strong staples bound with iron fitted to one of the up-rights. Then, inch by inch, these were drawn up tight, so that Jumbo stood with his fore feet about three feet apart. Now came the task of hobbling the hind feet, and fixing them in the same way as the others. As fast as an attempt was made to pass the loop round his one foot, he contrived to step upon it with the other, and evade it; now and again, as other means failed him, going down upon his knees and stretching himself to the utmost. Time after time did the attempt to snare him fail, but after about half an hour of patient work the hobble was fixed on the leg, and the next instant passed around the staple. This was accomplished about 10:30, or two hours and a half from the commencement of the business. During the afternoon a number of men were digging away the ground in front of the box, and sloping it upward to form an inclined plane. When this was accomplished, and planks had been laid down, six strong horses were harnessed to the huge car, and the task of drawing it up to level ground commenced. Night came on, and the work proceeded slow by lamp light. The car had traveled one hundred yards in five hours. The night was clear and starlit, with a crescent moon in the sky and a chill wind blowing. Jumbo was protected from the keen air by tarpaulins stretched across the bars of the two ends of his box.

At 10 o'clock the horses were taken out and led away. At about 10:15 the elephant began moving about uneasily in his box, put his trunk out, played with the straw in front, fished up one of the nosebags of the horses, and afterward threw it out on to the head of an attendant. Then, less good humoredly; with short, quick jerks of his hind legs, he made his chains rattle again. Next he began to jog rapidly backward and forward, butting as he came forward against the front bars of his cage, and making the ponderous box move backward and forward with his weight. Great clouds of steam burst from his trunk into the cold night air. As he felt his strength tell he appeared to redouble his exertions. The box rattled, and its frame quivered at every blow. It seemed merely a question of time to break it. If he had continued these tactics long enough nothing could resist them. One of the attendants spoke to him, and quieted him for a moment, but Jumbo began again. At length Scott, who had been taking supper, returned. The elephant was calmed at once, and shortly after had food and water. It may be stated that Jumbo snapped like tow a four inch rope which was used in fettering him.

At 11:15 Jumbo began to dance again, snorted, knelt down, worried his chains with his trunk, shook his box heavily, and would certainly have broken it if he had persisted; but at the command of his keeper he became quiet. At 12:15 the horses were put to; at 12:50 they tried to start, with ten horses harnessed two abreast, but the wheels had sunk so deep in the earth that it was impossible to move. Jacks were now employed to lift them, and at 1 o'clock a start was fairly made. At 1:25 the car was safely out of the gardens, and rattling off on the road to the docks.

The docks were reached at about 5:30 in the morning, the distance being about five miles. By this time it was almost daylight, and although it was now too late to think of utilizing the early morning tide for enabling the barge to leave the dock with Jumbo on board, it was decided to hoist the box on the lighter at once. Stout hempen ropes were passed round the structure in which Jumbo was confined, and both the elephant and his temporary prison van, weighing together between ten and eleven tons, were hoisted into the air and gradually lowered into the barge Clarence, which floated alongside the dock.

From the barge the caged elephant was readily transferred to the steamer Monarch, and in the course of twelve days safely landed on the wharf in New York. Thence he was conducted to the elephant home of Mr. Barnum, at Bridgeport, Conn., and after a recuperation in that comfortable place, Jumbo made his appearance as a regular member of "Barnum's greatest show on earth." This magnificent animal proved a great attraction to Mr. Barnum's menagerie, and soon repaid the indefatigable manager for all the money and time he had spent in bringing him to the New World. For several years wherever the show went Jumbo was the conspicuous star.

The immense animal had just been exhibited at St. Thomas, Ontario, on the 15th of September, 1885, and was being led along the railway track with Tom Thumb, the baby elephant, to be loaded into their respective cars, when a heavy freight train, running at the rate of forty miles an hour, bore down upon them. As soon as Jumbo saw the train, he made a rush for Tom Thumb, and grasping him in his trunk, threw him away across the tracks as easily as if he had been a kitten. Jumbo then tried to save himself, but it was too late, and he was crushed to death between the engine and the cars on the siding. The poor beast's devotion was unfortunately wasted, for Tom Thumb's leg was broken, and he had to be shot the following day. The engine and several cars of the colliding train were thrown from the track.

Our engraving shows the appearance of Jumbo after his death, as he lay against the side of the railway embankment.

The remains of Jumbo continue as a double attraction in Barnum's show. His bones have been finely mounted, and his skeleton forms a remarkable object to look upon. His skin has also been stuffed in the best manner, by the process here illustrated. Skin and skeleton are thus made to contribute to the curiosity of the public and, in some degree, to the advantage of science.

NEBULÆ AND PLANETS.

By H. GOUPIL.

THE stars composing the same system are submitted to mechanical laws which secure the equilibrium of their various motions, and, in a large measure, protect their existence against the destruction that might result from disturbing causes. The forces that concur in such equilibrium are attraction on the one hand and inertia on the other.

Attraction may be considered as an active force. It is, in a manner, the life of matter, comparable with muscular energy, which, in an organized being, is controlled by its will. Inertia, a passive force, seems to be designed for balancing the other, and to be an essential-

ly material property. It takes the place of a force, but is not one in the proper sense of the word.

In a revolving system inertia manifests itself through centrifugal force. If, in such a system, we consider any congeries whatever, a nebulous agglomeration, for example, in a cosmical state, centrifugal force, which tends to make an agglomeration of this nature fly from the center, acts upon it precisely as if it were unique in space. The rest of the mass has no influence upon the said force. The centrifugal force, then, that acts upon this particular nebulous particle is exclusively connected with two factors, viz., velocity and the distance to the axis of revolution.

The same is not the case with attractive force. That which acts upon any molecule whatever will depend upon the mass as a whole and the distribution of the same in the space existing around the nebulous particle.

It results that the distribution of the centrifugal and attractive forces that act upon the different parts of the cosmical mass is very variable, according to the distances to the axes of revolution; and that the equilibrium in the various parts of the whole will be much altered if, by reason of its very molecular constitution, the distribution of the materials that form the mass is itself variable.

It is easy to see what foundation there is for the theory of the formation of stars through successive rings detaching themselves from a cosmical mass. Let us, in the first place, imagine two cosmical masses having convergent directions in space. Let us remark that there already exists an infinite number of chances to one that the direction will not be exactly upon the line of the centers, and that the two masses will not be equal in bulk, density, nature and velocity. According to the laws of attraction, they will approach each other with accelerated velocities; and if they were first spherical, they will become elongated, because the parts in conjunction will attract each other more strongly than those that are in opposition. They will therefore deviate from their primordial directions in describing two curves, and, at the moment of contact, will have the appearance shown in Fig. 1.

Fig. 1.

Fig. 2.

Fig. 3.

The velocities required, then, will, at the moment of union of the two coalescing masses, constitute the different velocities of revolution at each point of the radius of the vortex that is going to form. In the beginning, the parts tend to form a spherical nucleus; but the mass increases in bulk and intensity in measure as material arrives, and the attraction is therefore increasing so that the newly arrived parts have velocities greater than the first. As these velocities are sensibly tangential, they give the new concentric zones rotary velocities greater than those of the center; and the whole becomes lenticular, and vaster and vaster.

Finally, the last parts unite in directions less tangential, by reason of the increase of the sphere's diameter; their components in a tangential direction give less gyrating velocities; and it follows that the parts that have the greatest linear velocity of gyration are the median ones (Figs. 2, 3, and 4).

Fig. 4.

As the nebula thus formed is composed of two masses that are of unlike nature, density, etc., it is not homogeneous, either as a whole or in the same concentric zone.

In time, such homogeneousness will occur; but the slight density of the whole, its large dimensions, and the slight power of the attractive forces, defer the formation to so far off a date that the disturbances created by this want of homogeneousness have time to disunite the various substances of the nebula, and to convert it into a planetary system.

It is plain that if, at all parts of the mass, the attractive force were exceeded by the centrifugal, the nebula would form a ring, which would increase until an equi-

librium was established. The lenticular form, on the contrary, satisfies the opposite condition.

It may occur that the last portions that are proceeding toward the vortex shall escape it through the great velocity that they have acquired; in which case, according to the laws of Kepler, they will pursue their route in space with very elongated orbits, and may thereafter form periodical comets, or never return again.

The lenticular nebula (Fig. 5) will be governed by

Fig. 5.

Fig. 6.

Fig. 7.

Fig. 8.

centrifugal and attractive forces, whose laws (Fig. 6) will be such that the former will at all points be superior to the latter. But such laws will become modified in different ways. By very reason of the fact that, at every place, attraction exceeds the centrifugal force, the concentration takes place through the slow compression of the gaseous fluids and the equally slow precipitation of the cosmic dust; consequently, an increase in the rotary velocity and centrifugal force.

The attraction further increases by reason of the reduction of the radii; so that if, during such transformation, the attractive force is constantly surpassing the centrifugal at every place, the nebula will finally resolve itself into a fixed star. But, as the two laws are not connected by one principle, other combinations are possible. In the first place, a point of contact may form (Fig. 7), and, later on, a crossing and recrossing (Fig. 9).

At *a* and *b*, in Fig. 9, the two contrary forces are

Fig. 9.

Fig. 10.

equal, and every part comprised between the circumference, *a*, and the center will continue to concentrate, since attraction is surpassing the centrifugal force there. But, for a contrary reason, the parts between *a* and *b* will become more distant from the center, while those situated beyond the circumference will approach the center. Therefore, there will be a concentration at the center and upon the circle *b*, and then upon the circle *a*; hence the formation of a ring (Fig. 10). This ring, when once separated from the mass, will be free, and will preserve its rotary velocity independently of the transformations that it is to undergo.

The rest of the nebula will continue to concentrate, and the slow modifications in the attractive and centrifugal forces will soon lead to new inequalities and expurgations favorable to the detachment of a new ring, until the concentration becomes so great as to no longer lead to such a result. The central core will become more and more spherical, and it is easy to see that, since the cause that creates the rings keeps on getting weaker, the latter will become of less and less bulk, as will also the stars that result therefrom.

Again, it will be seen that while the first rings are larger in bulk, they may be less in ponderable mass than the secondary ones, by reason of the fact that they have been formed by the nebula's zones of least density, and at an epoch when all the parts were still very near their minimum of density. It seems logical, then, that the secondary rings will furnish stars of the greatest mass (Jupiter).

We now come to the conversion of the ring into a sphere.

We may readily ascribe the reason of the breakage of the rings to their want of homogeneousness, the source of which we have already explained.

Say we have a ring (Figs. 11 and 13) whose mean circle, *b* (Fig. 10), has a certain velocity. This ring will continue to concentrate itself upon the circle, since it is in a state of equilibrium with respect to the rest of the nebula. There remain, as transforming forces, the attractive action upon each other of the same parts of the ring, since the attractive action of one point, with respect to that of another one diametrically opposite, is imperceptible, seeing the enormous distance that separates them. It is not the same with the parts which are approximate, and which act upon each other throughout the entire circumference of the ring. The latter, then, would be indefinitely preserved were it homogeneous, since these actions would balance each other at every spot.

But, having admitted (Figs. 11 and 13) that a portion, *A*, of the ring (Fig. 11) is denser than another portion, *B*, a greater concentration will occur at *A* than at *B*, and, like a drop of oil that spreads out in a circle, the mass will tend likewise to flow before the ring. It will go along the latter, become rarefied at *B* and accumulate at *A*, and the ring will soon take on the form of a crescent, and afterward become concentrated at one spot,

where it will form a small nebula, in every respect like the mother nebula, while at the same time preserving its rotary velocity around the latter.

Let us now see what the direction of such a rotation will be.

In passing from B toward A, and that, too, during the general rotation, the various particles acquire accelerated velocities, which on the side C are additives of the velocity, V, of rotation, and on the side D are reductives of the same. There will form, then, two tails, one of which—that on the side C—will increase its cen-

Figure 11.

trifugal force, and the other—that on the side D—will decrease it. One of these tails will be within the mean circle, and the other extend to it, and for these reasons the little nebula will be found in the condition shown in Fig. 3.

When these tails have become disengaged, they will tend to communicate their live power to the mass, one of them contrary to the other, that is to say, to bring about a rotary motion in a direct sense. But, if it happens (Fig. 11) that the linear velocity is greater

Figure 12.

near the internal edge of the ring than at the outer, the effect will be to produce a retrograde motion, while, if the contrary is the case, the motion will be direct. In the first case it will therefore depend upon the relative sizes of the masses, A, and of the tails, whether the motion will be retrograde or direct.

As in Neptune and Saturn the rings are very large, the fall of the tails upon the place of concentration has occurred without great deviation in the mean circle, the great radius of the latter, and the feebleness of the centrifugal and attractive forces of the mother nebula;

Figure 13.

and, moreover, as these rings are inside, it has been possible for a relatively large excess of internal velocity to exist over the external. Then the tails have been insufficient to prevent the retrograde motion resulting from the latter fact.

The contrary is the case with smaller rings (Fig. 14). Finally, we shall remark that an asymptotic law, decreasing on moving away from the center in the angular velocities of the different parts of the nebula, may give linear velocities that first increase up to a certain distance, and then decrease; in which case, all the rings

Figure 14.

that become detached beyond the place of maximum velocity will give stars that have a retrograde motion, and all others beyond will give stars that have a direct motion. Such factors, then, as mass, extent, bulk, and distribution of matter, play an important part, and the effects may be various. They are, so to speak, of chance origin, although governed afterward by fixed laws. It is due to chance that a hen has 5, 8, or 12 eggs

to sit upon, but, whenever the latter are hatched, fixed laws preside over the development of the chickens.

If the rings are very homogeneous, they will not break; but if some resistance reduces their rotary velocity, they will close up upon their center (Saturn).

It is obvious that, under the velocity of gyration, the nebula derived from a ring will flatten, and perform the evolutions already pointed out. It will detach other rings, which will form planets. These phenomena occur so much the more rapidly in proportion as the mass is smaller; consequently, the moon, although formed after the earth, may be older than the latter, Jupiter, detached before the earth, may be younger than she, and, finally, all the planets are older than the sun, which is nevertheless their father.

A ring having been detached, the rest of the nebula, by reason of the laws of inertia, may move its axis forward in space, and the same is the case with secondary nebulae, when they have given off the secondary rings. The result will be various obliquities in the planes of the rings and in those of the orbits, and also obliquities of the planets, which are themselves formed upon their own orbits.

Finally, every solar nebula may have been the transformation of a vast ring detached from a still larger nebula. Upon becoming a nebula, a broken ring increases the mass at the place of concentration. A slight modification takes place in the attraction, and hence an approach toward the primitive center until the increase in velocity resulting therefrom leads to a contrary excess, from whence oscillation. Admitting that the ring has first described a perfect circle, the star formed will, according to the laws of Kepler, follow an elliptical orbit.

Different places of concentration may exist upon the same ring, and, in this case, if two of such places are diametrically opposite, two secondary nebulae will follow the same orbit; but, however slight be the difference in velocities, these nebulae will certainly unite, and if the stars are then in process of formation, there will be a shock. Or, if the two masses get to a sufficient distance from each other, a two-star system will be constituted, one star gravitating around the other, unless they coalesce, as shown in Fig. 1.

The system of the nebulae, then, seems to satisfy all the combinations possible; and if the theories according to which the formation of the planets and their satellites has been deduced be true, we should find in these great phenomena, as we find in smaller ones, and as in the moral evolutions of peoples, some fundamental principles, which through the intervention of slight causes of attraction, a little disorder, and a few ferments of discord, lead to evolutions and transformations whose causes escape our observation, but which must co-operate, whatever they be, to one final end, to an unknown ideal.—*Chronique Industrielle*.

THUNDERSTORMS.

At a recent meeting of the Physical Society, Berlin, Prof. Bornstein communicated the results of his investigations into the thunderstorms of July, 1884. The days from July 13 to 17 were very prolific in thunderstorms, and respecting them the speaker had collected and elaborated observations from more than 200 stations in Germany. For 24 separate thunderstorms, drawings were made of the "isobronts," isobars, and isothermals, from which it appeared that a fall in the barometer always preceded the outbreak of the storm; that with the occurrence of the sinking of the barometer the atmospheric pressure rose very steeply and then relapsed gradually to its former level; and that the temperature, which was very high before the storm, declined rapidly with the outbreak of the storm. Local observations had formerly led to the same result. The "isobronts," or the lines uniting the places where the first peal of thunder was simultaneously heard, had in general a north-south direction. The "isobronts" made the passage from west to east with an average swiftness of from 38 to 39 kilometers an hour. The "isobronts" were attracted by the mountains, so that the part in whose west-east direction a mountain was situated approached it sooner, and, after the passage of the "isobronts," delayed there longer than did the remaining part. Rivers retarded the progress of thunderstorms, and small thunderstorms often terminated at large rivers without crossing them. This relation of thunderstorms to mountains and rivers might be explained on the assumption that the storms were caused by ascending air currents. When such an ascending air current approached a mountain, then the mountain hindered the horizontal air from flowing in at the anterior side of the ascending current. The air flowing in at the posterior side, on the other hand, thereby obtained the preponderance, and urged the phenomenon with all the greater force to the mountain. The reverse occurred after the thunderstorm had surmounted the mountain. The horizontal currents in front then obtained the preponderance, and delayed the progress of the storm. The influence of the rivers found its explanation in the fact that the air above the water was considerably cooler than the air above the land, whereby a descending air current was continuously maintained, operating in opposition to the ascending current of the thunderstorm, to the possible degree even of annulling it. The speaker had been able artificially to produce an imitation of all these processes by causing, in accordance with the directions of Dr. Vettin, visible currents to ascend in a glass box filled with tobacco smoke, by means of local depressions of temperature, by setting these currents in constant motion, and making them strike against obstructions (corresponding with the mountains), as also on descending currents, which were likewise artificially created. In the discussion which followed the above address, Dr. Vettin laid stress on the fact that precisely at the moment when the barometer mounted steeply from its lowest position the thunder followed the lightning most rapidly, and discussed how, in accordance with his conception of the nature of thunderstorms, by the curving round of the ascending air current, a whirling movement round a horizontal axis came into shape, whereby, as determined by its situation and its extent, were produced thunderstorms, sleet, and hail.

Prof. Von Helmholtz described the formation of a thunderstorm, observed by him in Rigi-Kaltbad. From a free point of prospect, allowing a survey of the plain as far as the Jura, he observed how the lower warm and moist layer of air was distinguished by a sharp horizontal boundary of somewhat long strips of

cloud from the upper dry and cooler air. The cloud masses resembling the stripe-shaped cirri diffused themselves and formed a coherent level boundary layer between the two air masses. He next noticed, at different spots, balls of cloud arise above the boundary layer, evidently as the effects of ascending air currents. The different cloud heaps then rose higher and grew into larger cloud masses, within which different electric sparks leaped from one spot to another. It was only subsequently that he saw the lightning fly downward to the earth. At last a heavy rain rendered the lower air mass, bounded by the horizontal cloud basis occupying a position nearly at a level with the height of the standpoint, which had hitherto been clear, opaque. The phenomenon had developed itself under weather in which the wind was at rest, and could be followed very precisely into its details.—*Nature*.

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