we found produced by the stripped boron atom. Now the principal lines in the spectrum of hydrogen are also doublets and a beautiful theory was developed by Professor Sommerfeld for explaining these doublets. He showed that there ought to be two orbits, one circular and one elliptical, which would have exactly the same energy if it were not for the fact that the mass of the electrons in the elliptical orbit should grow greater as its speed increased in going through perihelion and smaller as it went through aphelion, and that because of the dependence of mass upon speed which is required by the Einstein theory of relativity. He further computed exactly with the aid of that theory the differences in the energies of two orbits, the one circular and the other elliptical, and found that this theory, which yielded a formula in which there were no undetermined constants at all, predicted completely and exactly the observed frequency separation of the hydrogen doublet. We now tried this relativity doublet theory upon the doublets which we had found in lithium, beryllium, boron, and carbon, and found that this purely theoretical formula predicted exactly the observed separations in all cases. We then predicted from this formula the separation of the doublet which ought to be produced by the stripped nitrogen atom and looking in the nitrogen spectrum found a nitrogen doublet with precisely the correct separation and at a wave length which we could also predict by our theory. We had thus brought to light a most powerful instrument with which we can now alanyze the light that comes from any kind of a source, for example, a very hot star, and know at once by comparison with the theory of observed lines whether stripped atoms of a whole series of substances exist or do not exist in the sources. In this way, we have definitely proved the existence in our hot sparks of stripped atoms of lithium, silicon, phosphorus, and sulphur, this last atom having been stripped of six valence electrons, phosphorus of five, silicon of four, aluminum of three, magnesium of two, and sodium of one.

These methods bring to light new ways of going on eclipse expeditions in the study of the astronomy of the sub-atomic world and they reveal new possibilities for the reading of the conditions existing in the stars. Truly, we are just now entering upon a period of the fascinating study of the astronomy of the atom, a period in which the spectroscope is the instrument with which we must bring to light wonders no less fascinating than those which the telescope has revealed in the study of the stars.

READING REFERENCE - Russell, Bertrand. The A.B.C. of Atoms. New York, E.R. Dutton & Co., 1923.

Mills, John. Within the Atom. New York, D. Van Nostrand Company, 1922.

ASTRONOMERS DEBATE EINSTEIN'S SHIFT OF SOLAR SPECTRUM

Einstein's third prediction, that the spectrum of the sun is shifted slightly toward the red end as compared with light from the earth, is not borne out by experimental evidence presented to the National Academy of Sciences at its annual session at Washington, by Dr. Heber D. Curtis, director of the Allegheny Observatory, Pittsburg.

This negation of one of the important points in the Einstein theory of relativity stirred the scientists gathered here because Dr. Charles E. St. John of the Mount Wilson Observatory, California, at the same session presented evidence in favor of Einstein's prediction of the effect of the gravitational field of the sun upon the light emanating from it. Dr. St. John made a preliminary announcement upholding Einstein last fall.

Dr. Curtis explained that the very minute shift toward the red end of the spectrum required by the Einstein theory amounted to only about eight thousandths of an Angstrom unit, roughly two one-millionths of the wave-length of the light.

The accuracy of the measurements made by Dr. Curtis with cooperation of Dr. Kelvin Burns of his staff and Dr. W. F. Meggers of the National Bureau of Standards is more than ten times that of this predicted shift. The apparatus used was a combination of an interferometer with a powerful grating spectrograph applied for the first time to a systematic investigation of the solar spectrum.

The measurements show shifts of the spectrum, but they are of a complex nature rather than the simple and uniform amount predicted by the relativity theory, Dr. Curtis announced.

"Instead of all the solar lines being shifted by an equal amount to the red," Dr. Curtis said, "and instead of that amount being the quantity predicted by Einstein's theory, a very marked line-intensity factor is found. For the very faint solar lines there is little, if any, shift, and the amount of this shift increases as the wider and stronger lines are used."

For a solar line of very weak of 0 or 1 intensity the shift to the red amounted to only two ten-billionths of a millimeter, while Einstein's prediction calls for a shift of eight ten-billionths of a millimeter. In the case of very strong lines of those of 15 intensity, the shift was nearly double that predicted by Einstein, or fifteen ten-billionths of a millimeter. (A ten-billionth of a millimeter is one one-thousandth of an Angstrom unit.)

"There is thus seen to be an unmistakable progression in this shift, which must be due to some factor or factors other than relativity, and it does not seem possible to reconcile these results with that theory," Dr. Curtis concluded. "For the theory requires that all solar lines be shifted to the red by a certain amount, while our results showthat the very weak solar lines are shifted only at a quarter or less of that amount. That is, if the relativity prediction is true, we must postulate some cause to shift the very weak lines back toward the violet. Now, while various causes may shift spectrum lines to the red, there is no known case of anything shifting them to the violet, except velocity, which seems untenable in this case."

On the other hand, Dr. St. John holds that the shifting of the lines of the solar spectrum are in the main satisfactorily accounted for by the Einstein theory of relativity, and that the minor deviations from the theoretical displacement observed in the rays coming from the high and low levels of the solar atmosphere are due to the motion of the currents of the hot gas. In the outer atmosphere the cooler vapors, which are settling downward, and therefore drifting away from us, cause a shift of the lines toward the red, in addition to the Einstein effect. While in the lower levels of the sun's atmosphere, three-fourths of the light is emitted by the hotter rising gases, and this motion toward the earth produces a shift toward the violet which tends to reduce the Einstein effect. Recent observations made on Mt. Wilson show that there are up-

ward and downward convection currents of incandescent gases in the stars like those in the sun, but of vastly greater velocity.

AN UNFINISHED PAPER

By Dr. Edwin E. Slosson.

At the moment when he was completing his demonstration of new radio waves Ernest Fox Nichols fell back upon the exedra in the rotunda of the new building of the National Academy of Sciences. His wife rushed to his side with restoratives, but in vain, for a few minutes later, President Michelson announced his death, and the adjournment of the session of the A cademy. Shorthly after, the Academicians were walking in procession down the marble steps through the newly planted garden following the body of their distinguished colleague.

Professor Nichols had died as he had lived, in the active promotion of science. Research was his life work, and although he had twice been tempted into administrative office, by serving as president of Dartmouth College from 1909 to 1916, and by accepting an appointment to the presidency of the Massachusetts Institute of Technology in 1921, he gladly returned again to his investigation of the laws of light.

Visible evidence of his ability as an experimenter was close at hand for while he was yet speaking visitors in a room next to the rotunda were examining the apparatus with which he proved the pressure of light. By touching a button of this ingenious mechanism, one can turn on an electric lamp and actually see for himself that the beam of light exerts a definite pressure upon whatever object it strikes. This pressure is so minute that it had never been observed until Prof. Nichols demonstrated it twenty-four years ago. Yet as we now know the sunlight falling daily upon the earth amounts to a weight of more than 100,000 tons. It is this light pressure that makes the tail of a comet by driving the infinitesimal dust particles away from the sun. It is also light pressure that keeps the gaseous stars like Betelgeuse swelled out to their gigantic size in opposition to the attraction of gravitation tending to draw them together into a solid mass. The actual demonstration of the fact that light produced a pressure effect was of espedial importance, since it is involved both in Maxwell's theory of the similarity of electrical and light waves and also in Einstein's more recent theory of relativity.

The life of Ernest Fox Nichols was cut short at fifth-five, yet few of his elder colleagues in American science have accomplished more. He was born in Leavenworth, Kansas, and being early left an orphan, was brought up by his uncle, General Fox. He went first to the Agricultural College at Manhattan, Kansas, and afterwards studied at Cornell, Cambridge and Berlin. At Berlin University, under Professor Rubens, be began his work on the long wave lengths about which he was talking when he died. While professor of physics at Dartmouth, he developed a radiometer of such delicacy that he was able to measure the heat that comes to us from the stars. In his last paper he was engaged in closing in the"mising link" between the longest of the heat waves and the shortest of the radio waves thus completing the series of the spectrum which runs from the "gamma rays" of radium,which are a hundred thousand times shorter than light waves, to the "wireless waves" which are miles in length.