simply this. Suppose I light a match, the smaller the match the sooner will it go out, and similarly the larger a fire the longer will it last. So if you are dealing in space with those illuminations which disappear in hours, days, or weeks, you cannot be dealing with any large mass; therefore the collisions in question cannot be between large masses of matter, but it must be a question of collisions amongst the smallest particles of matter we can conceive.

It is interesting to consider one of the possibilities which may explain why small nebulæ may be overlooked in telescopic observations. In the so-called achromatic telescope, all the rays of light are not brought to quite the same focus, so that when ordinary stellar observations are being made, the focus is adjusted for yellow rays which are most luminous to the eye. Now the greater part of the visual light of a planetary nebula is confined to a single line of the spectrum in the green, so that the focus which is best adapted for observations of stars is not suitable for the observation of a small nebula, the nebula being out of focus, and its feeble light thus reduced by the diffusion of the image. This difference is much more marked in large than small telescopes, and Prof. Campbell has pointed out that a small nebula like Nova Aurigæ will in general appear relatively brighter in a small telescope than a large one.

I will next go into some details touching the phenomena of the Novæ in relation to the hypothesis.

First let us see the crucial phenomena we have to explain. We have (1) the sudden bursting out of light and accompanying spectra; (2) the indication of the existence of two bodies revealed by the spectra; (3) the variations and dimming of the light and accompanying spectral changes; and (4) the final stage giving us the spectrum of a nebula.

Since the new era of spectroscopic work has begun, Nova Aurigæ and Nova Normæ have proved to us that the sudden illumination was, to say the least, associated with two bodies, and that these were in different stages of condensation. On the meteoritic hypothesis it was shown that the main differences between bodies giving bright and dark line spectra is one of condensation only: a sparse swarm gives us bright lines because the number of meteorites in unit volume is small and the interspaces are great; a more condensed swarm gives us dark lines because the number of meteorites in unit volume is greater, and the atmospheres of cooler vapour round each meteorite in collision begins to tell because the interspaces are reduced. I am the more justified in insisting upon the importance of this view that two bodies in different stages of condensation are involved, because years after it was formulated Dr. Huggins apparently arrived at it independently—at all events he makes no reference to my prior announcements when he brings it forward as an explanation of the phenomena.

The following quotations will show how this matter stands:—

"If we assume a brightening of the meteor-swarm due to collisions as the cause of the so-called new stars, we have good grounds for supposing that in these bodies the phenomena should be mixed, for the reason that we should have in one part of the swarm a number of collisions probably of close meteorites, while among the outliers the collisions would be few. We shall, in fact, have in one part the conditions represented in Class III*a*, and in the other such a condition as we get in γ Cassiopeiæ."[1]

"The discussion of the observations which have been made of the changes that take place in the spectra of new stars, has already shown that the sequence of phenomena is strikingly similar to that which occurs in cometary spectra after perihelion passage. In general, however, there will be a difference: namely, that in comets there is usually only one swarm to be considered, whereas in new stars, there are two, which may or may not be equally dense. In new stars, we have accordingly the ntegration of two spectra, and the spectrum we see will depend upon the densities and relative velocities of the two swarms."[2]

"The spectrum of Nova Aurigæ would suggest that a dense swarm is moving towards the earth with a great velocity, and passing through a sparser swarm, which is receding."[3]

"The circumstance that the receding body emitted bright lines, while the one approaching us gave a continuous spectrum with broad absorption lines similar to a white star, may, perhaps, be accounted for by the two bodies being in different evolutionary stages, and consequently differing in diffuseness and temperature."[4]

1 November, 1887. Lockyer. *Proc.* R.S., vol. xliii. p. 147.
2 November, 1890. Lockyer. *Phil. Trans.*, 182 A, p. 407.
3 February 11, 1892. Lockyer. *Proc.* R.S., vol. l. p. 435.
4 May 16, 1892. Dr. Huggins. *Proc.* R.S., vol. li. p. 494.

Now two sheets or streams of meteorites interpenetrating and thus causing collisions will produce luminosities which will indicate the condensation of each, and the spectra of the two Novæ we are considering thus indicate that the colliding swarms were of different degrees of condensation, and the variations of light observed indicate several such encounters between less dense swarms after the most dense one had somewhat cooled down. The final stage was arrived at and the pure nebula spectrum produced when the most condensed swarm had ceased to indicate any disturbance, after all the others had returned to their pristine quiet and invisibility.

It is important to insist upon the fact that the nebulæ are now almost generally conceded to represent "early evolutionary forms." We have then from the first appearance of a Nova to the last a "backwardation" in the phenomena ending in an "early evolutionary form." Increase of temperature is accompanied by spectral changes in a certain order; if the temperature is reduced the changes occur in reverse order, until finally we reach the "early evolutionary form," which cannot be a mass of gas because its temperature is lower than that of the sun, which it is potentially, and it must contain all the substances eventually to appear in the atmosphere of the sun.

On the hypothesis, then, we imagine a nebula in the position occupied by Nova Aurigæ not chronicled for the reason stated. This nebula is approaching us. It was disturbed by a much sparser stream leaving us, the relative velocity being over 500 miles a second. During the time of impact, the disturbances produced in the two swarms gave rise to bright-line spectra in the sparse swarm, and to dark-line spectra in the more condensed one. The spectrum of the sparse swarm disappears, the spectrum of the dense swarm changes gradually from dark to bright lines, and ultimately it puts on the original nebula spectrum. It is still there, and still approaching us.

We have next to consider the objections which have been urged against this hypothesis. They are of a most trivial nature. An objection made by Vogel is that it is improbable that the velocities could have been so great after collisions. The reply is easy. The light was produced by the disturbed members of the two swarms which escaped end-on collision. On the meteoritic hypothesis we can escape from the difficulties produced by the old idea of collisions *en bloc*. Such objectors would urge that the velocity of a comet as a whole would be retarded by passing through the sun's corona, but we have instances to the contrary.

Another objection has been raised by Dr. Vogel because in relation to the Nova I did not restate all I had previously written concerning the origin of the cause of bright and dark line spectra in stars. It has been difficult for him to understand how one (temporary) star should have bright lines in its spectrum, and another (temporary) star should have dark lines. All I can say is that upon such objectors lies the onus of producing a more simple (and yet sufficient) explanation than that I have suggested.[1]

J. NORMAN LOCKYER.

(*To be continued.*)

1 It has been stated that the meteoritic hypothesis has received a fatal blow from the observations of the Nova (*Astronomy and Astrophysics*, 1892, p. 509). Capable and unprejudiced persons I think will not be of this opinion. I append a quotation from an article by Prof. Campbell, which has appeared since the lectures were delivered.

"As bearing upon any possible theory of Nova Aurigæ, perhaps it will not be out of place to say here what I said last winter in another journal (Pub. A.S P. vi., 52, 133.) The Harvard College Observatory has shown that both Nova Aurigæ and Nova Normæ at discovery possessed substantially identical spectra of bright and dark lines, similarly and equally displaced. Both diminished in brightness, and both assumed the nebular type of spectrum. The new star of 1876 in Cygnus probably had nearly an identical history: passing from a bright star with a spectrum of bright and dark lines, to a faint object with a spectrum consisting of one bright line (undoubtedly the nebular line λ 5010, or the two nebular lines λ 5010 and λ 4960 combined). We may say that only five 'new stars' have been discovered since the application of the spectroscope to astronomical investigations, and that three of these have had substantially identical spectroscopic histories. This is a remarkable fact. We cannot say what the full significance of this fact is. One result, however, is very clear: the *special* theories propounded by various spectroscopists to account for the phenomena observed in Nova Aurigæ must unquestionably give way to the more *general* theories." (*Astrophysical Journal*, Jan. 1895, p. 51.)

THE INTERNATIONAL GEOGRAPHICAL CONGRESS.

THE International Geographical Congress, now a recognised institution, has this year met for the first time on British ground. Originating in a festival organised to celebrate the inauguration of statues of Mercator and Ortelius at Antwerp and Rupelmond, the first Congress was held at Antwerp in August

1871, under the name of the "Congrès des Sciences géographiques, cosmographiques, et commerciales," and under the influence of the revival of geographical learning subsequent to the Franco-German War, it has met from time to time at different centres, gaining strength and vitality on each occasion. The second Congress assembled at Paris in 1875; the third at Venice in 1881; the fourth at Paris in connection with the Great Exhibition of 1889; and the fifth at Berne in 1891. In each case the representative Geographical Society of the country concerned was responsible for the organisation and arrangement of the meeting, and at Berne it was definitely resolved that in future the Congress should be constituted at intervals of not less than three, nor more than five years, the resolution taking practical shape in the acceptance by the Royal Geographical Society of the responsibilities of a meeting in London in 1895. A proposal, emanating from the Berne Geographical Society, to the effect that the chief officials of each Congress shall retain office until the meeting of the next, is to be submitted this year, and its acceptance would mark a further step towards the establishment of a great permanent organisation for the systematic study and exploration of the globe.

The sixth Congress differs from its predecessors in a characteristically British fashion, inasmuch as it is practically a private enterprise; no State or municipal aid being forthcoming, as on previous occasions. Nevertheless the Royal Geographical Society, aided by grants from a few of the City companies and by private generosity, has been able fully to cope with the demands made on its resources by the immense influx of geographers from all parts of the world. Accommodation has been found in the Imperial Institute, which affords ample room for private and public business meetings, for exhibitions, and for all manner of social functions, as well as opportunity for that private intercourse which goes so far to enhance the value of such meetings. The Congress is under the patronage of the Queen and the Prince of Wales, and the honorary presidency of the King of the Belgians, the Duke of Connaught, the Duke of York, the Crown Prince of Denmark, and the Grand Duke Nicolas Michailovich. The President is, according to the custom of the Congress, the President of the Geographical Society under whose auspices it meets; in this case the President of the Royal Geographical Society, Mr. Clements R. Markham, C.B., F.R.S. A large number of eminent public men and geographers have accepted the position of honorary vice-presidents.

The work of organisation has been carried out by a number of committees, under the chairmanship of Major L. Darwin, R.E.; the general secretaryship is in the hands of Mr. J. Scott Keltie and Dr. H. R. Mill; and the exhibition is under the direction of Mr. E. G. Ravenstein, Mr. John Coles, and Mr. John Thomson.

In devising the general arrangements, it has hitherto been the practice to abstain from formulating any rigorous rules, and to leave the managing Society a pretty free hand. In some cases, notably at Venice, the Congress was somewhat overwhelmed by the exhibition of geographical objects; while in others undue subdivision into sections has tended to defeat one of the most praiseworthy objects of the meeting. Profiting by the experience obtained, the Royal Geographical Society has kept the range of the exhibition within comparatively narrow limits. The Geographical Societies of Paris, Berlin, and St. Petersburg, and various Government departments and private individuals in all parts of the globe have sent representative exhibits of recent work, and the collections have been in many cases arranged entirely by the exhibitors. Another department is devoted to paintings and photographs of geographical interest, including, amongst other things, a series of historical portraits of eminent travellers, cartographers, and geographical writers, many valuable sketches and photographs contributed by explorers, and lantern slides and diagrams adapted to the purposes of geographical education. A third section, due to Mr. E. G. Ravenstein, consists of a loan exhibition, intended to illustrate the development of cartography from the time of Ptolemy to the end of the eighteenth century. Mr. Ravenstein is to be congratulated on the achievement of a remarkable success, for while no important stage of progress is unrepresented, those illustrated by fac-similes only are wonderfully few. The collection includes many priceless examples, such as the Leonardo da Vinci maps belonging to the Queen, the "Henry II." map belonging to the Earl of Crawford and Balcarres, the Mollineux globe from the library of the Middle Temple, the Agas map of London from the Guildhall, the manuscripts of the early Indian surveys by Ritchie and Rennel, Topping, Macluer, and Mackenzie, from the India Office, and extensive contributions from the libraries at Lambeth Palace, the Admiralty, the Ordnance Survey, various Geographical Societies, and the private collections of Mr. S. W. Silver, Mr. H. Yates Thompson, Mr. E. A. Petherick, and many others. It is to be noted that the catalogue of this exhibition, with its appended list of maps, portolani, and atlases in the British Museum, forms an excellent bibliographical outline of the subject.

A similar collection, though on a necessarily smaller scale, has been made by Mr. John Coles, in the department of surveying and meteorological instruments. The exhibits of the Hydrographic Department of the Admiralty and the Ordnance Survey Office are of great historical interest. We could have wished it had been possible to allot a further space to instruments used in deep sea explorations, especially as their modern developments are so well illustrated by Prof. Otto Pettersson and Dr. H. R. Mill.

A final section of the exhibition consists of the most recent equipments for exploration, surveying, mapping, and teaching geography, shown by numerous private firms.

The same leading idea, that of representing general features, has been kept in view in arranging the work of the meetings. While no attempt has been made to present popular programmes, the whole range of geography has been covered, and the chief effort directed towards furthering those larger interests which concern all geographers, rather than to the discussion of more minute technicalities, however important in themselves. Thus general meetings are to be devoted to Polar Exploration, the development of Africa, Exploration, and Cartography; and sectional meetings deal with Geographical Education, Photographic Surveying, Physical Geography, Geodesy, Oceanography, Geographical Orthography and Definitions, and Limnology.

The date of our going to press constrains us to defer a report of most of the work done in all these different departments until next week, except in so far as the earlier meetings are concerned. On Friday evening (July 26) the delegates were presented to H.R.H. the Duke of York by the Ambassador or Chargé d'Affaires of their respective countries. The following were represented, either by Government delegates or by delegates of Geographical Societies:—Austria-Hungary, Belgium, Denmark, France, Germany, Greece, Italy, Netherlands, Norway, Portugal, Roumania, Russia, Spain, Sweden, Switzerland, Turkey, United States, Mexico, Brazil, Japan, Persia, New South Wales, New Zealand, Queensland, South Australia, Tasmania, Victoria, Western Australia, Cape of Good Hope, and the United Kingdom. After the private reception, the Duke of York welcomed the whole Congress in the name of the Queen and the Prince of Wales, and the President made a brief address of welcome on behalf of the Royal Geographical Society, the other British Geographical Societies, and the Geographers of the United Kingdom. The Hon. Chief Justice Daly, of the New York Geographical Society, the oldest President of a Geographical Society living, replied on behalf of the foreign members and delegates, and the meeting adjourned, the remainder of the evening being spent in the gardens of the Institute, where music was discoursed by Strauss' orchestra.

On Saturday (July 27) the Congress assembled at 10 a.m. to hear the President's opening address, which paid a graceful tribute to the geographical work of the nations whose delegates and representatives he cordially welcomed, and gave a forecast of the work about to be undertaken by the Congress. A vote of thanks was proposed by Prince Roland Bonaparte, and seconded by Prof. von den Steinen. At noon two sections were formed. In Section B, which was presided over by Mr. Markham, supported by Chief Justice Daly and Prof. von den Steinen, Prof. Levasseur read a paper on geography in schools and universities, which outlined a system of geographical education extending through primary, secondary, and higher stages. Señor Torres Campos supported the views expressed by Prof. Levasseur, and discussion was continued by M. Ludovic Drapeyron. The importance of a university training for teachers of geography was urged by Dr. R. Lehmann in the second paper, and the needs of geography in secondary education were set forth by Mr. A. J. Herbertson in the third. Thereafter Dr. W. Henkel allowed a paper on geography and history in schools, standing in his name, to be held as read, in order to allow time for discussion. Mr. H. J. Mackinder advocated the establishment of a central school of geography in London, in order to place geographical teaching in this country on a proper footing. Mr.

G. N. Hooper referred to the work done by the London Chamber of Commerce, and the discussion was continued by Messrs. Phillips, Burgess, Batalha Reis, and Yule Oldham. The President proposed that a committee, consisting of Chief Justice Daly (chairman), Prof. Levasseur, Prof. Lehmann, Mr. Mackinder, and Mr. Herbertson, should be appointed to consider a resolution on geographical education, to be submitted to the Congress.

Section C, which met at the same time, concerned itself with photographic surveying. The presidential chair was occupied by Prince Roland Bonaparte and General Walker jointly. In a paper read on his behalf by M. Schrader, Colonel Laussedat considered the application of photography to the rapid determination of points in levelling, and a combined camera and theodolite was exhibited. M. de Déchy, in discussion, insisted that photography must always be merely auxiliary to triangulation, and must not in any way replace it; and Mr. Coles described his work in constructing a map of the Caucasus from photographs alone. Captain E. H. Hills then read a paper on the determination of terrestrial longitudes by means of photography, in which he described improved methods of exposing and measuring plates used in photographing lunar distances, by means of which he had obtained better results than those obtained by Schlichter and Runge. An abstract of a paper by Prof. J. Thoulet, suggesting the extended application of photography to the survey of rapidly shifting sandbanks, was read in his absence. Mr. Coles described and exhibited Colonel Stewart's camera for producing photographs of the whole horizon, and the proceedings closed with an informal communication by M. Janet on the determination of longitudes without instruments of precision.

HELIUM, A CONSTITUENT OF CERTAIN MINERALS.[1]

II.

(II.) *The Properties of Helium.*

FROM what has preceded, it appears that up to now only three minerals are available as sources of helium, unless, indeed, very large quantities of samarskite and yttrotantalite are worked up. These three are clèveite, the uraninite investigated by Hillebrand, and bröggerite. And here we wish to express our indebtedness to Prof. Brögger for his great kindness in placing a large stock of bröggerite at our disposal. It has furnished a large quantity of the helium which we have had in our hands.

Although, so far as we were able to judge by throwing into a two-prism spectroscope of Browning's the spectra of samples of gases obtained from the minerals previously mentioned, all the specimens of helium were identical, still a further proof was desirable. Owing to the small quantities of gas yielded by these minerals, amounting in most cases to a few c.c., it was impossible to ascertain whether these samples were of the same density; but the case was different with the gas from clèveite and from bröggerite. In each case a sufficient quantity was obtained to make it possible to determine the density with fair accuracy. It will be convenient therefore to describe the methods of extracting the gas and the methods determining its density.

In the communication to the Royal Society it was stated that the maximum density of the original gas from cleveite was 3·89. The spectroscope showed the presence of nitrogen in this sample; the bands were very brilliant at high pressure, but on reducing the pressure the yellow line became brilliant, and the nitrogen spectrum disappeared. This always happens when the tube has platinum electrodes and a strong discharge is passed for a considerable time. An attempt was made to remove the nitrogen from this sample of gas by circulating it over red-hot magnesium; but an unfortunate accident caused the admixture of about its own volume of air, carrying with it argon, from which at present there is no known method of separating helium.

It appeared important to decide whether the gas evolved from these minerals is helium, or a compound of hydrogen and helium; for in the preliminary set of experiments the treatment was such that a hydride would have been decomposed either by sparking with oxygen or by passage over copper oxide at a red heat.

[1] A paper by Prof. William Ramsay, F.R.S., Dr. J. Norman Collie, and Mr. Morris Travers, read before the Chemical Society on June 20. (Continued from p. 308.)

The result of experiments directed to this end is to show that no combined hydrogen is present. Gas was extracted from nineteen grams of bröggerite by heating it in a combustion-tube to dull redness; the combustion-tube was connected with a Töppler's pump by means of thick-walled india-rubber tubing, wired carefully. Special experiments showed that the leakage through the india-rubber amounted between Saturday and Monday to less than one small bubble. The bröggerite yielded about 75 c.c. of gas, a large portion of which was absorbed by caustic soda, leaving about 35 c.c. A second charge of 18·3 grams gave 58·5 c.c., and a third, of 22·1 grams, gave 66·0 c.c. The amount of gas evolved depends largely on the temperature. The evolution is rapid at first, but becomes very slow after three hours, and the heating was always stopped before all the gas which might have been extracted had come off. The last portions, as will be seen later, were extracted by fusion with hydrogen potassium sulphate.

This crude product from bröggerite blackened mercury, doubtless owing to the presence of hydrogen sulphide.

The density of this sample was determined; the data are these.

Volume of bulb	33·023 c.c.
Temperarure	22·9
Pressure (corr.)	766·7 mm.
Weight...	0·0327 gram
Density (O = 16)	11·90

The exceedingly small capacity of the bulb calls for some remark, but for no apology. The object here is, not to determine the density with the utmost accuracy, but to secure a guide, sufficient for our purpose, which will indicate the probable molecular weight. Now the hydrogen contained in such a bulb at 0° and 760 mm. weighs approximately 0·0030 gram. A sensitive balance by Oertling, adjusted for the special purpose, could easily be read to 0·00005 gram, without resorting to the the reading of oscillations of the pointer; and this gives an accuracy of 5 parts in 300, or 1·7 per cent. Hence the density of hydrogen, thus determined, might vary between 0·983 and 1·017. It is evident that such an approximation is quite sufficient for our present purpose. The total volume of this gas was 124·5 c.c. A solution of soda was introduced by means of a pipette, and after all absorption had ceased, the residue measured 78·0 c.c. The density was again determined.

Volume of bulb	33·023 c.c.
Temperature	21·6°
Pressure (corr.)	765·4 mm.
Weight	0·0058 gram
Density (O = 16)	2·105

This gas was now left in contact with palladium sponge for a night. The sponge was made by reducing the chloride in a current of hydrogen, at a dull red heat. As it was somewhat porous, it was hammered on a steel anvil before introducing it into the gas, which, of course, was confined over mercury. The contraction amounted to abont 1/30th. The density was again taken.

Volume of bulb	33·023 c.c.
Temperature	19·2°
Pressure (corr.)	760·2 mm.
Weight	0·00630 gram
Density (O = 16)	2·284

This gas had undergone no treatment which was of a kind to remove combined hydrogen, unless, indeed—a very improbable assumption—it be supposed that the compound should be decomposed by contact with metallic palladium. The gas was therefore placed in contact with copper oxide, which had previously been heated to redness in a vacuum, and a tube filled with phosphoric anhydride was so interposed as to absorb any water produced. The gain in weight of this tube was 0·0016 gram, indicating the oxidation of about 2 c.c. of hydrogen. In all probability this hydrogen had remained over after treatment with palladium; for it bears no proportion to the total quantity of gas—78 c.c.

The density was again determined.

Volume of bulb	33·023 c.c.
Temperature	16·67°
Pressure (corr.)	754·9 mm.
Weight	0·00720 gram
Density (O = 16)	2·606