X-Rays Show Structure of Atoms

Physics

Haloes Produced by X-Rays Tell Size of Molecules

X-RAYS have for years revealed to the eye the arrangement of the bones in our bodies, and they now show how the electrons are placed in the atoms of which all matter is made. For many years physicists have been able to study the arrangement of the atoms in larger aggregations by the use of X-rays, but further studies in the last few years have revealed new facts about the structure of the atoms themselves, Prof. Arthur H. Compton, of the University of Chicago, told the American Physical Society at its Ithaca meeting.

"Several weeks ago I noticed a beautiful halo around the moon," he said. "Half an hour later the halo was visibly smaller in diameter, and it was no surprise when a few hours later rain began to fall.

"The interpretation of such haloes, as due to the diffraction of the moonlight by droplets of water suspended in the air, is well known. The larger the droplet the smaller the angle of diffraction necessary for the appropriate phase difference between the rays coming from the two sides of the drop. So by observing the diameter of the halo, we can estimate the size of the water drops which cause it. A shrinking halo means a growing drop, and hence probable rain.

"In a very similar manner it is possible to find the size of molecules and atoms in a gas, by observing the diffraction haloes produced when they are traversed by a beam of X-rays. For many years it has been possible by this method to make rough estimates of the sizes of the atoms; but only very recently has the theory of the process become well understood, and the experimental technique become sufficiently developed to give us precise information regarding the electron distributions in atoms.

"When we review the many atomic theories that have been proposed and discarded, it may perhaps appear too bold to say that the particular theory now in vogue has any finality. One by one the vortex ring atom of Kelvin, the positively charged jelly of Thomson, the minute solar systems of Rutherford, Bohr and Sommerfeld, as well as the tiny atoms of Crehore, the ring electron atoms of Parson, and the cubic atom of Lewis and Langmuir have given way to more promising successors. We replace even Schrödinger's diffuse cloud of negative electricity by a probability cloud of electrons after the manner of Heisenberg. It now appears, however, that the only one of these many proposals which can account for the observed X-ray diffraction haloes is that of Heisenberg."

After giving details of the methods used in interpreting these X-ray experiments, he concluded:

"We may say with some confidence that the aspect of the problem of atomic structure which is concerned with the distribution of the electrons in atoms is finding a satisfactory solution. It is a relief to note that a theory is at hand which affords a reasonable interpretation of the electron distributions which the experiments show.

"In a bulletin of the National Research Council, published in 1922, having experiments of this character in mind, I had the temerity to predict that within ten years the electron positions in the lighter atoms would probably be known as reliably as were the positions of the atoms in certain crystals. I believe that prediction is now verified. For this information regarding electron positions in atoms is based upon precisely the same principles as is for example our information regarding the position of the oxygen atoms in a calcite crystal.

"I suppose it would be fair to say that experiments such as these come the closest of any yet performed to showing us 'what the atom looks like.' For after all is not seeing an object a diffraction phenomenon similar to those under discussion? And when we thus 'look' at the atom we find it composed of electrons diffusely distributed."

The mass of each item in this list, prepared by Prof. Stewart, is about a million times smaller than the one preceding it:

The known material universe
A large spiral nebula
A very large star
A good-sized planet
An ocean
A mountain peak
A forest
MAN
A butterfly
A paramecium
A bacterium
The largest organic molecules
A few score electrons
A quantum of ultraviolet light.

THE hugest thing under study by science is about as much larger than man himself as his body is larger than the smallest known thing. To the American Physical Society Prof. John Q. Stewart of Princeton detailed the range of masses in the material universe.

"The total range of mass represented is something like a trillion decillion decillion, with man about in the middle," Prof. Stewart said. "The physicists deal with the lower, the astronomers with the upper reaches. These two sciences have vastly extended our knowledge of the material universe, and doubtless will continue to push outward its boundaries (although there are mathematical physicists who believe that something like a maximum limit to the size of space will present itself). Literary men and artists being familiar with only a small range of the whole, the general public is without an adequate guide book to the universe. In the regions north of oceans and south of butterflies only the scientific men know their way around."

A suggestion as to the way in which the atoms of stars may be made to release their constitutional energy was given by Prof. Stewart. His theory is that the enormous accelerations of the atoms, set in motion by the great heat, may help in releasing this energy. Millions of times a second a molecule probably collides with another, but between collisions it is probably traveling with a uniform speed. But Dr. Stewart held forth no hope of man's being able to apply any such methods to solve his own power problems.

"The hypothetical process here outlined presents a magnificently inefficient mode of releasing power," he said. "In order to generate only one kilowatt, a mass equal to the earth's would require continuously to be subjected to an acceleration of about 3500 million times that of gravity."

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