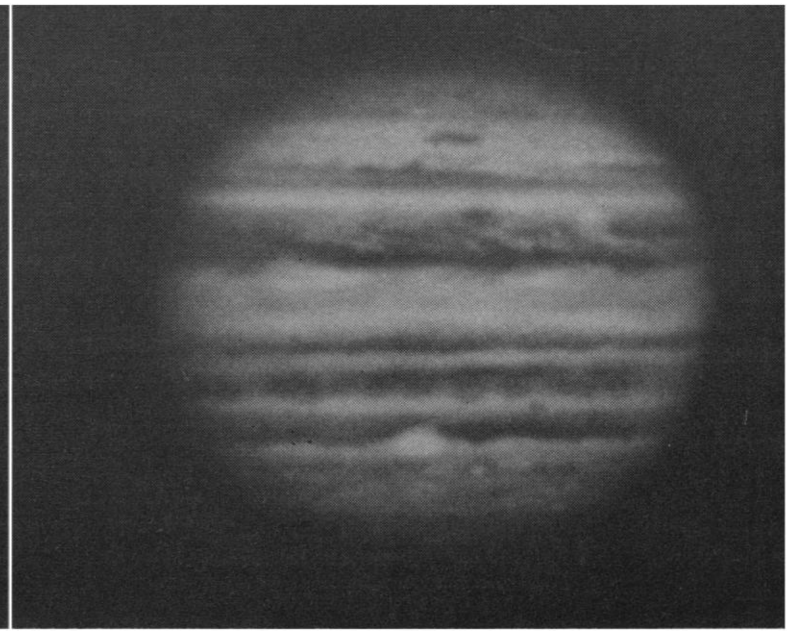

Jupiter and the Outer Planets

AAAS Symposium • 29–30 December 1968 • Dallas, Texas

The recent success of Soviet and American spacecraft in probing the atmospheres of Mars and Venus has sharply focused our attention on the common and distinctive characteristics of the inner planets. No man-made instruments have yet been sent to explore the vast reaches of the solar system beyond the orbit of Mars. Nevertheless, we already know that the outer (or Jovian) planets constitute a family that is very different from the inner group (Table 1). Jupiter, Saturn, Uranus, and Neptune are all massive bodies of relatively low density, and all contain large amounts of hydrogen and helium. Uranus and Neptune have a relatively higher proportion of the heavier elements than Jupiter and Saturn, while Pluto is clearly a special case since it is so small. It may be an escaped satellite of Neptune; but without a good value for its mass, we cannot specify its bulk composition with any certainty.

The gross differences between the outer and inner planets of the solar system might be explained by assuming that the Jovian planets have retained the original proportions of the materials that composed the primitive solar nebula, that is, the agglomeration of dust and gas from which Sun and all the planets were formed. We could then expect the atmospheres of these bodies to exhibit this same composition, which would be very different from the secondary, outgassed constituents found in the atmospheres of the inner planets. Obviously this is not quite true for Uranus and Neptune, which may comprise an intermediate category. In the case of Jupiter and Saturn, however, the assumption appears to be a good one. If such proves to be correct, an investigation of their atmospheres should provide detailed information about the original composition of the solar nebula. Furthermore, such studies would have a significant bearing on the problem of the origin of life on Earth, since the environment in which the critical early steps in this process occurred may have been very similar to present conditions in the lower atmospheres of these planets.

It is thus apparent that studies of the outer planets may lead to insights into some of the most fundamental problems confronting the scientist interested in the origin and evolution of the solar system. As space missions to Jupiter are currently being scheduled for the next decade, a review of recent investigations seems especially timely. The symposium on Jupiter and the outer planets to be held in Dallas 29–30 December will consist of interdisciplinary discussions of problems of particular current interest, with a general emphasis on the atmospheres of these bodies.

The first session will be devoted to reports of new observations and theoretical studies that are related to problems of atmospheric composition. In order to determine how these planets were formed and what their subsequent history has been, we need to know the relative abundances of the elements and how they compare with solar and cosmic abundances. Isotopic ratios have a particular significance in this respect. Once the basic composition has been established, chemical equilibrium calculations can be used to predict abundances of minor constituents that must then be consistent with observational results. In the case of Pluto, such inquiries can be simplified to the basic question of whether there is any atmosphere at all.

The second session of the symposium will be concerned with problems of atmospheric structure: the composition and location of clouds and the

Table 1. Characteristics of the planets.

Planet	Radius (Earth = 1)	Mass (Earth = 1)	Density (g/cm^3)
Mercury	0.05	0.38	5.4
Venus	0.82	0.96	5.1
Earth	1.00	1.00	5.5
Mars	0.11	0.53	4.0
Jupiter	318	11.19	1.3
Saturn	95	9.47	0.7
Uranus	15	3.73	1.6
Neptune	17	3.49	2.3
Pluto	0.8 (?)	0.47 (?)	(?)

variation of pressure and temperature with altitude. It is possible to develop some guidelines a priori from a knowledge of the phase diagrams of various atmospheric constituents. These constraints can be employed to interpret observations that indicate the relative concentration of aerosols at different positions on the disk and measurements of temperature as a function of wavelength (and thus altitude). The structure of the cloud deck and its variations with latitude and solar zenith angle have an obvious bearing on the interpretation of spectral absorption lines in addition to their intrinsic significance. Similarly, temperature measurements may also be used to determine whether or not substantial amounts of heat are presently escaping from a planet's interior.

The answer to the last question has a direct bearing on the subject of the next session: atmospheric dynamics. Any heat released from the interior of a planet must combine with the absorbed solar radiation to form the source of energy for the planetary meteorology. In the case of Jupiter, this meteorology is an enormous and complex subject, still in its early infancy. Under high magnification, the parallel bands for which the planet is famous are resolvable into many intricate, constantly changing details—festoons, spots, and streaks, all moving across the disk of the planet at varying speeds with pastel colors of changing intensity and hue. The most famous of these features is the Great Red Spot which still remains an enigma, although indications of its structure are being obtained from the behavior of the atmosphere in its vicinity.

The last session of the symposium will begin with a discussion of a possible mode of origin for Jupiter. In several respects, Jupiter may be said to resemble a very small star and one might ask whether it could have formed in a manner similar to the condensation of a star from a cloud of gas and dust. Alternatively, one could imagine the planet being built up by the accretion of smaller bodies, but in this case it might be very difficult to retain the observed relative abundances of its constituents. These are problems that must be explored with the help of theoretical models.

The final topic to be considered is the possible production of complex organic compounds as a result of chemical reactions among major atmospheric constituents. It has been recognized for some time that the thermal and electrical energy that must be available in Jupiter's atmosphere could form products which might be responsible for the colors observed in the cloud layers. But the identities of these compounds and the details of the reactions leading to their formation remain obscure. The problem takes on a special significance when it is realized that such substances may reach a sufficient degree of complexity to qualify as the first links in the long chain that ultimately leads to the self-replicating molecules to which we owe our present existence. The implications of such a possibility are obvious and profound and certainly provide ample incentive for continued studies of the giant planets.

TOBIAS OWEN
IIT Research Institute,
10 West 35 Street,
Chicago, Illinois 60616

Speakers and Topics

Arrangers: Tobias Owen (IIT Research Institute) and Carl Sagan (Cornell University).

29 December (morning)

Atmospheric Composition

Chairman, Hyron Spinrad (University of California, Berkeley).

Rocket Observations of Jupiter's Spectrum from 2400 to 3000 Angstroms, Edward B. Jenkins (Princeton University).

Collision Narrowed Curves of Growth for H_2 Applied to New Photoelectric Observations of Jupiter, M. J. S. Belton (Kitt Peak National Observatory) and Uwe Fink (University of Arizona).

Theoretical Estimates of the Abundances of Spectroscopically Active Compounds in the Upper Atmosphere of Jupiter, John S. Lewis (Massachusetts Institute of Technology).

The Spectra of Jupiter and Saturn in the Photographic Infrared, Tobias Owen.

High Altitude Infrared Spectra of Jupiter and Saturn, Gerard P. Kuiper (University of Arizona).

New Observations of the Major Planets, Guido Münch (Mount Wilson and Palomar Observatories) and Robert Younkin (McDonnell Douglas Corporation).

A Review of Recent Work on Pluto, Robert Hardie (Vanderbilt University).

29 December (afternoon)

Atmospheric Structure

Chairman, Guido Münch.

The Clouds of Jupiter and the Ammonia-Water System, John S. Lewis.

Interpretation of Polarimetric Observations of Jupiter, Benjamin Herman (University of Arizona).

Observations of Jupiter from 2.8 to 15 μ, F. C. Gillett (University of California at San Diego, La Jolla).

Interpretation of the 8–15 μ Spectrum of Jupiter, Wendell C. Demarcus (University of Kentucky).

Observations of the 8–15 mm Emission from Jupiter and Their Bearing on the Atmospheric Structure of the Planet, William J. Welch and G. Wrixon (University of California, Berkeley).

Thermal Emission from Jupiter at Wavelengths of 3 to 10 cm, Glenn L. Berge (California Institute of Technology).

30 December (morning)

Atmospheric Dynamics

Chairman, Patrick Squires (University of Nevada).

Color Photography of Jupiter and Saturn, Gerard P. Kuiper (University of Arizona).

Morphology and Motions of Jovian Clouds, Bradford A. Smith (New Mexico State University).

Symmetrical Baroclinic Instability as an Explanation of the Banded Structure of Jupiter: An Experimental Verification, Seymour L. Hess (Florida State University).

Problems of Planetary Origin and Subsequent Atmospheric Evolution

Chairman, Gerard P. Kuiper.

Models of Jupiter during a Hypothetical Collapse Phase, Wendell C. Demarcus.

Organic Matter in the Jovian Atmosphere, Carl Sagan.

Chemical Synthesis in Simulated Jovian Atmospheres, Cyril Ponnamperuma (NASA Ames Research Center).