ASTRONOMY-PHYSICS

Power Secret in the Stars

With Temperatures at Heart of Sun 36,000,000 Degrees, Collisions Among Atoms Yield Tremendous Energies

By JAMES STOKLEY

IN THE SUN lies the secret of atomic power!

While scientists on earth work frantically to solve the problem of how to unlock stores of atomic energy, and release them for our own use, they look most longingly at the sun and other stars. For there the process is taking place all the time, as it has been ever since the stars began to shine.

Not always has it been known that the source of stellar energy is atomic. Centuries ago the only source of heat known was that of burning, so it was assumed that combustion kept the sun hot. But this proved entirely inadequate. Then the contraction theory had its day. This supposed that the sun's gravitation pulled its gaseous molecules together, generating heat as it did so.

This also was insufficient, for it provided a mere 25,000,000 years in the past during which the sun could have held its present output of energy. Yet geologists are sure the earth has been receiving heat from the sun at something like the present rate for at least a hundred times that figure.

First glimpses of atomic energy came nearly half a century ago.

It was in 1896 that the French physicist, Henri Becquerel, discovered the curious phenomenon of "radioactivity," by which some mysterious rays that could travel through black paper to fog photographic plates were given off from an ore of the metal uranium. Soon after this Professor and Madame Curie discovered that the uranium ore contained a new element—radium.

Then it was learned that radium, and similar elements, are continually disintegrating. They change into other elements, with liberation of energy, and emission of three different kinds of rays. Heat is generated in the process, at a rate sufficient for an ounce of radium to raise the temperature of a pint of water from freezing to boiling point in 14 hours. And this will continue for about 2500 years.

In the decay of radium different elements are formed ending with lead, but this is not quite the same as ordinary lead. Though it has similar properties, its atoms weigh a little less. Most elements known to the chemists are made of mixtures of these chemical twins—"isotopes," they are called.

Uranium, the element which starts the series in which radium appears, has several isotopes, all but two of which are present in almost infinitesimal amounts. Most abundant is the one of atomic weight 238, making up about 99 per cent of ordinary uranium. The remaining 1 per cent is mainly the isotope of weight 235, and this is the one that may be useful for atomic power.

Reason is that these atoms can be split relatively easily by neutrons—neutral atomic particles—of low energy. Further, there seems to be a "chain" reaction. A few neutrons, from a bit of radium mixed with the metal beryllium, for instance, are used to split one uranium 235 atom. Then, it seems, the splitting atom itself gives off the neutrons which will split another, and so on.

Assuming that proper control for the process can be established, all that is needed is a source of pure uranium 235. Two groups of scientific workers have succeeded in isolating microscopic amounts of it. Now, they, and others, are at work to find the means of speeding up the separation, so the stuff may be obtained in as much as pound lots. Pound for pound, it liberates about five million times as much energy as burning coal, so the possibility of important applications can be easily seen.

But there is another way of getting at atomic energy. All that is needed is to raise the temperature sufficiently. The hotter a gas, the more rapidly are its atoms moving. At temperatures of millions of degrees, the movements are so violent that the atoms, or pieces of atoms, hitting each other cause continual splitting of their hearts, with, of course, liberation of energy. With these temperatures, for example, lithium and hydrogen can combine to form helium, giving off enormous amounts of energy as they do.

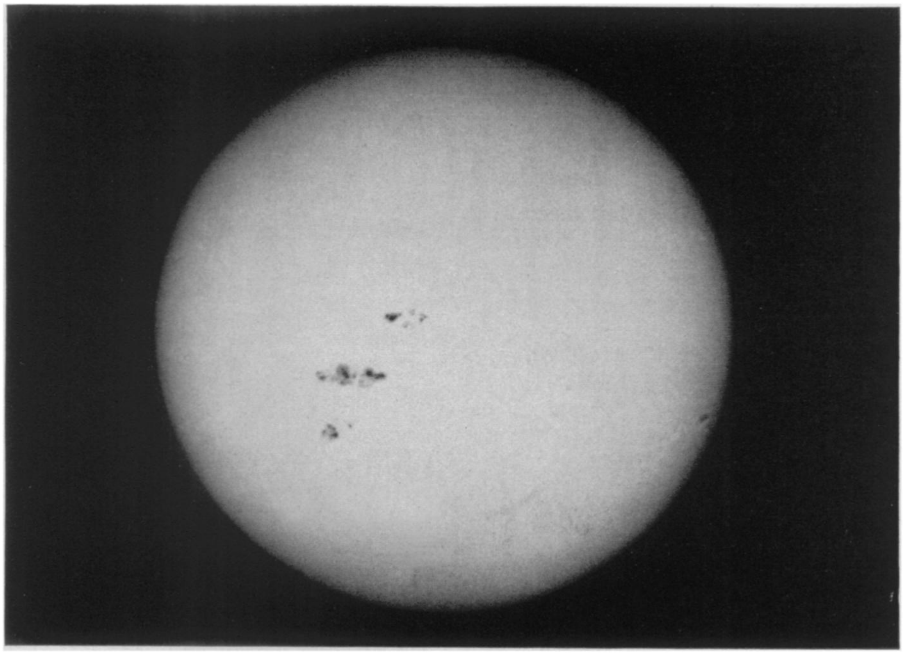
On earth, we cannot even remotely approach such temperatures. Electric furnaces at best can reach only a few thousand degrees. Literally exploding thin threads of metal by forcing large amounts of electricity through them, temperatures up to 30,000 degrees F. have been reached, but only for a fraction of a second.

The sun, at its surface, has a temperature of around 11,000 degrees F. Inside, it is vastly increased. While we cannot poke a thermometer into the heart of the sun, theory has provided science with what seems to be an accurate means of measuring the sun's heat. Using what he calls an "analytical boring engine," an English astronomer, Sir Arthur Eddington, has calculated that the interior of the sun has a temperature of about 20,000,000 degrees Centigrade or 36,000,000 degrees Fahrenheit!

Ordinary "burning" consists of the formation of compounds by the combination of atoms either free, or in combination in other compounds. For example, coal consists of carbon. When it burns, it unites with oxygen from the air to form carbon dioxide. But at internal stellar temperatures, this cannot take place. Indeed, compounds are broken up into their elements, so the carbon dioxide would be "unburned" to carbon and oxygen. Even these elements cannot exist in their usual form inside a star, for the protons and electrons of which

ANDROMEDA GALAXY

This great spiral structure consists of many millions of stars. Each one, according to current theories, is giving out energy by converting hydrogen to helium.



HOLDS IMPORTANT SECRET

The sun, most important of all the stars to us earth-dwellers, is shown here with a large crop of sunspots in a photograph taken at the U. S. Naval Observatory.

they consist are themselves torn apart. The atomic hearts or nuclei are rushing around at tremendous speeds, so are the loose electrons, and they are continually colliding with each other.

Understanding this, astronomers have now come to a satisfactory explanation of how the sun and other stars keep up their terrific broadcasting of energy. The sun's radiation, in a single minute, could melt a 40-foot shell of ice completely surrounding it!

In 1929, Robert Atkinson and an associate, Fritz Houtermans, working with him in Berlin, demonstrated that the speed of the atomic fragments in the stars, and the violence with which they hit each other would break up the atoms, with the liberation of energy. They did this with the use of a formula that had been worked out the previous year in Russia by Dr. George Gamow, who is now at George Washington University.

Not until 1938, however, were the actual atomic nuclei involved finally identified. Independently, Dr. Carl von Weizsacker, in Germany, and Dr. Hans A. Bethe, of Cornell University, found a series of changes which yielded almost exactly the right amount of energy. All other possible reactions gave either too much or too little.

This is between hydrogen and carbon. A number of steps are involved. The nuclei of hydrogen atoms strike the carbon atoms, and transmute them into an isotope of nitrogen. This is unstable and quickly decomposes into carbon, but not the same isotope with which it started. Another hydrogen nucleus comes along, the carbon is changed back to nitrogen, this time of the ordinary variety, with atomic weight 14. This is hit by still another hydrogen nucleus, and changed to a very uncommon variety of oxygen. This quickly decomposes into a third isotope of nitrogen, of atomic weight 15, which makes up about one-700th of the nitrogen in the air.

Then the fourth, and last, hydrogen nucleus happens along. There is a magical change, for now we have helium, gas used for inflating airships, and carbon of atomic weight 12, with which we began! The carbon is now ready to start over again. Or, if we like, we can start the cycle with the nitrogen, then we come back to it. But the hydrogen with which we started is gone, replaced by helium, the "ashes." In the process, various rays associated with radium are given off at different stages, as well as large amounts of energy. This output is very close to the actual rate observed for the sun, while all the other reactions that Dr. Bethe studied are far different. Thus we have good reason for believing that, at last, we have a pretty good idea of what is happening in the sun.

An interesting feature of this work is that it gives a clue to the future of the sun. The only element that is used up is hydrogen, and the sun has enough of this to last some 35,000,000,000 years, using it at the present rate!

The structure of the sun is such that this process tends to regulate itself. The flow of energy outwards from the center produces a pressure which balances the gravitational pull inwards and keeps it in a stable condition. If the production of energy should increase, added radiation pressure would increase the size, the gases would expand, their temperature would be lowered, and the output of energy would decrease. Reduction in the output would work oppositely. The sun would contract, pressure and temperature would increase, and normal production would be restored.

So atomic energy has been achieved, and that ages and ages ago. It is going on all the time—in the sun and the other stars. From astronomical studies, we may be better able to understand it, and to put it to work for ourselves.

Science News Letter, February 15, 1941

EVOLUTION

Ancient African Ape Had Hands Like Human's

HANDS like those of a human being, used little or not at all in walking on all fours, belonged to the puzzling man-like ape of Ice Age date, known as Plesianthropus transvaalensis, Dr. Robert Broom of the Transvaal Museum, Pretoria, South Africa, has concluded after examining the principal wrist-bone of one of these animals, found recently in the now classic cave site at Sterkfontein. Dr. Broom has sent an illustrated report on the find to the British weekly journal, *Nature,* copies of which are expected in the United States shortly.

The bone was compared with analogous wrist bones of three genera of apes—gorilla, chimpanzee and baboon—as well as with similar bones from the primitive African race of Bushmen. The fossil was decidedly more like the human bones than it was like those of any of the apes, indicating strong human resemblances in form and therefore, presumably, in function.

Dr. Broom holds that this is not to be particularly wondered at, since it is already known that this extinct ape had teeth very nearly like those of men. The bone was found in the same cave, and close to the same spot, where the lower jawbone of a female of the same species was discovered a short time ago.

Another strong resemblance to a human condition is shown in the sinus structure of Plesianthropus, Dr. Broom