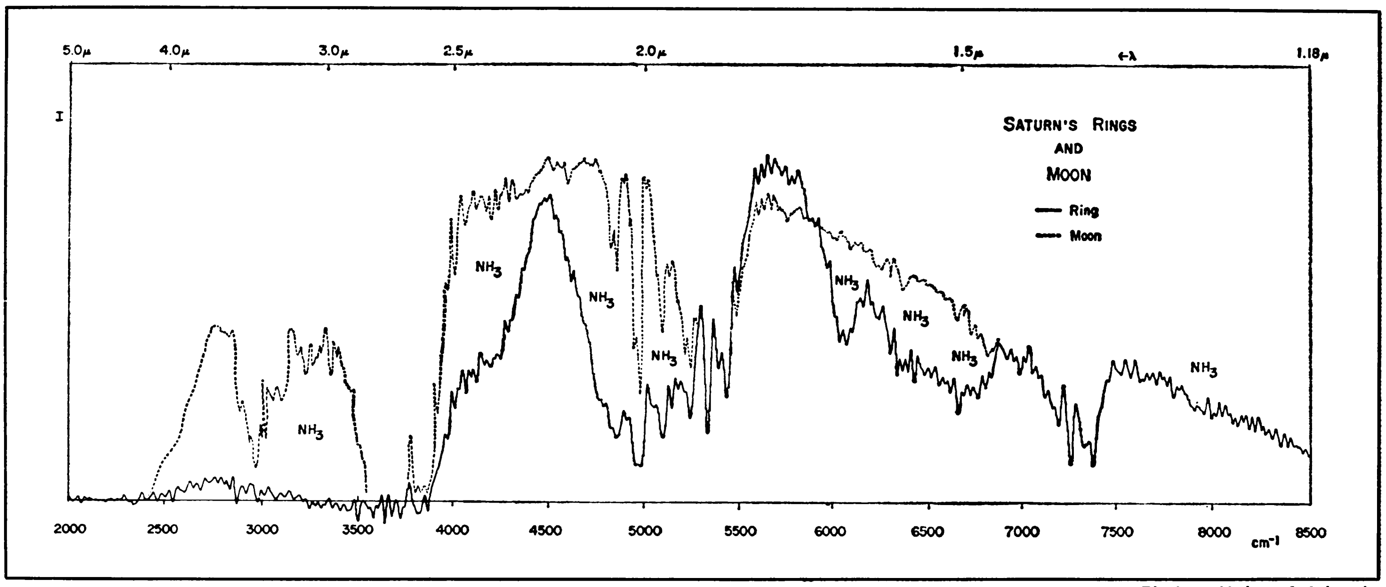

Photos: Univ. of Arizona

Infrared absorption spectrum of Saturn's rings shows dips at eight solid-ammonia wavelengths, labeled NH_3.

PLANETARY ASTRONOMY

Clues from ammonia

The composition of Saturn's rings can mean the planet was formed early in solar-system history

Kuiper: Saturn formed early and cool.

The sun, the nine planets and their various satellites participate in one or more kinds of rotary motion. Since the whole system is going in circles, it is tempting to assume—and some astronomers have assumed—that it all came from a single rotating nebular cloud that condensed and contracted to form the sun while leaving behind a droplet here and there to form the planets.

If the solar system did condense from a nebular cloud, the contraction evidently left different substances behind at different locations; in the rings of Saturn, it now appears, the condensation left ammonia ice.

The determination that the rings are ammonia ice was made on the nights of Nov. 19 and 21 by Drs. Gerard P. Kuiper, Dale P. Cruikshank and Uwe Fink of the Lunar and Planetary Laboratory of the University of Arizona.

"It came as a surprise to me," says Dr. Kuiper. "I had observed the rings of Saturn 22 years ago and found that the infrared does drop off from one to two microns wavelength." This drop-off showed the substance was ice, and at that time he assumed it was water ice.

The November data, however, give eight wavelengths at which the rings absorb infrared radiation, and this pattern is best attributed to solid ammonia. The temperature of the rings, 75 degrees K., is just about the point where solid ammonia would begin to evaporate into the vacuum, so their stability is a touchy and somewhat surprising thing.

There is probably also some water ice in the rings, says Dr. Kuiper, "but water is not major."

Not only the rings but also the inner satellites of Saturn seem to be mainly ammonia ice. In the case of the satellites the evidence depends on their high reflectivity and low density rather than on the spectroscopic analysis used on the rings.

The rings and the inner satellites are, as Dr. Kuiper puts it, "almost atmospheric phenomena." That is, they are made of light substances usually associated with planetary atmospheres rather than the heavy silicates and metals found in the cores of many planets.

The lightness gives a clue to the time at which the Saturn system was formed. Ices of such light materials form at cold temperatures and evaporate if their environment ever gets hot. According to this evidence, Saturn and its inner satellites were formed at an early stage in the contraction of the solar nebula, when the future sun was still quite an extended and fairly cool body.

This is not so for Jupiter, the next planet toward the sun from Saturn. The inner system of Jupiter, says Dr. Kuiper, shows evidence of having been formed at a hotter stage. Following this theory, according to which the beginning of each planet occurred at succeeding stages, one comes to Mercury, which, says Dr. Kuiper, should be related to a quite hot stage.

The whole contraction should have taken only a few million years, a mere moment in the 4.7 billion or so years of the solar system's history; but it was the moment in which the compositions of the planets were determined.

At the other extreme from Mercury, these ideas could solve the question of how the comets can be stable. The comets are made of very light solid substances that can remain solid in a vacuum only at extremely low temperatures: 20, 30 or 40 degrees K. These could have formed and remained stable, says Dr. Kuiper, if they formed at an early stage in the nebular contraction, at a location beyond the orbit of Neptune. Most comets seem to come from the part of the solar system. *DT*