A Caltech physicist reveals results of a four-year computer study of

PULSATING STARS

by Graham Berry

Using a computer to imitate the behavior of the type of pulsating star that our sun is expected to evolve into, Robert F. Christy, professor of theoretical physics, has refined an important yardstick involved in measuring cosmic distances. The yardstick consists of a group of oscillating objects called RR Lyrae stars, which are sprinkled throughout our Milky Way Galaxy. He has determined that all these stars are about 50 times brighter than the sun; that they are about half as massive as the sun; and that about 30 percent of their surface layers consists of helium.

RR Lyrae are easy to distinguish from other stars because, as they pulsate, they dim and brighten in periods of a day or less. As yardsticks for cosmic distances it is vital to know their intrinsic brightness (i.e., the brightness of one of them compared with that of the sun, if both were placed side by side). Their distances are determined by comparing their apparent and intrinsic brightnesses.

RR Lyrae are slowly evolving stars, thought to have once had about the same mass as our sun, that have consumed enough of their hydrogen to swell up and become cool giants. Although now only half as massive as the sun, their diameters are about five times that of the sun. Further evolution elevates their surface temperatures to near that of the sun, causing their outer layers to become unstable. The instability is reflected in pulsations that persist for probably 10 million to 100 million years, a brief time in the life of these stars that are believed to be nearly as old as our galaxy.

To reach his results Dr. Christy has developed a new method of using a computer to simulate the behavior of stars. The method is an outgrowth of techniques that evolved at Los Alamos during World War II in calculating the design of the first atomic bomb. In the present study, he fed Caltech's IBM 7094 computer with numbers representing various masses, luminosities, surface temperatures, helium contents, and the physical properties of helium and hydrogen. He then fed to the computer the equations from applicable laws of physics. Finally, he instructed the computer to use all this information to imitate an RR Lyrae star.

The computer simulated some 100 possible models of the stars; each required about 100 million computations. The behavior of some of the models closely simulated the observed behavior of RR Lyrae stars.

It has been known that RR Lyrae stars have similar surface temperatures, ranging from 11,000° to 13,000°F. Stars of similar size, but with different temperatures, do not pulsate. Thus, it was assumed that the pulsations depended on the surface temperature.

The computer models showed that this is not completely true—pulsation also depends on the amount of helium in the surface layers. By testing models containing various amounts of helium, he determined that stars with little helium pulsated only at the lower end (11,000°F) of the temperature range, while stars very high in helium pulsated only at the higher end of the range (13,000°F).

The model containing 30 percent helium pulsated exactly within the observed range. Thus, Dr. Christy concluded that RR Lyrae stars probably contain about 30 percent helium.

The large helium content, which is considerably more than was expected, lends support to the "big bang" theory of the birth of the universe. If the surface helium content is representative of their composition at birth, these stars demonstrate that our galaxy was already rich in helium when it was very young. The helium could come from some unknown mechanism active in the early time of our galaxy, or it could come from a big bang that some scientists believe triggered the birth of our universe more than 10 billion years ago.

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