with the three lines in the middle band of the carbon spectrum.

This resolution into lines was seen by Professor Brackett, as well as by Mr. McNeill and myself, on June 29th; it was still evident on July 2d, but no longer on July 3d.

The coincidence with the middle band of the flame spectrum, has always appeared to be precise; but to obtain further evidence as to the exact position of the band a careful comparison was made on July 2 with the *b* lines of the magnesium spectrum, using the Grubb spectroscope with a dispersive power of *four* sixty-degree-dense flint prisms and a magnifying power of about 25. The slit was opened until the well defined upper edge of *b* just touched the lower edge of b_2. Then, the spark producing the magnesium spectrum being suppressed, the bright wire of the micrometer was set upon the lower edge of the comet band; finally, the spark being restored, the distance was measured from the edges of b_2. In this way twelve readings were obtained by Mr. McNeill and myself, all giving results ranging between 5160.0 and 5169.5, the mean being 5164.8 ± 0.7. I do not think the possible error can exceed 2 divisions, or three times the probable error. If so, the Comet spectrum cannot possibly be identified with the *second* Carbon spectrum, (the spark spectrum of a Geissler tube containing C O). Since the corresponding band of that spectrum has a wave-length of 5198.4. The wave-length of the band in the flame spectrum is 5165.3—both according to the figures of Dr. Marshall Watts, given in *Nature*, vol. 20, page 28.

As a further test, on July 3d, the suggestion of Dr Watts, made in the paper referred to, was followed out by confronting the comet-spectrum by means of an occulting bar, directly with Geissler tubes containing CO and CO_2, and with the Bunsen-burner flame. The bands on this night were more distinctly defined than on previous occasions, though the nucleus spectrum was less brilliant, and the result of the confrontal was very satisfactory and decisive. The upper and middle bands were found undoubtedly coincident, so far as the power used could show, with the flame spectrum, and *not* with the bands of the tube spectra. In the case of the lower band, the evidence was less conclusive, because the edge was ill defined and faint, making pointing difficult, and because bands of the flame and tube spectra are nearly coincident here. Still, even with this band, the evidence of about half a dozen pointings turned in the same direction.

On the whole, I consider it now absolutely certain, that the comet-spectrum is not the *second* spectrum of Carbon, whether it be the *first* or not. As to this latter point I do not feel quite sure, but the coincidences are certainly very remarkable and close, hough the peculiar appearance of the upper and lower bands when the comet was brightest requires explanation.

C. A. YOUNG.

PRINCETON, *July* 4, 1881

PRIMORDIAL COSMIC RINGS.

III.

BY EDGAR L. LARKIN.

The doctrine that a sphere of atoms, abandoned rings, or any other shaped masses can develop into planets is a physical error. It is impossible that the ball revolved. Face the south, hold the plane of the page of "SCIENCE" horizontally, call the paper the centre of the sphere, and it will be seen that to cause rotation force must be applied, if above the centre, from west to east; below, from east to west; to the right, from below, upward; and to the left, from above, downward. The gas was of excessive tenuity, and external force instead of causing rotary motion would displace the atoms in front of it. The mildest, or most violent force alike, would be unable to cause revolution in a globe of atoms of such extreme mobility. But there was no external force; energy is a property of matter, and the nearest matter was 20 trillions of miles away. If the sphere rotated the motion came from internal causes, none of which could have at that time existed. There were no vortices, currents, tides or whirlwinds in matter of such rarity; no force outside, and none within save the slowest possible radial descent. The sphere was at rest. No point in the experiment of M. Plateau had analogy to the generation of rings on the gaseous globe. He placed a globule of oil in a fluid having like specific gravity, passed a wire through it, and turned it as an axis until the sphere of oil partook of the rotation, flattened and detached a ring. The cosmical mass was of rare gas, and existed in a void, with no external power to turn it. If Plateau had suspended a ball of hydrogen in a vacuum, annihilated the attraction of the earth, and then made it revolve without applying force, the cases would be similar.

Neglecting the laws of Nature we will assume that the primitive sphere was in rotation. Admitting it, a demonstration will be made that if by unknown law it cast off a ring or any other form of mass, said portion could not have been abandoned anywhere in the vicinity of the orbit of Neptune.

First proposition:—If the sphere by rotary motion, or other mode of force cast off its equator, matter which condensing made Neptune, then that planet formed, and now moves on a line that coincided with the *Centre of Gravity* of the discarded mass, no matter what was its shape, size or density.

This statement we deem self-evident, incapable of argument, and an absolute truth.

Second proposition:—If the ring that contained the matter now existing in Neptune, was thrown off the equator of a sphere, a section of the ring perpendicular to its length would be either a circle, or a segment of a circle. That is, the ring would be either cylindrical, or flat inside and curved outside, the curvature being the arc of a great circle, a meridian bisecting the poles of the sphere. We can conceive of no form of mass capable of being detached from the circumference of a sphere. other than cylindric or segmental.

Third proposition:—If the Neptunian ring was not cast off when the mass was a sphere, it was abandoned after the ball had depressed at the poles, and elongated at the equator. And a perpendicular section of such detached protuberance would be some one of the Conic Sections.

Draw a chord of an arc from north to south any distance below the orbit of Neptune, so that it does not de-

scend farther than half way to Uranus, or 500,000,000 miles; then all the matter alluded to in this paper will be above the chord. So long as the mass remains spherical the chord will cut out a segment of a circle. Now let the cosmic sphere receive some unknown impulse that will accelerate its velocity of rotation, and the mass will change to a spheroidal form. The chord of the arc will shorten, matter at the equator will become elevated and sections of the protuberance will change curvature. Make both ends of the chord points of tangency, and produce tangents to the curve to infinite space. Then if rotation accelerates, the curve bounding the ascending equatorial protuberance must continually change form, and the tangents, direction; while sectional curves will pass all varieties of the hyperbola, parabola and ellipse. Thus let the mass become very oblate, pass a cutting plane down to the chord, and the curve cut out will be hyperbolic. Increase rotation; the equator will become higher, the chord shorter and the sections parabolic. Let the velocity be still accelerated, the equatorial matter will be lifted to greater altitudes, the chord will be shorter than ever, and the sections elliptical. To this reasoning the objection may be raised by some that no matter how flattened the mass might become, sections cut to the chord of the arc would in every case be elliptical. We do not insist that they would be hyperbolas or parabolas; but will prove if ellipses, that elliptical segments are more fatal to the theory of ring formation than are segments of any other form of curve. Two factors engaged in the evolution of cosmic rings—gravity and an opposing force generated by rotary motion. We attack the whole Nebular Hypothesis with the fact that if the revolving gaseous mass abandoned matter at present existing in Neptune, the planet is now in the position of the centre of gravity of the detached portion. This being true, Neptune never became a member of the solar family by displacement of its material from the original mass, because no mass could have been cast off whose centre of gravity coincided with the orbit of that world. Let us see if the Neptunian ring was abandoned when the cosmic mass was a sphere. If so, the ring was either cylindrical or a segment of a circle. But the centre of gravity of a section of a cylindric ring is in the centre of the section. Since Neptune now traverses a path once the centre of gravity of the ring, it follows that when detached the spere of gas was larger than a ball bounded by the Neptunian orbit, as there must have been as much matter above the centre of a section of the ring as below. The larger the sphere the slower the rotation, hence it did not rotate as rapidly as it would, had it been equal in size to a globe having the diameter of Neptune's track. But it had to revolve faster to detach a ring because Neptune now moves on an orbit with a velocity of 3.36 miles per second; yet displays no tendency to leave it on a tangent. And greater detaching force would have been required to cause a ring to leave the equator than would now be necessary to throw Neptune off its orbit, because the force had to overcome what little cohesion the dissociated atoms had. The sphere must have been far larger than the path of Neptune, because the ring, being abandoned at the equator, had to be hundreds of millions in thickness to secure gas enough to condense into the planet, and its rate of rotation proportionately less than its present velocity.

It is certain that the ring whence Neptune was formed was *not* cylindrical. The only other possible form of ring is segmental. The distance of centres of gravity of all circular segments from the centre of the circle can be calculated. The problem resolved itself into this:—given the distance of the centre of gravity of the segment of a circle from the centre, to find the dimensions of the segment, and radius of the circle. We know that Neptune is in the position of the centre of gravity of whatever shaped mass was detached. But it lies on the circumference of a circle whose radius is the distance to the sun. Therefore the circle must have been larger than its orbit to be able to afford a segment having sufficient size to have its centre of gravity coincide with the track of Neptune. In all these computations we take the distance of Neptune from the sun to be 2,780,000,000 miles.—Elements of 1850, Newcomb's Astronomy. The ring of whatever shape is supposed to be detached, severed, straightened, and cut into an infinite number of sections perpendicular to its length. In the case in question, sections are segments of a circle, and we are in search of the radius of the circle whence the segment was cut. We have found the length of the radius to be 3,000,000,000 miles, by means of the formula, $G = \frac{C^3}{12A}$, wherein

G=the distance of the centre of gravity of the segment from the centre of the circle.

C=the chord of the arc, or base of the segment.

A=the area of the segment.

That is—"Divide the cube of the chord of the segment by twelve times the area of the segment; the quotient will be the distance of the centre of gravity required from the centre of the circle."—Vogde's Mensuration p, 237. Making approximation with a circle whose radius was 2,900,000,000 miles, with chords at different distances within the Neptunian orbit, it was found in two trials that a circle of that radius was untenable. Using a circle having a radius of 3,000,000,000 miles, and chord descending 300,000,000 miles, it was soon found that the centre of gravity of that segment was in distance from the centre equal to the distance of Neptune from the sun. But the chord was 2,600,000,000 miles long! Does anybody believe that a break took place along a line of such length, and 300,000,000 miles below the equator of the sphere? Was detachment possible when the sphere rotated slower than the orbital velocity of Neptune now is, yet shows no signs of elevating to a tangent to its path, though moving with unimpeded force? The first world was not abandoned by the cosmical mass when a sphere.

Could it have been formed from the matter contained in the segment of any other curve known to geometers?

To find the centre of gravity of a parabolic area:—"The centre of gravity is on the axis, at a distance from the vertex equal to three-fifths the altitude of the segment." Peck's Calculus p. 175. Then Neptune, as it is the centre of gravity of the parabola must be two-fifths above the base or limiting plane of the curve, We have made calculation of the altitudes of several possible parabolas, by locating the base at different distances between the orbits of Uranus and Neptune. The following table shows the distances of the limiting planes below Neptune, the altitudes of the segments, above the base,—above Neptune,—and also gives the diameter of the mass on the hypothesis, that it could have been so elongated as to make it possible that parabolas could be cut out of the equator by perpendicular planes.

TABLE I. ALTITUDES OF PARABOLAS. DISTANCES IN MILES.

Distances of Base Below Neptune.	Altitudes Above Base.	Altitudes Above Neptune.	Diameters of Mass when so Expanded.
500,000,000	1,250,000,000	750,000,000	7,060,000,000
400,000,000	1,000,000,000	600,000,000	6,760,000,000
300,000,000	750,000,000	450,000,000	6,460,000,000
200,000,000	500,000,000	300,000,000	6,160,000,000
100,000,000	250,000,000	150,000,000	5,860 000,000
50,000,000	125,000,000	75,000,000	5,710,000,000
25,000,000	62,500,000	37,500,000	5,635,000,000

Should these figures be deemed unsatisfactory, because they relate to sections or surfaces, while actually considering a solid ring, a table of *paraboloids* is inserted. The ring was 17,467,000.000 miles long, cut it in an infinite number of parabolic sections; revolve each

about its axis considered motionless, and an infinite number of paraboloids will be generated, all interlacing throughout the length of the ring. The centre of gravity of a paraboloid is two-thirds the distance from the vertex to the limiting plane.

TABLE II. ALTITUDES OF PARABOLOIDS IN MILES.

Distances of Base Below Neptune.	Altitudes Above Base.	Altitudes Above Neptune.	Diameters of Mass when so Elongated.
500,000,000	1,500,000,000	1,000,000,000	7,560,000,000
400,000,000	1,200,000,000	800,000,000	7,160,000,000
300,000,000	900,000,000	600,000,000	6,760 000,000
200,000,000	600,000,000	400,000,000	6,360,000,000
100,000,000	300,000,000	200,000,000	5,900,000,000
50,000,000	150,000,000	100,000,000	5,760,000,000
25,000,000	75,000,000	50,000,000	5,660,000,000

No tables of altitudes of hyperbolas or hyperboloids have been inserted, as the distances of their gravitation centres differ so little from parabolic segments, that it was not thought best to fill up the columns of "SCIENCE" with useless figures. For those who think the ring could not have been left when sections were parabolic or hyperbolic, we give a table of altitudes of ellipsoids, that is when sections cut to the chord as before, were ellipses. "The centre of gravity of a semi-prolate spheroid of revolution is on its axis of revolution and at a distance from the centre equal to three-sixteenths the major axis of the generating ellipse."—Peck's Calculus, p. 175.

Therefore Neptune is 3-16 above the conjugate axis, and 13-16 below the vertex of the ancient semi-ellipsoid, all the worse for the theory of ring detachment. Consider the ring cut by perpendicular planes descending to the chord, into an infinite number of semi-ellipses. The chord becomes the conjugate; revolve each curve about its semi-transverse axis regarded as stationary, then the ring will be made up of an infinite number of semi-prolate spheroids of revolution, each so nearly coincident with the next as to have the surfaces fail to coincide only by infinitesimal space. The table is computed by calling the conjugate diameter, the chord of the arc, and the semi-axis major, the line reaching from its centre up to the equator, Neptune being in the centre of gravity of the solids of revolution.

TABLE III. ALTITUDES OF SEMI-PROLATE SPHEROIDS.

Distances of Conjugate Axes Below Neptune.	Altitudes Above Base.	Elevations Above Neptune.	Diameters of Cosmic Sphere When so Elongated.
500,000,000	2,667,000,000	2,167,000,000	9,894,000,000
400,000,000	2,134,000,000	1,734,000,000	9,028,000.000
300,000,000	1,600 000,000	1,300,000,000	8,160,000,000
200,000,000	1,066,000,000	866,000,000	7,292,000,000
100,000,000	533,000,000	433,000,000	6,426,000,000
50,000,000	266,000,000	216,500,000	5,592,000,000
25,000,000	133,000,000	108,250,000	5,778,000,000

These tables of absurd figures are inserted to show the hypothesis irrational. No such extension of the mass was possible, and no protuberance could have arisen above the equator able to afford perpendicular sections, hyperbolic, parabolic or elliptic. Nor could the chord become the limiting plane of any parabola, hyperbola or conjugate axis of any ellipse. Yet, the tables are logical deductions from the doctrine of ring detachment, for if the mass depressed at the poles, and elongated at the equator, curvature of radial sections must have assumed all varieties of conics. Since the centres of gravity of all these curves, and solids generated by their revolution are known, the figures are correct if the theory is true. It will be shown in a paper on mass, volume and density, that most of these equatorial elevations could not have contained matter enough to form Neptune.

Is it credible that the primeval mass ever detached rings or any other shaped portions? From the altitudes of these conoids it is seen that to cast off the Neptunian material the rupture in every case took place at depths of hundreds of millions of miles, where cohesion was greatest and rotary velocity least! In all these computations the abandoned masses were considered as homogeneous, as difference in density in a gas of such excessive rarity cannot enter as a factor at depths of a few hundred million miles. It may be said that cohesion in a gas so rare, was not a factor. Granted, then *rotation* was not, since a ball of gas of such tenuity as to have no cohesion, could not possibly be set in revolution. The equatorial edge of the mass could not have become angular, for sections cut to the base would be triangles, whose centres of gravity are two-thirds the distance from the angle to the base, and nowhere near where Neptune exists. Neither could sections have been cissoidal, conchoidal, cycloidal or sectoral, nor of any other similar curvature known to geometry. The surface was not irregular; loose masses did not float above the periphery; the matter was all of the same specific gravity, hence *buoyancy* did not obtain on a mass of dissociated atoms. The mass existed in a void, else external matter by friction would have induced currents from east to west. No modes of energy save rotary force, existed to detach a ring, no internal repulsion, as that had vanished in dissociation. The dogma is beset on all sides with difficulties. When the mass was spherical, matter enough to form Neptune was unable to leave the equator; when elongated, segments of enormous depth had to be left by the shrinking mass, to afford material sufficient to condense into the oldest planet; and the break occurred where it was most difficult to be made, and where the power necessary to make it was the least.

Not only the most complex, but the simplest laws of nature dispute the Nebular Hypothesis. Even primary schools have text books wherein laws are laid down that subvert it! Primers of natural philosophy teach that if a revolving sphere diminishes in diameter, its velocity of rotation becomes accelerated, and the same primers teach that if the diameter increases the velocity diminishes. Therefore, if the primeval gaseous sphere ever revolved, said rotation caused the equatorial diameter to increase in length; but as soon as lengthened the velocity of rotation diminished and the mass again became a sphere, the oscillation always remaining within small limits. The diameter of the mass when spherical was 5,560,000,000 miles; can it be believed that rotation so far gained mastery over retardation as to allow the mass to attain diameters ranging between 6,000,000,000 and 7,000,000,000 miles to detach parabolic segments; and between 6,000,000,000 and 9,000,000,000 miles to abandon semi-prolate spheroidal sections to make up a ring? We are unable to conceive that valid argument can be made in favor of the detachment of matter in any form or volume from the mass. This theory, opposed by every known law of nature has actually been entertained by eminent physicists, geometers and astronomers, fully conversant with these same laws that destroy the doctrine; a thing long noted by psychologists, wherein delusions hold sway over fine minds with greater tenacity than ideas known to be true.

SEISMOLOGY IN JAPAN.—The labors of the Seismological Society of Japan have established the fact that there is a chronic center of disturbance within a radius of a few miles from Yokohama. We are glad we do not reside in the said Yokohama; at the same time, we congratulate the society on the success attending its researches.