SATURN'S TORES.

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So much misconception exists in regard to the new discoveries about Saturn, that it may prove useful as well as interesting to the readers of the *SCIENTIFIC AMERICAN* to have the facts at first hand. For, to begin with, there is a lack of knowledge of what has just been seen, strikingly exemplified by the portrait of Saturn given in the *SCIENTIFIC AMERICAN* of November 23, which is not only not "a portraiture of the planet as it now appears," lacking indeed every one of the present features, but bears a strangely familiar resemblance to Saturnian pictures of thirty years ago.

In the next place, there seems to be a sad ignorance of celestial mechanics prevalent on the subject, both professional and profane. Perhaps as a mathematician I may be allowed to explain the matter, as I think its general points can be made comprehensible to even a non-mathematical reader. For not only is it perfectly certain that the rings are in process of falling in upon the planet, but this is an inevitable consequence of the mechanical principles involved.

There is an ingrained conservatism in most people to prolong the present; an inertia of mind akin to the inertia of matter, of which it is indeed but a form. The stability of Saturn's rings is an interesting instance in point. Astronomers of the eighteenth century had no misgivings on the subject. Not until Laplace took up the question was there any doubt that Saturn had been eternally aureoled, and solidly at that. Since then, the idea has known one long chronicle of crumbling down. First, Laplace showed that if the rings were of the breadth they seem to be they could not endure, as the tremendous strains to which different parts of them would be subjected by the attraction of Saturn must end in disruption. He accordingly supposed them subdivided into a series of very narrow ones, which would greatly diminish the stress. Peirce then showed that Laplace's supposition was not enough; that for stability the rings must be fluid. Lastly, Clerk-Maxwell took up the subject, and proved that even fluidity was fatal; the rings to be stable must be composed of separate particles, "brick-bats," he called them. But some time before this, in 1848, Edward Roche had pointed out that the rings must be composed of discrete particles, because they lay within the limit discovered by him at which a satellite could revolve without disruption from tidal action by the planet. It is amusing now to see discreteness without discretion taken as a last word on the subject, in view of the fact, if my memory serves me rightly, that Clerk-Maxwell himself pointed out that the particles must, in time, some fall in upon the planet, some be driven off to form a satellite. The proof of this is as neat as it is cogent, and not beyond every-day comprehension.

A swarm of particles—particles like our meteorites, these probably are—traveling round a planet in stable motion *only in the absence of collisions*. For the moment one of the neighbors collides with another, unless both be perfectly elastic—a condition not fulfilled with any substance—a part of the energy of motion is converted by the impact into heat, and thus lost to the system. Now, the energy of motion, or *vis viva*, as it is called, is expressed by $\frac{1}{2}mv^2$, where m is the mass of the body and v its velocity.

The effect of the collision is thus to slow down one of the bodies without adequate compensation to the other, to shorten its orbit in consequence, and so bring it nearer the planet than it was before. The next collision helps on the work, and so it continues until at last some particles fall upon the surface itself, while others pushed outward collect beyond Roche's limit into a new satellite. So much for the inevitable effect of collision.

But collisions are certain to occur in a swarm of the sort, unless the particles are so far apart that no possible perturbation from one another or from outside bodies can cause them to touch. Now, the brightness of the chief rings of Saturn shows that the particles are not at great distances apart, on the contrary are relatively crowded. So that even from their mutual pulls upon one another, still more from the action of the satellite, collisions must be common, and thus the stability of the system is certain to be wrecked. But there is nothing catastrophic about it. The system was doomed to die from the moment of its birth, has been breaking up in fact from the instant it began to be. That it will outlast our grandchildren is a safe prophecy, but that it is in process of dissolution is as assured as the law of gravitation itself.

The interest of the new observations consists in no such simple spectacle as a catastrophe, but in a much more subtle and satisfying thing—in the proof they afford, not only of the fact but of the manner of the disintegration of the rings. For they turn out to give evidence of a very pretty case of celestial mechanics, which, though too abstruse to be popularly appreciated, can nevertheless be so put as to be generally understandable.

The ring system of Saturn is composed, beginning from the outside, of ring A, about 10,000 miles in

breadth, which extends to Cassini's wide division and is itself divided about half way by Encke's narrow one; from Cassini's division stretches toward the planet, ring B, 16,000 miles, to where the crepe ring, known as ring C, begins, which in its turn continues in, according to the latest previous measures, up to 7,400 miles from the planet's surface. I say previous because the measures just made at Flagstaff show that it extends nearly 4,000 miles farther in.

Now then, for the facts of recent observation.

The first new and interesting circumstance connected with the present appearance of the Saturnian system was the detection at Flagstaff on June 19, 1907, by the writer of a very fine black line threading

THE RINGS OF SATURN VIEWED EDGEWISE.

the central part of the much less dark shade that banded the (approximate) equator of the planet. The detection of the phenomenon speaks for the definition at Flagstaff, thus supporting the space penetration there shown for stars; for at the Yerkes Observatory, Prof. Barnard had not caught it, as he told the writer a few days ago, and it has not been reported from the Lick, though it was visible to all the observers at Flagstaff who examined the planet critically. (The photograph presented above of a drawing made on November 13 shows this detail of the band.

This core to the shadow of the rings is the first point of interest about the new appearances, and proves in a sense anticipatory as well as corroborative, as the reader will presently see, of the explanation about to be given of the much more easily seen phenomena in the rings themselves.

To begin with, it is at once evident that the dark medial line is the shadow of such part of the ring as is plane. Its observed width, 0.10 sec., makes it probable that it is the shadow of the ring A only which is here concerned, and that that ring is therefore practically plane. The dusky band on both sides of it one might at first suppose its penumbra, but calculation shows that it cannot be such, because that penumbra would be only 0.05 sec. wide, whereas the measured breadth of the band is 0.46 sec. Nor can it be due to the shadow of the whole ring system regarded

DIAGRAM ILLUSTRATING DR. LOWELL'S THEORY OF SATURN'S RINGS.

as a plane, for that would only measure 0.26 sec. across. Thus the observed shadow is too wide to be accounted for, unless *parts of the rings are out of the general plane of the system*. In that case, however, the phenomenon is just what we ought to see. The dusky fringe on both sides of the dark core becomes explicable when we so consider it, and only then. The shadow as seen at Flagstaff thus tells us that certain parts of the ring system are not flat, but of the nature of tores, a tore being a sort of flattened anchor ring. Tores then are certain portions of the rings, symmetrical all round the planet.

Passing now from the shadow to the appearance presented by the rings themselves, the reader must realize that they are now viewed almost edgewise to the earth, for the elevation of the earth above the

plane of the rings was only 40 min. N. on November 3 and 50 min. N. on November 13. For the most part, the rings showed only as the finest of lines of light stretched on either side the disk like golden threads, but in two places upon them brilliant star-like beads stood strung, symmetrically placed on either side the disk and of easy perception. (All six observers saw them instantly.) Detection of agglomerations of the sort is not new. Herschel, Wray, Struve, Bond, etc., perceived such long ago, and the present ones were seen some months since by Barnard at Yerkes, and later by the Lick before they were looked for at Flagstaff, as the planet was not then an object of special study. But the careful measures made at the latter of their position, when reasoned on, prove to negative the old explanations and to lead to a new one of some curiosity. Figures here become necessary.

In radii of Saturn the agglomerations lay at 1.10—1.46, the inner, 1.72—1.92, the outer, from the center of the planet, while a conspicuous gap occurred at 1.58. The inner tore is thus much broader than the outer one.

Now Olbers's explanation, adopted by Seeliger and recently advanced again as if it accounted for the present phenomena, consists in attributing the agglomerations to the piercing by the line of sight across the widest presented breadth of the several rings' supposed plane. It puts the maxima at 1.60 and 2.00, or exactly where the minima now fall, and the observational maxima where the theoretical minima lie. This explanation therefore fails. We must, then, have recourse to another, and the only one which presents itself to answer satisfactorily the requirements is this: That at the points of agglomeration the eye is looking *through particles outside the ring plane* at the points where these swing into greatest perspective at their ansæ.

So much for the evidence afforded that certain portions of the rings are not flat, first by their shadows and second by themselves. But when we consider the character of the witnesses, we perceive that each tells its story from a different standpoint, since in the one case we are looking athwart the rings transversely, in the other longitudinally, and in consequence the phenomena are different, though the conclusion is the same. Each thus greatly strengthens the testimony of the other.

So much for the direct deductions from observation. Now, can this state of things be accounted for? It can, and the answer is one of the prettiest applications of celestial mechanics. It is a consequence of the disturbing effect of the nearer satellites of the planet upon certain particles of the ring, for all are not equally affected. Not only does proximity to the satellite play a part in all disturbance, but commensurability of periods between particle and satellite comes in for a curious role in the performance. To conceive it, let the reader imagine two bodies revolving round a third with different angular speeds. At some points in their orbits the two will approach closer to one another than anywhere else, and here the disturbing pull of the outer upon the inner will be greatest. If the periods of revolution of the two bodies are not commensurate, the two will return to conjunction at a different part of the orbits, and a certain compensation in the deformation of the orbits be effected. But suppose the periods bear a simple ratio to one another, two to one for instance; then conjunctions will occur in the same place over and over again, and the disturbances instead of being compensated will become cumulative and finally very great.

This action is exemplified in what is called the great inequality of Jupiter and Saturn, by which the place of Saturn may be out by as much as fifty minutes of arc; it is also shown by the gaps in the zone of asteroids due to commensurability of period with Jupiter; and lastly, it is instanced in the divisions of the rings of Saturn, Cassini's division and Encke's division being both due to this cause.

Now conceive a particle thus acted on by Mimas let us say, and to collide in consequence with a neighbor. The centers of the two will not probably be in the plane of the rings, because, however thin the ring, there are many particles in any cross section of it. There will therefore be a resultant throw out of the plane, and the particles will thenceforth travel above or below it. Such tossing of the particles out of their original level by satellite action will be most pronounced just inside the point where the perturbations are greatest. For at each collision there must be, as we saw above, a loss of *vis viva*, and the disturbed particles will eventually be found in consequence chiefly inside the line of maximum action.

According to this principle, let us see where we ought to find tores. For the analytical treatment of the subject, too technical of course to be given here, shows us which ratios are the most important, and these turn out to be the very simplest. The greatest disturbing ratio is when the periods of disturber and disturbed are as 1 to 2. This occurs in the case of Mimas, the most potent perturber of the particles of the rings, at Cassini's division. The first tore, then,

should lie just within this or in the outer part of ring B. This is precisely where we find it. The next most powerful proportion is 1 to 3, also due to Mimas. This occurs at the boundary of B and C. The next tore then should be in the outer portion of ring C. This is where the second observed tore actually begins. But we saw that it was very broad, much broader than tore B. Now, the third most effective ratio is 1 to 4. And this in the case of Mimas takes place about two-thirds way in along ring C. Here then is a reason why that tore should be so broad. The only other case of commensurability of like importance is with Enceladus, the next outer satellite, and is as 1 to 3, and its action falls in Cassini's division, so that it helps Mimas to cause tore B. Here then is a very elegant exemplification of a case of celestial mechanics, that of commensurability of period. The tores in Saturn's rings observed and measured turn out to lie where deduction from the law of gravitation leads us to infer that they should be found.

Recent Flights by Farman and De La Vaulx.

BY OUR PARIS CORRESPONDENT.

On November 18 M. Farman made a formal trial for the Deutsch-Archdeacon \$10,000 prize for the kilometer in a closed circuit, and while he did not succeed, the results were promising. He easily reached the turning post at 500 meters distance (1,640.4 feet), but he was not able to make the turn around it. On the last trial he made the turn, but he had touched the ground several times while doing so, although he succeeded in returning to the starting line while in flight. In this attempt the motor did not seem to be working well, which, according to M. Farman, accounts for the irregularity of the flight. Darkness stopped further trials for the day. Among the assembled crowd were noted Santos Dumont, Senator Henri Deutsch, Capt. Ferber, Messrs. Tissandier, Jacques Faure, Charron, Besancon, the secretary of the Aero Club, our correspondent, and one of the members of the editorial staff. Among the persons present was Mr. Orville Wright, who has been in Europe with his brother negotiating for the sale of their aeroplane, which is kept as close a secret as ever. Mr. Wright did not think it *apropos* to give his opinion at length as to M. Farman's performance, although he considered the flights as excellent and believed that Farman is in a fair way to win the Deutsch-Archdeacon prize, while being easily ahead as far as Europe is concerned. He has a high opinion of M. Farman's ability and thinks that his experiments are doing much to advance the progress in aeroplane work. M. Farman would be glad to compete for the SCIENTIFIC AMERICAN trophy, as he thinks he has already practically won it, and regrets that it cannot be competed for in France. On the same afternoon the airship "Ville de Paris" made its appearance, sailing over the grounds in fine style, and this, of course, added to the interest of the event. It was piloted by the aeronauts Henri Kapferer and Paulhan. After sailing about in several curves, it descended on the grounds during M. Farman's flights. Toward dark it rose up easily in the air, and returned to its headquarters at Sartrouville.

On November 23, for the third time, M. Farman once more competed for the Deutsch-Archdeacon prize. He was unable to make more than one attempt on this date, however, owing to a violent storm of wind and rain, which came on in the midst of the trial. After leaving his shed, in order to reach the starting point, he was obliged to make a flight across the field. Starting with the wind he crossed the field, described a semi-circle, and landed against the wind, having covered a distance of 900 meters (2,952¾ feet). While preparations were being made for the flight for the prize, the wind suddenly veered and increased in intensity until it was blowing from 12 to 18 miles an hour. M. Farman, nevertheless, started his machine, and rose in the air at a high rate of speed. As the wind threatened to carry him beyond the limits of the field, he decided to descend and wait for better weather. The fact that he was able to maneuver the aeroplane and keep it on a fairly even keel under such adverse conditions, is another evidence of the inherent stability of this type of machine.

On November 19, while experimenting with his new aeroplane, Count de la Vaulx had an accident, which fortunately was without serious results. The aeroplane, which is of the monoplane type and has a total surface of 40 square meters (430 square feet), was being driven at about 30 miles an hour by its two propellers actuated by a 50-horse-power Antoinette 8-cylinder engine when suddenly one of the wings gave way, and the machine fell over upon the other wing. The front part of the machine dug into the ground, and the entire aeroplane turned upside down. Count de la Vaulx was hurled to the ground with great force, the motor falling on top of him and pinning him to the ground. To add to the danger, some of the gasoline caught fire, but the flames were quickly extinguished by on-lookers. The Count fortunately escaped with a few cuts and bruises, though his machine, which he was trying for the first time to fly, was demolished.

The Experiments of M. Bordas in Producing Gems? by Means of Radium.

An interview with M. Bordas, who has been reported as having produced various gems by the use of radium, is published in *Le Temps* of Paris. The New York Tribune summarizes the interview, showing that M. Bordas's work is not such as will revolutionize the jewelry trade.

The material of which a certain class of gems—rubies, sapphires, amethysts, and emeralds—consists is corundum. What M. Bordas has effected is merely an alteration in the color of the specimens with which he experimented, the change being attributed to the action of radium placed in close proximity to the stones. In this manner, it is announced, a white crystal was made to assume a yellow hue, a sapphire was turned from blue to green, and the tint of a pale ruby deepened. It was noticed, moreover, that if the exposure to radium was sufficiently prolonged the color of a ruby would change in succession to violet, blue, green, and finally to yellow. The interviewer shows that there is nothing in the transformations thus far observed which threatens to afford a supply of jewels produced inexpensively. He remarks reassuringly: "Let us rid our minds of the idea that M. Bordas has taken cheap stones—corundums and topazes—and elevated them to the dignity of gems—sapphires, emeralds, and rubies. Quite the reverse."

Though no intention of deceiving his hearers can be imputed to M. Bordas, the report of his recent experiments to the French Academy of Sciences was unfortunate in one particular. It was entitled "A Contribution to the Synthesis of Precious Stones." By "synthesis" the chemist means the putting together of certain elements for the manufacture of a substance having entirely different qualities. A molecule of grain alcohol, for instance, contains one atom of oxygen, two of carbon, and six of hydrogen. If man could persuade these ingredients to unite in the proper proportions and undergo the transformation which nature alone is able to bring about he would call the product "synthetic" alcohol. M. Bordas, it will be observed, makes no pretence of having effected a combination of materials for the production of something unlike the original elements. In each instance, according to his own statements, he began with corundum and ended with corundum. The only change he made was one in color. He has apparently not thrown any light on the synthesis of gems.

It has been supposed that the characteristic hues of the ruby, sapphire, amethyst, and topaz were due to the presence of metallic dyes in diminutive quantities. M. Bordas dissents from the accepted theory. He infers from his experiments that the differences represent differences in the degree to which the stones have been acted upon in the earth by substances possessing the properties of radium. All gems of the corundum class, he holds, were originally red. Those which by circumstances were well shielded from the influence of radio-active minerals retained their color. The amethyst, sapphire, and emerald indicate successive alterations, according to M. Bordas, while the topaz might be regarded as the ultimate product of the magic agency.

Though there is enough in this ingenious hypothesis to invite examination by persons who make a study of nature's processes, the practical importance of the work on which it is based is evidently small. The utmost which a jeweler could hope to do with the aid of radium apparently is to alter slightly the tint of a gem, but apparently an attempt to do so would be attended with uncertainty as to the result. Where there is a chance that a precious stone may be damaged, instead of being improved, the wisest policy would seem to be to let it alone.

The Death of Prof. Asaph Hall.

Prof. Asaph Hall, best known for his discovery of the two moons of Mars, died at Annapolis on the night of November 22. Prof. Hall was born in Goshen, Conn., in 1829, where he acquired a common school education. Surmounting great difficulties, he pursued his studies somewhat further, at Central College and at the University of Michigan.

In 1857 he began work under Prof. Bond in the astronomical observatory of Harvard, staying there until 1862, in which year he went to Washington to take the examinations preliminary to acquiring a post in the Naval Observatory. He passed these examinations, and was made an assistant professor of mathematics in the United States navy, being raised to the position of full professor in the January following. For thirty years he was attached to the Naval Observatory.

Many government astronomical expeditions were headed by Prof. Hall, and many important discoveries made by him, notably of the two moons of Mars in 1877. He was a member of the National Academy of Sciences, a foreign member of the Royal Astronomical Society of Great Britain, and held membership and offices in many other learned bodies.

Both Yale and Harvard universities conferred upon

him the degree of Doctor of Laws, while Hamilton College made him a Doctor of Philosophy.

Retired from the navy in 1891, he was in 1895 appointed professor of astronomy at Harvard University.

Recent Awards of Scientific Prizes and Medals.

The American minister at Stockholm has advised the State Department that the Nobel prize for physicists has been granted to Prof. Albert A. Michelson, of the University of Chicago, because of his invention of an improved method of measuring the velocity of light.

The above mentioned honor comes almost on top of the Copley medal for optical investigation, which was awarded to him some three weeks ago by the Royal Society of England. Prof. Michelson is head professor of physics in the University of Chicago, of which faculty he has been a member since its founding in 1892. He received the Rumford medal from the Royal Institute of Great Britain, which made him an honorary member in 1899.

His first notable invention was an instrument for measuring the velocity of light, for an improved method of which he has now received the Nobel prize. He is also the inventor of a spectroscope that has a higher resolving power than any other instrument in use, and of several instruments for measuring distance by means of light waves. One of his most famous inventions is an interferometer, that not only measures light waves, but counts them as well.

The Nobel prize for chemistry has been awarded to Sir William Crookes, of London, while according to a dispatch to the *Petit Parisien* from Stockholm, it is stated that Dr. Laveran, of Paris, who is well known for his investigations of the propagation of tropical fevers by mosquito-conveyed microbes, has received the same prize in medicine.

The chief of the department of health and sanitation of Havana, Dr. Carlos Finlay, was recently presented with the Mary Kingsley medal in recognition of his discovery of the transmission of yellow fever by the mosquito. The Liverpool School for the Study of Tropical Diseases awards this medal in memory of Miss Mary Kingsley, the African traveler. Governor Magoon made the presentation at the University of Havana, before a large assemblage of officials and scientists, in his address congratulating the Cuban people on the great services that one of their countrymen had rendered humanity by remarkable researches in a field that entailed no mean personal danger.

The Davy Medal, founded one hundred years ago in honor of Sir Humphry Davy, has been awarded to Prof. Edward M. Morley, of West Hartford, because of his excellent determinations of the atomic weight of oxygen.

Changing Tints of Autumn Foliage.

The common idea regarding autumn coloring is that frost causes the brilliant color of the leaves. This popular fallacy is without any foundation in fact; frost has absolutely nothing to do with tinting of the leaves except that it hastens their fall. Autumn coloring is due to oxidation, which is caused by the action of light and heat, somewhat similar to the rust on iron. With leaves it is due to the fact that in fulfilling their mission they become choked by their own excretions, and the acids thus formed are acted on by the oxygen.

In extremely moist atmospheres the colors are not usually very bright, as in England, for example. And in very dry climates the leaves dry up suddenly, and their skin, which is very thick to prevent the escape of moisture, is not sufficiently transparent to allow of the color being seen beneath. In the regions where the autumn foliage is most vivid we find that an average season produces the finest colors. Neither a very dry nor very wet summer and early autumn will result in much brilliancy.

The extraordinary range of colors in trees of a single species is very noticeable, particularly so with the sugar maples; and it is remarkable that an individual tree will continue the same colors year after year; not only that, but the same branch will show the first tinge of color year after year.—Retail Druggist.

The Discovery of Ether Anæsthesia.

Active steps are being taken to honor the memory of Dr. C. W. Long, of Jefferson, Ga., the discoverer of ether anæsthesia. An act has been passed authorizing his statue to be placed in the statuary hall, Washington, D. C., and steps are being taken to have a suitable statue in position without any unnecessary delay. A marble statue forty feet high will be erected to his memory in Jefferson. The unveiling ceremony is to be performed by the president, for the time being, of the Georgia Medical Association, and is fixed for April, 1909. A suitable memorial building bearing a bronze tablet will be erected at Athens, Ga., on the site of Dr. Long's residence. The tablet will be inscribed with the date of Dr. Long's first operation and tell of his arduous and beneficent work in Athens.