cerned with industrial property, professors of universities, members of legislative bodies and lawyers of recognized standing and authorities on the subjects discussed. The United States was represented by Mr. Walter Chamberlain, Assistant Commissioner of Patents; Hon. Lawrence Townsend, United States Minister to Belgium; and Mr. Francis Forbes, of New York.

ORBITS OF REVOLVING DOUBLE STARS.

BY DR. EDWARD S. HOLDEN, LATE DIRECTOR OF THE LICK OBSERVATORY.

Sir William Herschel observed toward the close of the last century that many stars, seen as one body to the unassisted eye, were double in the telescope; and his measures of the relative positions of the two objects led him to the important discovery that, in many cases, one of the stars was revolving about the other in an orbit, or, to speak more accurately, that each of the bodies was revolving about their common center of gravity. It was not until the first third of our own century that the orbits of some of these revolving double stars were calculated, and the calculations showed that their revolutions were performed in obedience to the law of gravitation.

Newton's law of gravitation was thus demonstrated to extend to the stars; it was shown that gravitation was, in fact, universal. The universe was everywhere subject to one fundamental law. This was a great step forward because in Newton's time it had not been proved that gravitation extended further than to the confines of the solar system. Saturn was then the outermost known planet (its distance from the sun is nine and a half times that of the earth). In 1781 Herschel discovered the planet Uranus (nineteen times the distance of the earth), and in 1846 the planet Neptune was found (at a distance thirty times as great as the earth's). Both the new planets obeyed the law of gravitation in their motions round the sun. It was indeed by minute departures of the observed positions of Uranus from its calculated positions that the existence of an exterior planet—Neptune—was suspected, and subsequently verified.

The distance of the stars is almost infinitely greater than that of the earth. The nearest of them is some 20,000,000,000,000 miles from the sun. It was a great step then to have brought such distant systems under obedience to the same law that governs the fall of heavy bodies on the earth.

During the present century tens of thousands of new double stars have been found, as telescopes have been improved and as observers have become more assiduous and more skillful. Of these thousands many hundreds are, in all likelihood, binary—that is, they form a physical system, and are not merely perspectively projected on the background of the sky at the same spot. Such perspective doubles have no special interest. They are, as it were, the results of accident. The physical systems are, on the other hand, of the highest interest. Here are two suns (for stars are suns) forever linked together by gravitation; forever revolving about the same center. If they are accompanied by planets (and who shall say that they are not?) the conditions of life on such planets are strangely different from our own. Days and nights and times and seasons in such a system depend on complex configurations not readily to be conceived.

Not only have revolving double stars been detected by the telescope, but the spectroscope has stepped in to aid in such discoveries. A double star in the telescope appears as two separate stars, often so exceedingly close together as to appear single, except to the most searching vision under the most favorable circumstances. There is a limit of nearness below which a given telescope cannot separate two stars into two images, but at which it will present them as one. A telescope one inch in diameter, for example, will show two stars as one image, unless the angular distance apart of the two exceeds four and a half seconds of arc. A telescope thirty-six inches in aperture cannot separate two stars close together unless their angular distance from each other exceeds one-tenth of a second of arc; and so in other cases. If we were obliged to depend upon the telescope alone, it is clear that there might be a whole universe of very close double stars that would forever remain sealed to our sight. The stars are so exceedingly distant that the distance between the two components of a binary, while large if expressed in miles, is yet very small when expressed in its angular dimensions as viewed from the earth.

When a single star is looked at through the spectroscope its light is spread out into a narrow brilliant band of prismatic colors—the spectrum—crossed by a number of narrow dark, or, it may be, bright, lines—the Fraunhofer lines, so called. When a close double star is viewed, only one spectrum band of prismatic color is seen, but that band is crossed by two sets of dark lines. One set of dark lines belongs to each star. If the stars are revolving about each other we know that their distance apart, as seen from the earth, will change; but the unaided telescope can show nothing of this motion. In the spectroscope, however, it is shown by the distance apart of the pairs of lines in the spectrum. A certain line in the spectrum comes from the presence of hydrogen, let us say, in the atmosphere of one of the stars. It is always accompanied by a comparison line due, in its turn, to hydrogen in the other star. If the distance apart of the two stars changes, the distance apart of the two hydrogen lines will change. The changes in the distance of the lines can be measured in millimeters; and from them the motion of the two stars can be calculated in miles.

By methods like those which have been here summarily described, and by other methods based on the measurement of the light of a star around which a dark body is moving, so as to periodically obscure and occult some of its light, our present knowledge of the universe of revolving double stars has been amassed. It is far from complete, but it is now possible to form some kind of a general view and to enumerate the different species. The minute study of particular stars will be one of the researches of the coming century.

One class of revolving stars is typified by the variable star Algol, whose brightness varies periodically in such a way as to make it certain that the variations in brilliancy are caused by the revolution of a "dark star" about the bright Algol. Algol is commonly a star of the second magnitude. After remaining of this brilliancy for about two and a half days it falls to fourth magnitude (that is, it loses seventy per cent of its pristine light) in a short time—about four and a half hours. It remains of the fourth magnitude for about twenty minutes, and in about three and a half hours it regains all its light and remains at this brilliancy for two and a half days, and so on. These changes have been observed since 1667. They are caused by the revolution of a dark satellite of large dimensions about the principal star. The bright star is about a million miles in diameter, and the dark satellite about eight hundred thousand. Their distance apart is about three million miles. Each of these stars is, then, about the size of our own sun, but the mass of both of them combined is only two-thirds of the sun's mass. Their density is thus much less than that of water. They resemble spherical clouds, one brilliant, the other dark. Other systems of the sort have lately been discovered by spectroscopic means. One of them, Mu Scorpii, has a period of thirty-five hours only. Mizar, one of the stars of the Great Bear, has a period of fifty-two days. Others have periods of a year or more.

Binary stars discovered by means of visual observations with the telescope all revolve in much longer periods. To be seen at all, it is necessary that the principal stars should both be bright, and that they should be separated by large distances. Gamma Virginis, for instance, has a period of one hundred and ninety-four years, and its components are situated at a distance of four seconds. Other systems of shorter period are known, but until very recently the binary star of the shortest known period (excluding stars of the Algol class) was Kappa Pegasi, whose periodic time is over eleven years.

Prof. Hussey, at the Lick Observatory, has recently printed the results of his calculations on Delta Equulei, and his conclusions are that the components of this star revolve in the remarkably short period of five and seven-tenths years. Otto Struve, among others, long ago, suspected the short period of this star, but the results of Prof. Hussey, although given out with cautious reserve, seem to bear out the conclusion which is of especial interest, as it bridges the interval between stars of the Algol class with periods of a year or less, and telescopic binaries with periods of a dozen years up to several hundred years. It appears to show that revolving double stars exist having periods of all lengths from a day or so up to several centuries. A priori this was to be expected. At the same time the actual discovery of a telescopic binary of very short period is a matter of uncommon interest.

A PRIZE FOR BEER-COOLING MIXTURES.

A first prize of $375 and a second prize of $125 are offered by the German Brewers' Association for the best cooling mixtures for beer. The conditions specified are that the mixture shall not contain anything that may be injurious to health, and it must not cost more than twelve cents for a cooling capacity equal to that of 100 pounds of ice. It must also be capable of maintaining the beer, when treated, at a temperature of 45 deg. to 47 deg. F. The formula must be sent to the president of the association, Herr Henrich, Neue Zei, No. 68, Frankfort-on-the-Main, Germany.

WHILE plowing in a field upon a farm near Leighton Buzzard (England), an old earthen vessel was turned up in a furrow. Upon examination, the vase was found to contain sixty-three ancient British gold coins, each measuring about 1½ inches in diameter. It was in this same district, a few years ago, that a rich haul of one thousand two hundred gold pieces of the period of King Cymbeline, B. C. 55, was discovered.

SCIENCE NOTES.

The late Prof. Marsh, of Yale, bequeathed his house and grounds for a botanical garden. They are to be made the home of the newly created School of Forestry.

Prof. E. W. Scripture, head of psychological laboratory of Yale University, has been awarded a gold medal at the Paris Exposition for his lantern for testing color vision.

Prof. C. H. Eigenmann has discovered a new type of cave salamander, an active creature about four inches long, with protruding eyes and a tail longer than its body, speckled brown and yellow, and the peculiar formation of its feet enables it to climb vertical walls of glass and even move like a fly across the ceiling.

M. Camille Flammarion, the French astronomer, does not place the slightest credence in the idea that the inhabitants of Mars are trying to signal to our earth. He considers that the lights observed in the Icarium Mare were, in his opinion, simply the reflection of the rays of the setting sun on the clouds over that sea.

Chippendale's workshop adjoins No. 60 St. Martin's Lane, Charing Cross, London. It extended a considerable way to the rear, and was approached through a long entry. His rival, Cobb, in the making of artistic furniture, had workshops not far away, at the corner of St. Martin's Lane, at what is now known as Garrick Street.

The London Lancet calls attention to the fact that canned tomatoes are now being extensively colored, in order to make them look attractive and as if made from ripe fruit. Among the colors so employed are coal-tar colors and cochineal. The subject of artificial coloring and preservation of food is now receiving great attention in England.

A penny lunch room was recently opened in Chicago. The average amount received for each check was 3¾ cents. Every article on the bill of fare is one cent, and for three cents a man gets a good, wholesome breakfast. The projectors intend to operate twenty rooms, and expect to feed from 25,000 to 30,000 persons a day. The experimental lunch room has proved to be a great success.

A national Physical Science Laboratory, in connection with Kew Observatory, is to be established at Bushey House, Bushey Park, which has been placed at the disposal of the Royal Society for this purpose by Queen Victoria. In view of the controversy between the observers at Kew and the London United Tramways Company, it is also rumored that the observatory will possibly be removed from its present location to Hampton Court.

The scarcity of agricultural labor in Yorkshire, England, has resulted in the widespread introduction of mechanical appliances in order to cope with the work. One of the most novel is a mechanical milking device, but which, however, has not been employed with very great success. The results of mechanical milking are far below those obtained by hand, which is principally due to the fact that no two udders are alike, and also because the animals object to the tubes.

The fourth Cloaca Maxima has been discovered in the Forum. Signor Boni has been very successful in exploring the great sewers of ancient Rome and in preventing the flooding of the Forum whenever the Tiber rises, and also has been enabled to explore the Cloaca Maxima itself. This led to the discovery of three other cloacæ maximæ, each older and larger than the one hitherto known. They have been found to contain many fragments of Etruscan vases and other interesting relics. It is possible that the recent overflow of the Tiber may result in more discoveries of value to the archæological world.

Further valuable discoveries of antiquities have been made in the course of the excavations in the Forum between the Temples of Vesta and Castor, the most important of which is the unearthing of the fountain of Juturna and a shrine. The altar of the latter has a bas-relief depicting the final meeting of Juturna with her brother Turnus, before the latter met his death in single combat with Eneas. In close proximity to the shrine a suite of rooms lavishly decorated with mosaics was also discovered. Investigations point to the fact that this was probably the Statio Aquarum, the headquarters of the administration for the water supply of Rome. In the outskirts of Pompeii a magnificent bronze statue about four feet in height has also been unearthed. Signor Orsi, of the Archæological Museum, has examined the relic, which represents a nude male of Greek workmanship, and has concluded that it dates from the fifth century before Christ. He also considers it to be the most valuable discovery made since the excavation of the famous bronze Faun in 1870. The figure is in perfect condition, save for one arm, which, however, was found close by. The statue is estimated to be worth $100,000.

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