

## PHYSICS

# Understanding the Cosmos

► AN IMPORTANT advance in man's understanding of the universe, based on Einstein's theory of general relativity, was reported by Dr. John A. Wheeler of Princeton University, Princeton, N.J.

He has discovered that a picture of electrical charge can be built in curved empty space without assuming the existence of such a charge, as is done in other theories. "No mystic, magic jelly" is needed to explain electricity, Dr. Wheeler told the American Philosophical Society meeting in Philadelphia.

He said that "if electricity had not been discovered, but if a person knew of electromagnetic waves in empty space, as described by Maxwell's equations, and of curved empty space, as described by Einstein's general relativity theory, then the existence of the previously mysterious electricity could be predicted, provided that the space under consideration is multiple connected."

Dr. Wheeler said the existence of electricity in nature, the simple explanation for its existence in terms of a multiple connected space and the lack of any other explanation for electricity are good evidence that the physical world actually is multiple connected.

Dr. Wheeler explains the idea of multiple connected as follows:

A doughnut is a simple example of a multiple connected surface. Stretch a rubber string from one point on the surface of the doughnut around the small dimension and back to the same point. Or stretch it around the big circumference and bring it back to the point. There is no way to deform the rubber string so as to transform one route into the other. The surface is said to be "doubly connected."

In contrast, a flat or "Euclidean" surface

that extends to infinity is said to be singly connected—rubber strings can be freely deformed to transform one route into any other route. The idea has long been considered that space is not Euclidean at great distances, as evidenced in the idea of a closed universe. But consideration has been given to the idea that space has a multiple connected or "wormhole" character at small distances.

Dr. Wheeler's suggestions are also the strongest support to date for the idea that the universe is as Einstein pictured it, with one theory covering the spinning of atoms and the gravitation of star-filled space.

The vision that the physical universe is composed of curved empty space, and nothing more, animated Einstein's work, although he did not live to see his dream fulfilled. However, since his death in 1955, Dr. Wheeler and Dr. Charles Misner, also of Princeton University, have discovered a way to describe both electromagnetism and gravity by mathematical equations.

They call their theory the "Already Unified Field Theory," using "already" because Einstein himself had accomplished this long ago but did not realize it.

Dr. Misner found that an electromagnetic field leaves "footprints in space" sufficiently detailed so someone measuring the curvature of space can learn everything necessary about that electromagnetic field.

Using only electromagnetic and gravitational fields, Dr. Wheeler has constructed objects that he calls "geons," which show all properties of mass but contain no real mass. Large geons can be considered as lots of light in a ball held together by its own gravitational attraction, much as the earth (a ball of matter) is held together by gravity.

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can Geophysical Union meeting in Washington, D. C. The water originally came from water molecules in rock material that formed the moon a few billion years ago.

The frozen covering prevents any water in the moon's interior from reaching the surface and evaporating. Occasionally, a crack or break appears in the covering that causes "humps" on the moon's surface. This action is similar to the "frost heaves" that ruin United States roads during a cold wave.

The temperature extremes of day and night on the moon have little or no effect on the frozen layer because of its 100-foot depth, Dr. Gold said. The rate of evaporation at that depth is very low.

Future astronauts will be able to get drinking water by drilling into the layer and heating the layer to melt the ice crystals locked in the rock.

"If large amounts of water are trapped beneath the moon's surface, this would account for its low density," Dr. Gold said. Beneath the frozen layer, or "ice table," the moon's interior probably becomes progressively warmer.

The radio waves that probed the moon's interior came from U. S. transmitters and were picked up by U. S. radio telescopes, the scientist said. The waves ranged from four inches to three feet.

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## Naming Moon Features

► AN INTERNATIONAL system of naming the moon's surface features has been proposed by one German and two United States scientists.

The new system is purely descriptive and would eliminate any possible prejudice that might arise from the present naming method, the scientists told the American Geophysical Union meeting in Washington, D. C. They are Dr. K. von Bulow of the University of Rostock, Germany, Dr. G. C. Amstutz of the University of Missouri School of Mines and Metallurgy, Rolla, and Dr. J. Green of North American Aviation, Inc., Downey, Calif.

The present names for some features of the moon imply a volcanic or meteoric origin. The proposed system would permit an objective evaluation of how the surface features actually formed, and also advance the "basic concepts and theories on the structure of the moon and the planets," the scientists said.

The moon is subdivided according to size, shape and location of the moon features under the new system. It includes both purely geometric terms such as ring, line and wall, and descriptive terms such as continent, mountains or rays. Terms suggesting volcanic craters or meteor scars are omitted.

Scientists are currently divided into two schools as to how the moon's surface features formed. Some believe the wrinkles and valleys formed when the moon cooled from a hot, molten mass, whereas others stress the irregularities are due to meteorites pelting the moon.

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## ASTRONOMY

# Moon Has Electric Layer

► A THIN, electrically charged layer at the moon's surface is helping to smooth out the moon's valleys and ridges.

A sheath of electrons created by bombarding ultraviolet rays of the sun helps transport moon "dust" along the surface of the moon. The dust stops traveling when it falls into a crater or nestles in the shadow of a ridge.

Microscopic meteorites constantly pelting the moon raise a flurry of dust, Dr. S. F. Singer and E. H. Walker of the University of Maryland reported. The dust particles acquire a positive charge and are constantly repelled or "bounced" along by the electron layer. They finally lose their energy when they reach the dark side of the moon or a mountain's shadow.

This process has been going on since the moon formed a few billion years ago, the scientists suggested at the American Geo-

physical Union meeting in Washington, D. C.

The electron layer is very dense up to three feet above the moon's surface, averaging between 100,000 and 1,000,000 electrons per cubic centimeter. The total layer is about 45 feet thick but the electron strength becomes very weak farther away from the surface.

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## Frozen Layer on Moon

► A FROZEN LAYER nearly one-half mile thick probably lies 100 feet beneath the surface of the moon, Dr. Thomas Gold, a Cornell University scientist, reported.

Radio waves penetrating into the moon's interior show that water is bottled up as ice crystals in rock pores, forming a frozen ground layer, the scientist told the Ameri-