ASTRONOMY

Cubic Inch of Dwarf Star Weighs 18,000,000 Pounds

Such Extremely Dense Matter Could Not Be Supported By Any Earthly Substance; Would Drop Right Through

A STAR so heavy that a mere cubic inch of its matter weighs nearly 9,000 tons (18,000,000 pounds) was described to the Singer-Polignac Congress of Astrophysics in Paris by Dr. G. P. Kuiper of Yerkes and McDonald Observatories. Its name is Wolf 457 and it is one of the two strange "white dwarf" stars recently discovered by Dr. Kuiper with the new 82-inch telescope of the McDonald Observatory in Texas.

A piece of this star's extremely dense matter could not be supported by any earthly substance; it would drop through it like lead through air. Its density is half a billion times that of water.

"White dwarfs are self luminous stars with diameters about equal to that of the earth, or only about one per cent. of that of the sun," Dr. Kuiper said. "The largest white dwarfs are about double the size of the earth, the smallest about one-quarter of that size, or about equal to the size of the moon. But although the sizes of the white dwarfs are planetary, the masses are stellar, being about 150,000 to 800,000 times the mass of the earth. Moreover, the smaller the white dwarf, the larger is, on the average, its mass. The average densities (or mean specific gravities of the matter) are therefore of the order of a million times water; they vary from about 100,000 times water for the companion to 40 Eridani, and about 200,000 times water for the companion of Sirius, to roughly half a billion times water for Wolf 457."

The figure given for Wolf 457 is still uncertain, Dr. Kuiper explained, but probably of the right order of magnitude. Other dwarfs, A. C. 70 degrees 8247, Wolf 219, and Ross 627, have mean densities between about 10 million and 100 million times water.

Since the white dwarfs are very faint objects (between about 200 and 14,000 times fainter than the sun) they can only be discovered and studied if they are fairly close to the solar system, say, within 100 light years. For that reason Dr. Kuiper has been examining especially the stars of large proper motion which in general will be located in the solar neighborhood. In this way he has located eight of the 18 white dwarfs now known, including the two faintest objects known.

From the spectra of the white dwarfs, much information is derived about the composition of the atmospheres of the white dwarfs, and about the temperature and the gravity in the atmosphere. The surface temperatures vary between roughly 5,000 degrees and 30,000 degrees Centigrade. Most of the white dwarfs have surface temperatures near 15,000 degrees Centigrade.

"The surface gravities are stupendous from a terrestrial point of view," Dr. Kuiper said. "It is about 40,000 to 50,000 times that on earth for the two bright and relatively large white dwarfs mentioned, and increases to roughly 20,000,000 times that on earth for Wolf 457. In order to appreciate the meaning of these figures one must realize that the weight of every particle is increased by these factors.

"But the effect on the atmosphere of the dwarf is disastrous. The atmosphere would be compressed in the same ratio but for the fact that the high surface temperature somewhat offsets the gravity effect. The resulting atmosphere is only a few feet high, and the matter of the star becomes crushed by the weight of the higher layers already a few tenths of miles below the surface. The weight of the earth is insufficient to change the properties of the deep interior very considerably.

"Equally, in the sun the interior is not radically different from the solar atmosphere; temperature and density are high, but not enough to change the gaseous state of the matter.

"In the white dwarfs the excessive gravity causes the main body of the stars to be composed of crushed matter, built up not of atoms, but of the fragments of smashed atoms: electrons and atomic nuclei. Matter in that state is called degenerate, since it has lost its ordinary character.

"It is a magnificent accomplishment," Dr. Kuiper continued, "that matter in the extreme conditions prevailing in nature at large, as studied by the astronomers, can be fully described and understood by contemporary physics."

SURVIVOR OF CATACLYSM

The Crab Nebula is what remains of a supernova reported in China and Japan in 1054. The nucleus is the remainder of the supernova itself, and it is surrounded with the material ejected during the cataclysm.

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Mystery of Universe

SUPER-EXPLODING stars, the supernovae, although they are the most tremendous phenomena yet known to the mind of man, constitute an utter mystery to astronomers, Dr. Henry Norris Russell, of Princeton, dean of American astrophysicists, declared as chairman of the conference.

There seems to be no escape from the conclusion that a supernova may reach such amazing brilliance that it will shine for a few days with light comparable to that given off by a whole galaxy of stars, Dr. Russell explained.

"The fortunate recent discovery of two supernovae, one of the eighth magnitude, in time to permit detailed spectrographic observation, has greatly increased our information, and also our puzzlement," said Dr. Russell. "The spectra, though similar from one supernova to another, are utterly unlike those of any other celestial bodies, so that despite careful study it has not yet been possible to identify a single feature with any radiation known in the laboratory."

Dr. Russell declared that he has not given up hope that the problem of the kind of light emitted by supernovae will be explained by known properties of atoms, perhaps atoms that are moderately ionized, that is, with not more than half-a-dozen electrons stripped from them.

Two supernovae that occurred within the Milky Way, the galaxy in which the sun and earth are located, are authenticated, Dr. Russell said. These are famous Tycho's star of 1572, the brightest ever observed visually, and one recorded in China and Japan in 1054, which survives as the nucleus of the Crab Nebula, which itself represents the material ejected during the cataclysm.

There are lesser exploding stars, the ordinary novae, which are now occurring with extraordinary frequency. Six very conspicuous novae have appeared during the first 40 years of this century, an unequaled record. This happy accident—for astronomers—Dr. Russell attributed to the chance of our position in space because the actual dates of the outbursts differed by many centuries due to the differences in distance from the stars to the earth.

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Watch for Outburst

ONLY the outburst of an extraordinary exploding star or supernova in our own Milky Way will reveal to science the beginning stages of these most tremendous explosions known to man, Dr. Walter Baade of Mt. Wilson Observatory, Calif., said.

Only 30 of these supernovae are known to have occurred, and only two are believed to have been in the part of space in which the earth and sun are located. Fourteen of these 30 have been discovered from Mt. Palomar and Mt. Wilson, most of them during the intensive search for supernovae conducted by Dr. Fritz Zwicky and Dr. Baade since the spring of 1936.

Astronomers may not have a chance to observe such a supernova close at hand for many years to come. No one knows when one will occur, but the way they have flashed forth in distant galaxies causes Dr. Baade to estimate that only one supernova in several centuries will occur in a given galaxy. If a supernova happened in our own Milky Way it would be brighter than any star or planet and easily visible in daylight. At peak, a supernova may have the luminosity of 70,000,000 suns.

The interpretation of light given off by supernovae is a mystery at present, Dr. Baade told the conference. No bands in the supernova spectrum have been identified except some oxygen lines that make their appearance 180 days after maximum brightness. A curious and progressive red shift of the spectrum, discovered by Dr. R. Minkowski of Mt. Wilson Observatory, prevents attempts to assign definite wavelengths in the spectrum.

"One of the most surprising results obtained in this spectroscopic investigation of supernovae," said Dr. Baade, "is the remarkable uniformity of the development in all so far investigated. Spectra of different supernovae taken at the same phases are so closely identical even in the minor details that there is a complete lack of individuality as far as the spectra of supernovae are concerned."

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Temperature Determined

ONE major mystery of the supernovae, was declared solved by Dr. Cecilia Payne Gaposchkin, Harvard Observatory astronomer, at the Paris conference.

The enigma has been to determine the temperature of these super brilliant stars. Heretofore astronomers have assigned to them such stupendous temperatures as a million degrees Centigrade but Dr. Gaposchkin has shown that their temperature is considerably lower, probably in the range of 15,000 degrees.

Research leading to this finding was conducted with Dr. Fred L. Whipple, also of the Harvard Observatory staff.

The basis for the old million-degree guesses for the supernovae temperatures has been the peculiar appearance of the spectra of these objects. The so-called bright lines by which various component elements are identified are spread out or broadened by some heretofore unknown force. In almost all cases the broadening has been so complete that accurate identification was impossible.

Dr. Gaposchkin has now demonstrated that these high temperatures are not necessary for the observed broadening, that it can be explained as due to the terrifically high velocities of the expanding gases as the stars explode. The speed of these gases is believed to be as high as 4000 miles per second.

To prove her belief Dr. Gaposchkin made certain assumptions concerning the nature of a supernova and then reconstructed its spectrum to see if it checked with the spectra observed from these stars. Specifically, she assumed a temperature of 15,000 degrees Centigrade, comparable to that of ordinary novae; a star composed of elements found in ordinary novae and characteristic of all heavenly bodies—hydrogen, helium, iron, carbon, nitrogen and oxygen; and the estimated explosive velocity of about 4000 miles per second.

This artificially reconstructed spectrum was almost identical, point for point, with the observed spectra of supernovae.

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"Babies" Among Novae

THE familiar S. S. Cygni variable stars whose peculiar fluctuations have puzzled astronomers for some time were classified as the babies in the family of novae or exploding stars, by Dr. Sergei Gaposchkin, Harvard astronomer.

The brightness variations exhibited by these peculiar stars are due to the fact that they puff up like balloons, and then, instead of exploding as do ordinary novae, they subside and remain quiet for a while before repeating the entire process.

These stars are unique among celestial bodies, Dr. Gaposchkin said, no other known type of variable stars behaving in this manner.

Their period of fluctuation is about 50 days, Dr. Gaposchkin estimates.

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