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Astronomy.

LECTURE I.—BY J. P. NICHOL, L.L.D.

Reported for the Tribune by O. Dyer, the Phonographer.

Means of penetrating into space, and examining remote objects.—Estimate of the powers of the telescope.—General aspect of the starry heavens.—Questions as to the significance and extent of our vast firmament.—The milky way.—Limits of our great system.—Discovery of external clusters or masses of stars, each of which is to the individuals composing it, their own peculiar heavens.—Extent and magnificence of the material creation.—Its infinite variety.—Concluding reflections.

This distinguished astronomer was greeted on the evening of January 25 by a large and highly intelligent audience, who manifested the deepest interest throughout his lecture. He spoke as follows:—

Ladies and Gentlemen—Already I have learned enough of America to know how needless it is, that a visitor from Great Britain should begin an intercourse such as I propose to establish here with anything merely apologetic, for I believe that, these two nations resting on the opposite sides of the Atlantic, in whatever discussion of minor interests we may be severed, we are still neither of us inclined to forego the privilege derived from our common language, and also a common, and surely I may say an illustrious ancestry, of union in the grand task of exploring through the mazes of creation the mighty ordinances of God, and of contemplating together, for a moment, the deeds of those who have striven to unfold them. Confident, then, of an entirely kind reception—confident that I may almost drop the name of a stranger, I would now venture to bring before you some of those contemplations which greet us by a consideration of the laws which govern the great universe in which we are. I would venture that we cast our eyes for a while upward from the earth, toward the dazzling array of stars which, bursting forth as the luminary of day declines, summon us to the contemplation of those vast infinitudes in which they are.

It is my wish, during the present lecture, to pass with you upward from these confines of our solar system, toward that grand congeries of orbs of which our sun is the centre, and to trace among these, if we can, marks of that order and system which indicates to us, as do all the phenomena around us, that we are here amid an intelligence which preserves them even as first created. It is not certainly unnatural when one considers the depths at which these stars lie, the impassable character of the gulfs which separate them from the earth, that even at the threshold of the inquiry, we should be met by an unbelief in many respects, whether or not we can reach them, or, at all events, be able to carry there a precision of view, without which no permanence of understanding regarding their arrangements can well be discerned. On which account permit me, in the first place, briefly to place before you the principle on which these great instruments have obtained the power to which we owe our knowledge of these remote realms of space. I would for one moment, ladies and gentlemen, previous to entering upon the subject, request your attention to the character of that great telescopic power which has enabled us to pierce beyond the confines of our own system, and examine those mighty orbs which fill the boundless realms of space beyond it. The telescope is not a simple instrument; but when we look at it with regard to its more simple elements we see at once, and clearly, how it enables us to go into these great profundities. We find that when one views with the naked eye a distant object, the power of vision is dependent upon one plain and very distinct circumstance. It is this. We find that the power of vision cannot be made sensible, unless the light that comes to the eye from the object viewed is of a certain distinct quantity or density. There can be little doubt that, however far away the brilliant object is, if it is sending forth light through all space, that light must reach every nerve that is capable of receiving it; but still, unless it reaches the human eye with a sufficient power, density, or intensity, it will not enable that eye to have the sensation of sight or vision.

Suppose, for instance, we have a brilliant point A, as thus—

A B C

sending out light through all space; wherever an eye is placed capable of receiving light from that brilliant point, it must inevitably receive rays from that point; in other words, it must be acted upon by that point so as to receive the sensation of vision. It is so with regard to the human eye. Unless a certain density of light enters it, the sensation of vision will not be preserved. Notwithstanding what the distance of the object may be, light must enter into the eye from that object. Suppose, for instance, the eye is placed at C; the light coming from the object A, being dispersed through space, will necessarily be less than the light at B, and, while the light at B is a definite, distinct quantity, the light received by an eye at C may not be at all sufficient to operate upon the nerve, so as to cause the perception of vision. Now then, supposing that when the eye at C is presented to the brilliant point A, that that point is merely sending forth a quantity of light sufficient to cause the sensation of light and nothing more, what would be required to do in order to make this point or star brighter than it naturally is? It seems to me we would require to make the light coming from this star more dense than it appears to be when in its natural state. Now, the point is, how can this be done? How can we, by means of any art or science, place the eye in such a relation to the star, that it shall view a greater quantity of light than it naturally does? There is a principle in optics which comes to our aid, of a very plain and distinct kind, and which I think the audience will at once understand. Suppose that we place at B a lens, a piece of glass so shaped that when the rays of light pass from the star or the brilliant object A, through it, they shall no longer preserve their rectilinear course, but shall be caused by the lens to converge and fall upon the eye at C. The audience will at once perceive that the eye at C is altogether in a new position. Instead of receiving merely a faint, dim ray of light, it is now receiving a great, clear and strong ray of light, formed by the concentration by the lens of the numerous rays of light which previously were diffused over a large surface. This is the principle upon which the telescope acts. It collects the scattered rays of light, and causes them to fall upon the eye in the manner of the lens, just described. Let us see, then, what must be the power of the telescope, as compared with that of the eye. It is simply this:—If we have placed between the eye and an external object, any great lens, we will see that object with an amount of light, just as much greater as the lens through which we are viewing it is greater than the pupil of the eye. Now, it seems to me that, if we understand this very simple principle, the great power of the telescope can be easily and at once ascertained. Suppose then, we refer back to the telescope of Galileo—that little, simple telescope with which he first attempted to make his way in the heavens. We find that it is but a little more than an inch in diameter. Yet still, when we compare the surface of light which that inch necessarily met, with the quantity of light falling from any object upon the pupil of our eye, one cannot at all marvel that we should be able to see through comparatively small glasses, objects situated at great distances with very remarkable distinctness.

Until comparatively recently, the telescope had not at all reached the great power which it now possesses. The instrument recently used by us, was perhaps one whose object glass, or mirror, was not larger than eighteen inches in diameter. This was the one by which Sir William Herschel was enabled to make his grand discoveries. Recently, however, we have constructed instruments of much greater power. The vast telescopes of Lord Rosse have reached the diameter of four and even six feet. Now, if the audience will for a moment consider the immense surface of a mirror of six feet in diameter, compared with the surface of the pupil of the eye, I think that it will not be at all marvellous to them that the power of these telescopes should be so enormous as has been reported. The telescopes of Herschel, which were about eighteen inches in diameter, possessed ninety-five times greater power of penetrating into space than the naked eye; but the power of the telescope of Lord Rosse—the greatest one that has recently been introduced—seems to be something less than five hundred times that of the naked eye. Now, this immense space-penetrating power may be approximately realized, by referring for a moment to the great velocity with which light passes through space, which is about 200,000 miles per second. Now, it seems that Lord Rosse's telescope has the power of penetrating through space so far that the most distant star which it can reach is at such a vast distance from us, that its light, moving with this almost inconceivable velocity, cannot reach us in less than 60,000 years.

It is not, however, merely in regard to their powers as light-graspers, that the efficacy of these telescopes mainly depend. Let this power be ever so great, little advantage is gained unless there be perfect accuracy of image The great advantage of Lord Rosse's telescope depends not solely upon its power of penetrating into space, but also upon the accuracy with which it gives us the image of the object viewed through it. It is in these respects that that mighty instrument has achieved its greatest exploits. When the greatest magnifying power is applied, it shows not the slightest amount of distortion in the object. It is not possible to render the astonishing accuracy of Lord Rosse's telescope fully palpable. There is a minute point near Polinarius, so minute that it requires a good telescope at all to discern it. Now, with the very high magnifying power of Lord Rosse's telescope, I have seen that point, as clear, as distinct as a star of the first magnitude. With such powers in our possession, then, let us proceed reverentially, but still without dread, to scan those truths to which they have enabled us to ascend. When regarding the constitution of the Stellar Heavens, it is not unlikely that again we may be stopped by incredulity. According to our usual ideas, these starry heavens seem infinite. They appear as if they occupy all space, filling with crowds of constellations wherever the human mind can fancy that space is open to receive them; and, therefore, it would seem that although our augmenting telescopic power might bring us augmented knowledge, we are contending with what is hopeless. Now, as the removal of this popular fallacy lies at the root of all our modern views of the structure of the heavens, I must solicit for it your attention.

Even after we have ascertained how far the telescope is able to pierce, it may yet come back to us as a cause of doubtfulness, whether we can get a rational conception how the Stellar heavens are constituted. Is it not likely that these heavens which we see around us and over us, penetrating infinitely into space, present to the eye nothing different from what we see here? Suppose this question occurs to us, shall we be able to ascertain aught concerning the structure of these great heavens? Now it seems to us at first, perhaps, that this is a perfectly legitimate objection to our moving farther without inquiry. It may be said, that when we observe the skies on a clear night, we have before us all that can be seen. Now this grand conception, namely, that if we were passing through space we should simply meet nothing else than what we see around us—just constellation after constellation as we went onward through these depths of infinitude—I say that this conception is so very natural that it is difficult for us to conceive that it is not true. However, on a slight consideration I think we will be able to see that this is not what our heavens really indicate to us. If what I said were true—if the stars extend on through our skies towards infinitude, if as we went along—supposing we had it in our power—throughout these clusters we should see nothing but constellations after constellations, I think that our heavens would not appear to us as they do now. Suppose for instance we had reached far away beyond these constellations what would we see behind us? We would see the great, brilliant stars of the first magnitude, then we would see behind these, those of the second magnitude, behind these again those of the third magnitude and so on; but we would find always in every part of our sky when we reached that position where we could see no more stars, a sort of background—a dim diffused light called nebulous light. If that were the constitution of our skies this would be their appearance. You will find lying backward through the whole path of the sky this dim milky light. On the contrary, we see it only on one side of the heavens in that great range called the Milky Way. Now the question is, what is the cause of this? Why do we find this great milky belt, so to speak, passing over our sky in one direction and not in another? It seems to me that if we look at this question calmly this conclusion must necessarily occur to us, namely—that in that part of the sky alone, where we see the Milky Way is there a bed of stars diffused throughout the unfathomable depths of space. If it were otherwise, if this bed of stars was found to be diffused throughout all regions of the heavens, then, certainly, that peculiar appearance that strikes us as we look at the Milky Way would be found as the background of all the heavens. In every range we would see the stars of the first, second, third and fourth magnitudes; then, when we arrived at that part of the heavens where we could not distinctly trace the individual stars, we would find a background filled with this dim, milky light.

It seems then that our first notion, namely, that these stars stretch away throughout space is not a true one—that this Milky Way manifests to us a peculiar structure. Now the question is, what is that structure is? Belonging to the great bed of stars in the midst of which we are, we find, on looking at the heavens, that stars of the first, second and third magnitude are tolerably equally scattered throughout all space. It is only when we come to stars of the very smallest magnitude that we find a derangement of this distribution. What does this indicate to us? It seems to indicate the following, namely—that as far as the naked eye can reach, these stars, on to the very smallest magnitude, are pretty equally scattered throughout our skies; but that if we get beyond their region, peculiarities of constitution come into view, and we begin distinctly to see that we do not belong to a universal, but to a certain, definite and distinct class or mass of orbs with which we are connected—a mass of orbs with boundaries almost inconceivable, but still a definite and distinct mass.

The idea that I have thrown out may yet be pushed a little farther. It may be shown that if these stars were diffused through all space, our heavens would on every side blaze with a splendor so bright that the sun would not be visible to us at noonday. It is clear, then, that such cannot be the characteristic of our skies. It cannot be that these orbs we are discerning are spread infinitely throughout space, but, on the contrary, in all likelihood they are forming a great cluster or bed of stars of a peculiar and distinct shape. Those thoughts which I have just laid before you were first raised by the illustrious Sir W. Herschel, and although his conclusions cannot be placed before you as infallible, yet his first ideas lead us in our first progress toward a view of the heavens. Herschel's first conception with reference to the nature of the heavens was the following. He said, "It is clear that this great multitude of fixed stars is not what it was formerly supposed—the *infinite* heavens.—This great mass of stars is simply a vast cluster or congeries, and nothing more." When this great idea had dawned upon him, he asked, "Is it possible to ascertain what is the description, the general character of that vast body of stars in the midst of which we are?" The notion was certainly a very great and marvellous one, but still he was enabled to come to a conclusion not very far, I believe, from what we now think to be the true one. The idea upon which he worked was the following:—He said, "Suppose that this room is filled with persons, and that they are pretty equally dispersed over it. Now suppose that I turn my eyes in a certain direction and count the number of persons that I see before me, and then direct my eyes to another part of the room and again count the number of individuals that meet my gaze; then, being certain that these persons were pretty equally scattered throughout the room, I would be enabled to infer from the number of persons located in the sections of the room to which I had directed my investigations, how far I must be from the edge of the room in this or that direction." This was Herschel's idea, and he turned his great telescope in every direction round the heavens, judging how many stars he saw in every place, and he found in this manner how far he supposed he was from every portion of the edge of the cluster. The mode in which he attempted to make out a scheme of the character of the heavens was this.

[The lecturer here drew a diagram upon the black-board resembling a luminous body, from which rays of light emanated in every direction—the rays varying in extent in such a manner as to form a sort of elongated spheroid indented at the edges.]

Suppose this (pointing to the luminous body,) is the sun, and these lines (pointing to the rays,) indicate the directions in which his telescope was turned, and their lengths measure the number of stars he observed. Well, he turned his telescope all round through our heavens and drawing a sketch of this kind, he then joined the edges of these different lines, making a figure like this. And he said "this, in all likelihood, is something of the shape of the great cluster of stars in which we are."—His idea, perhaps, is better represented thus. Let the audience in imagination follow me. Suppose we had it in our power to move up through the Milky Way, and pass along that congeries of stars till we lose connection with the Sidereal system. The following phenomena would be observed:—We should pass from our present congeries, still moving, as it were, amid an infinite number of orbs, till, by and by, we should have no stars in advance of us and only the systems would be behind us. Suppose we should go still farther out amid these awful recesses till this vast scheme of ours would take on gradually and gradually the shape of a mere speck lying against the dim of the far heavens. Such would be the general aspect of that mass of stars with which we are in immediate connection. [Applause.]

The investigation which led Herschel to the conception that this was the scheme of our heavens, was the following—and you will perceive at once that it was subject to two great errors:—On trying to find out a view of the skies, he had the conception constantly in his mind, that the stars were pretty equally scattered through all space. Now, to return to my illustration: suppose that I were to count the persons in different directions around the room, and inferring from that how far I was from all sides of the room, I would necessarily rest upon the conviction that the people were equally scattered throughout the room. So Herschel said that the great mass of stars throughout the heavens were pretty equally distributed. Now, since his time it has been ascertained that this is not true. It has been found that all around us, so far from the stars being pretty equally scattered, they are, quite on the contrary, thin, as if in a desert. There was another thing in which he was erroneous. You will observe that when he looked all around in the sky, he could never have supposed that he was entitled to draw the conclusion with respect to the depths of the orbs in any direction, unless he knew, or had reason to believe, that his telescope enabled him to go to the end, or at least nearly to the end, of our system in that direction. Suppose, again, that I was here counting the number of persons that I see in any direction—unless I was sure that I had arrived at the end of the room, it is plain that my counting would be of no value as far as certainty is concerned. This was also another of Herschel's views, the inaccuracy of which has been fully proved. He found, and we find now, that not the largest telescope has ever been able to pierce to the extremity of our system. Perhaps the best inference we can draw is the following:—We are not speaking of the Solar System, but of that vast system of orbs that you see as a clear night beaming across the heavens. Well then, the question as to what our system is, is probably better explained by our looking at external objects than it can be by our viewing the aspect of what lies quite within it. For instance, this is one immense cluster lying perfectly apart from our system.

[The lecturer here pointed to a chart, on which was represented a brilliant cluster of stars, composed of three rings, one within another, the most brilliant being in the centre.

"The first idea when the power of the telescope was applied, to present an appearance like that in the chart. Now for this cluster is removed from us, it is utterly impossible to tell. Its appearance, however, is not very unlike what that of our system might be, if it were viewed from this distance. If we consider for a moment this statement, it will not appear improbable. The milky way is a great ring extending in two ranges through our heavens, so that it may be that our system is an immense ring similar to this cluster. If this idea is realized, another immediately suggests itself, and which Herschel early recognized. Vast as our firmament may be, has it boundaries or does it stretch away into infinitude? Are those awful spaces that surround it on every side void, empty, or are they tenanted by worlds and systems similar to our own? No wonder that a mind like Herschel's should have rushed to the conclusion that the space around our system was a vault in in whose capacious bosom myriads of mighty clusters like our own universe are placed. If it be true that this great scheme of ours is simply what Herschel first supposed it, but still a great, separate, *distinct* scheme, whose nature is, perhaps, more than anything else, represented by these singular nebulæ, what must we think with regard to it? Surely it is that, notwithstanding its immense diffusion, its vast confines, the great space through which its different portions range, there must lie around it on every side, vast unpeopled spaces, and if this be so may it not be that amid all that space also, there are floating great schemes of being like ours, schemes I say of different shape, of different character, but lying in those vast regions of space like ours, schemes quite as magnificent as that vast system to which we ourselves belong. If this is so, what a conception in regard to the material universe, must press itself upon our notice.

It seems to me that the conception must be just like that which a dweller upon an island in the great Southern Ocean, who had never passed beyond the limits of the little world in which he lived would experience, if to him were brought information that what he considered his world was but a diminutive island, and that around him in this ocean lay scattered large groups of islands and vast continents. Such is the information with respect to the Stellar Universe that has been conveyed to us by the powers of our great telescopes. [Applause.]

The great inquiry is this:—What is the character of these immense groups; what their form? what the nature of the shapes in which we find them collected; and what the density through which they are doomed to pass? Now, in the first place we find that these groups are for the most part approaching to circular—I should hardly use the word circular, but spherical. Now that this is not altogether true, that we do not find them altogether spherical may possibly be represented to you by merely looking at one mass of these elements. [The lecturer here exhibited another diagram, representing a nebulous group, of a nearly circular form.] This mass is something like what by far the greatest number of these different groups are; but when our greatest telescopes are brought to bear upon them, we find those which were thought to be spherical are not so; they approach nearer to a globe. Here is one which looked oval, but Lord Rosse's telescope brought it into a circle. Lord Rosse called it the crab nebula, because it resembles a crab.

Now, there occurs a very remarkable circumstance in reference to these comparatively sweeping circular masses of nebulæ. We find that they are not entirely circular, but the reverse, and that all around them, on every side, there are volumes of stars stretching out apparently as if they were rushing toward a central mass in consequence of the action of some great power—the power of gravitation. We find them approaching to spheres, and around their spheres we find these volumes apparently tending toward a centre, which ultimately may become the great central region.

If this is true—if the idea is correct that great masses such as this, for instance, are in the mean time merely in a condition of change—that all these orbs are now forming their volumes with a view to become ultimately incorporated with it—how stupendous the idea! It takes our thoughts from the more transitories of earth, and places them on the august things of eternity—it realizes, as closely as the material universe can do to man, the awful unchangeableness of that being who has created these things, whose steps fill eternity.—Coming from these remarkable spherical masses, on toward the irregular ones, we find that, although

we cannot at all [illegible] one, yet there are [illegible] of great, that we can [illegible] these clusters [illegible] upon the [illegible] diagram] as [illegible] to my figure. [illegible] years. If we look [illegible] that it is [illegible] curious that [illegible] when we look [illegible] ultimately have [illegible] of singular cases of [illegible] different positions from [illegible] plan. There is [illegible] in the forms of [illegible] once may have [illegible] to the Milky Way. [illegible] mean that it is not at all [illegible] distinct belt of brilliancy, [illegible] could infer that there is a [illegible] sion of great orbs stretching [illegible] instead of being a [illegible] like a succession of [illegible] cases, precisely like what [illegible] seated in the diagram. [illegible] so very remarkable that [illegible] said when he first saw it, [illegible] breaking up, and that [illegible] space lying between the [illegible] like the twinklings of eyes." [illegible] "after the lapse of ages [illegible] would disappear—that [illegible] separate distinct [illegible] succession of [illegible] clusters stretching [illegible] heavens, but [illegible] rate." He even [illegible] one of his great [illegible] breaking up of [illegible] him like the [illegible] manner of the [illegible] passing through [illegible] the mighty hand [illegible] plan of the material [illegible] ultimate like these [illegible] quote illustration. [illegible] yond any sphere to which [illegible] chinery can suspend.

The process of change [illegible] being probably beyond the [illegible] the [illegible] man rises, the [illegible] can never be evolved [illegible] comparison of all the [illegible] selves, which will [illegible] all the observations [illegible] comparison must [illegible] for the gratification [illegible] riosity, but for the [illegible] one of the greatest [illegible] cupied the attention of [illegible] vestigation your own great [illegible] Cambridge, at Cincinnati, [illegible] ces must assist, not, as I [illegible] the gratification of [illegible] view of having suggested [illegible] nebulous changes, that we may [illegible] law which governs the [illegible] wondrous bodies.

Ladies and gentlemen—I have [illegible] vored to give you some idea of [illegible] of the gorgeous universe [illegible] try movement of our [illegible] How strange that this universe [illegible] comprehensible by us human [illegible] veil of the sun's light entirely [illegible] wonders from our view—that [illegible] of the sun not been veiled by [illegible] of night we had lived amid it and [illegible] have known of the existence of [illegible] Universe. May it not be true that [illegible] during midnight, when these [illegible] appear to us from their [illegible] depths—may it not be true that [illegible] veils as this we are [illegible] consciousness of other universes [illegible] as the world of stars! But [illegible] to an idea so lofty, let me use the [illegible] of a great mind:—

Mysterious night! when our first parent knew
Thee by report divine, and heard thy name,
Did he not tremble for this lovely frame,
This glorious canopy of light and blue?
Yet 'neath a curtain of translucent dew
Bathed in the rays of the great setting flame,
Hesperus and the host of heaven came,
And lo! creation widened in man's view.
Who could have thought such darkness lay concealed
Amid thy rays, O sun! or who could find
What fly and leaf and insect hid conceited,
That to such countless orbs thou mad'st us blind!
Why do we then shun death with anxious strife?
If Light can thus deceive, why may not Life?

The lecturer resumed his seat [illegible] general applause of the [illegible]

A poor fellow, in his [illegible] other day, was asked if he [illegible] that court before, and for [illegible] been up for hooky stealing [illegible] thing at all," said the [illegible] recording a false-arrest [illegible]

Benjamin Brandreth.—A [illegible] about to remove his [illegible] quired the reason; [illegible] time that it was [illegible] stand for the business. [illegible] replied, with a [illegible] you, he's very [illegible] by gar, we stand all day, [illegible] to make me move!"