THE ORIGIN AND FORM OF HOARFROST.

BY THE ENGLISH CORRESPONDENT OF THE SCIENTIFIC AMERICAN.

At a recent meeting of the British Association for the Advancement of Science a series of interesting photos was exhibited by Dr. Karl Grossmann, F.R.C.S.E., F.G.S., and Mr. J. Lomas, A.R.C.S., F.G.S., demonstrating in detail the origin and formation of hoarfrost crystals. As is well known, the production of hoarfrost is attributable to the transition of aqueous vapor directly into the solid state, and so quickly is the metamorphosis effected that there is no apparent intervention of the liquid state between the two extremes of vapor and solid.

These two scientists have considerably extended the environment of our knowledge of hoarfrost crystals, and their present results represent some eleven years of patient investigation into the phenomenon. It first excited Dr. Grossmann's attention in the ice cave in Iceland. This particular cavern penetrates a mass of lava. In the course of time, the water deposited upon the external surface of the cave has percolated through the interstices of the rock and penetrated to the interior. The result is the formation of a number of beautiful ice cones.

In the photograph accompanying this article, which was secured by means of magnesium flash-light, some idea of the beauty of these formations may be gathered. They are perfectly transparent, being of a light bluish tinge. The transition in the cave has indubitably been direct from aqueous vapor into the solid state.

The walls of this cavern were coated with some remarkably fine hoarfrost crystals, and upon minute examination they were discovered to be of a shape not previously known.

It is well known that crystals vary in their shape of formation according to their nature. That is to say, frost is of one type, salt is of another, potassium chloride another, and so on. In 1867 Knop, in his work on the molecular constitution and growth of crystals, published at Leipzic in 1867, demonstrated the difference in the formation of the rock-salt crystals and the potassium chloride crystals (see diagrams 2 and 3). Each of these crystals originates in a cube, but the successive development is somewhat dissimilar. In the former, upon the fundamental cube, is superimposed a thin rectangular disk with a cube at each corner, another disk upon this, and so on, each successive step being somewhat larger than the previous one, so that a pyramid is thus formed, with the external faces complete and the central portions incomplete. In the case of the potassium chloride crystals, they are built up of successive cubes also in the form of steps. The construction of hoarfrost is analogous to that of salt crystals to a very great degree. In this instance the definite construction they assume is that of hexagonal hollow pyramids. But until the investigations of Dr. Grossmann, the form of construction and successive development was only incompletely known. The only previous scientist who had devoted his study to this subject concluded from his researches that the crystal was attached by one of its corners, and expanded therefrom. Dr. Grossmann has demonstrated this contention to be fallacious, for in no single instance has he found the crystals forming in any but one particular manner, with but slight variations, and the latter upon examination were attributable to adverse influences.

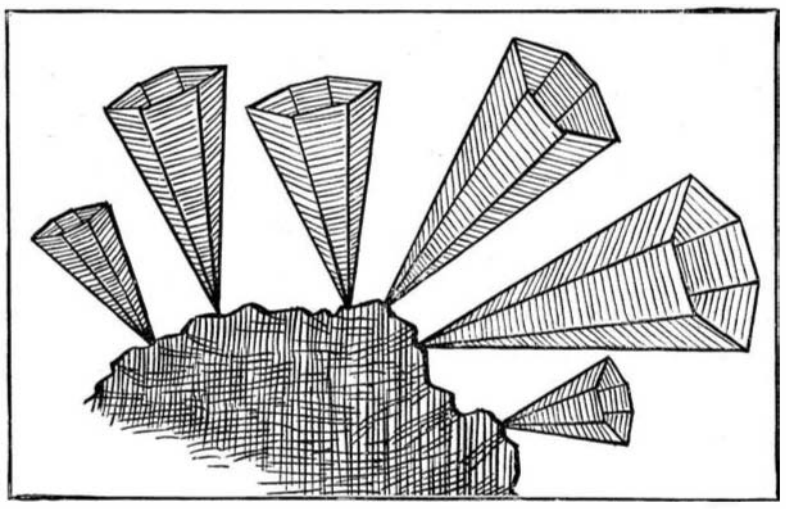

Fig. 1.—The Hollow Hexagonal Pyramids Springing from the Base.

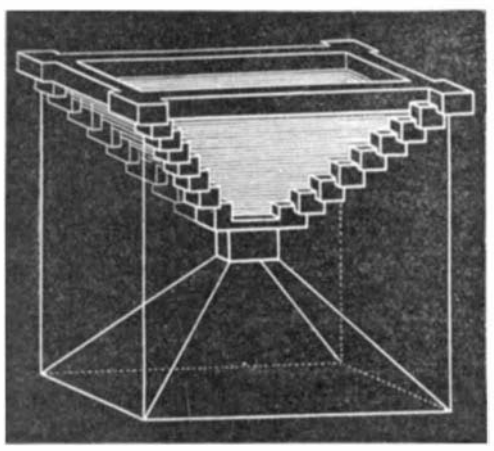

Fig. 2.—Skeleton Crystal of Sodium Chloride.

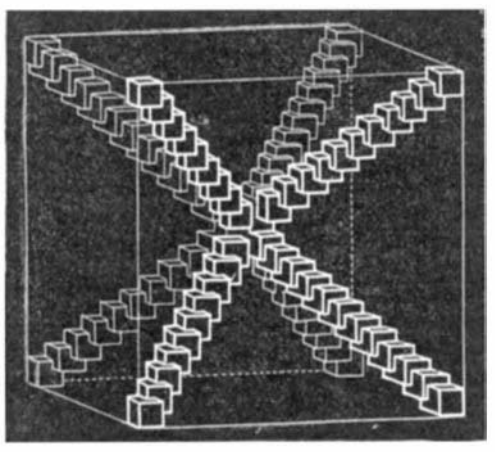

Fig. 3.—Skeleton Crystal of Potassium Chloride.

In the ice cave of Iceland Dr. Grossmann discovered that these hexagonal hollow pyramid crystals were very definitely formed. This was entirely due to the absence of extraneous atmospheric influences, for on the whole the air within the cave was comparatively quiescent. At those places where currents of air existed, or other influences were at work, the frost crystals assumed different shapes due to parts being broken or corroded, but in these particular cases it was also discovered that the crystal was built upon a hexagonal foundation.

From his investigations in the cave and his subsequent experiments, Dr. Grossmann discovered that the most favorable conditions for the production and development of large crystals were a moist air, at a low temperature, and the presence of a quiet, undisturbed atmosphere. As such conditions are rarely existent in connection with the formation of natural hoarfrost conditions, Dr. Grossmann, in order to obtain the most satisfactory and successful results, carried out his investigation with artificial hoarfrost, such as is produced in the refrigerating rooms of vessels and frozen-meat warehouses.

The process of formation of an ice crystal is as follows: A small, flat, hexagonal prism of extreme thinness springs from a solid base. Immediately this is formed there is a struggle for the attraction of material for further construction from the surrounding atmosphere. But as the outer edges of the hexagon have a wider area for attraction the molecules congregate thereat in preference to the center, forming a larger hexagon round the one beneath, with the edges overlapping. The edges thus grow more rapidly than the central face, which is left undeveloped and hollow owing to the dearth of material. This growth is continuous, and each successive hexagonal ring is larger than the preceding one so that a series of steps is produced. In our sixth illustration, which is a microphotograph enlarged twelve times, the pyramids may be seen, though it is in the fifth illustration that the pyramidical formation is best developed. In this illustration, owing to its broadside nature, the line of each step or hexagon is clearly indicated. This is the formation which all ice crystals assume, but occasionally may be found specimens

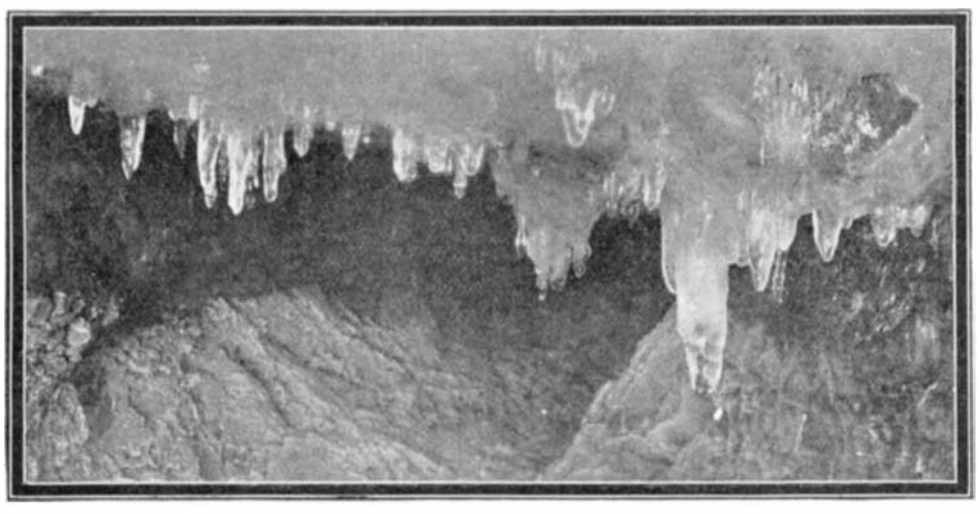

Fig. 4.—Ice Formations in an Iceland Cave at Surtshellir.

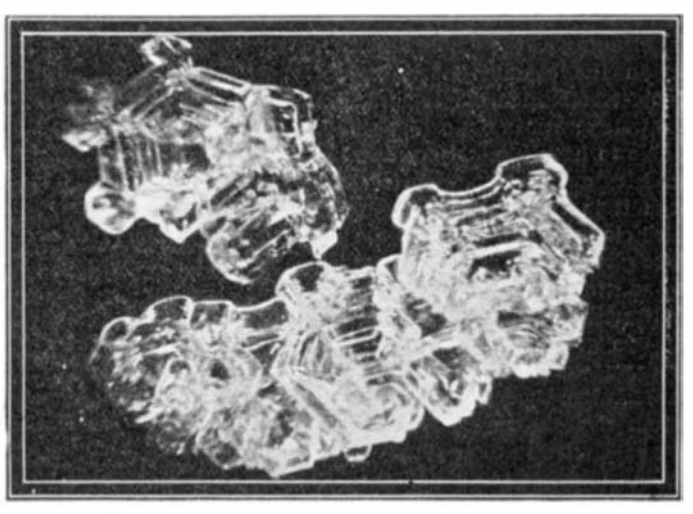

Fig. 5.—Artificial Hoarfrost—Hollow Pyramids with Corner Crystals.

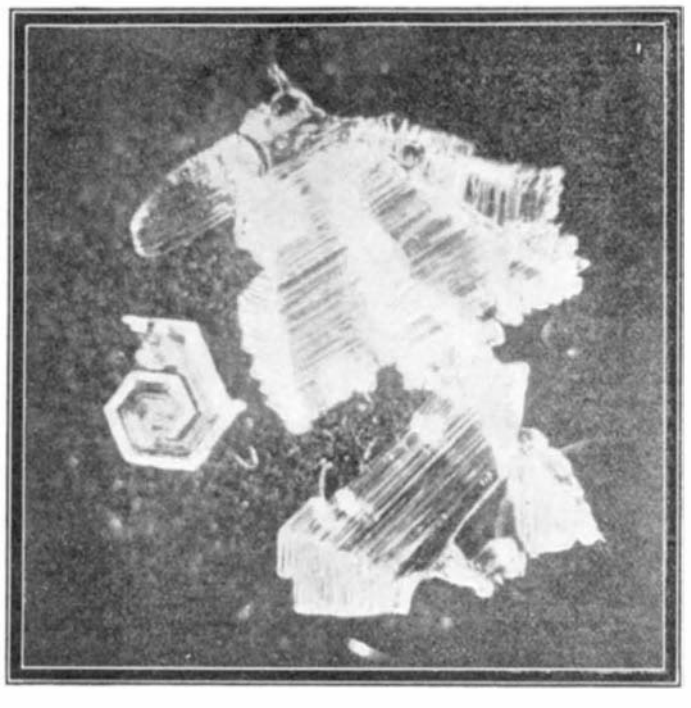

Fig. 6.—Microphotograph of Hoarfrost.

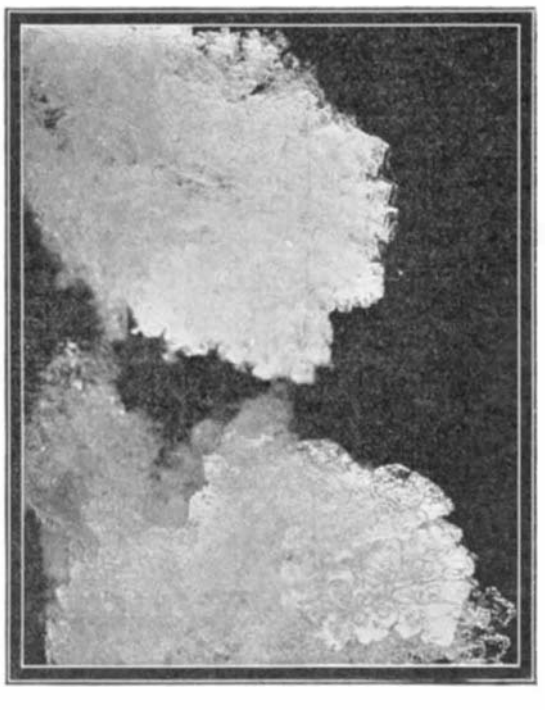

Fig. 7.—Artificial Hoarfrost.

with a cube at each of the corners. This peculiarity is shown in the fifth illustration, and it will be observed that these cubical crystals, which are similar to the bastions of a fortification, are precisely the same as the cubical crystals in the rock-salt pyramids.

Dr. Grossmann during the whole of his researches, both by himself and in conjunction with Mr. Lomas, has always found the crystalline forms exclusively those of the hexagonal, flat-topped prism. In no single instance has a terminal pyramid or a hemihedral shape been discovered. In our first illustration the method of hexagonal formation is very distinctly shown, and the regularity of the hexagons is also well defined. But it has already been pointed out that exceptions to this general formation have been observed. For instance, some have been noticed to be helix-shaped hollow pyramids, similar to the cubic helices of bismuth, also long solid or helix pyramids. Sometimes a crystal will be found wherein will be noticed needle-like spikes arranged in decided right angles. Such a formation is suggestive of the cubic or other rectangular crystals, but on examination it will always be found that the prism is an incompletely developed or damaged hexagonal prism.

The helices are curious but beautiful in form, rendering an impression of the home of the smaller shellfish. In this again, however, it will be observed by reference to our illustrations that the hexagonal form is preserved. The helix is in reality an original hexagonal pyramid that has been damaged. Owing to the extreme frailty of the construction of these crystals they are susceptible to the slightest adverse influences, such as air currents caused by moving objects, or heat radiation from bodies. The result is that one or more sides of the hexagon are broken or damaged, and Nature immediately attempts to repair the injury by the formation of a smaller hexagon upon the internal surface of the former hexagonal pyramid, and thereby the helix is produced.

In our illustration of a large area of hoarfrost (Fig. 7), round the extreme edge of the frost the peculiar distinctive formation of the hoarfrost construction is distinctly shown.

THE UNITED STATES NAVAL TRAINING SCHOOL AT NEWPORT.

(*Continued from page* 144.)

divided into four classes. Those joining from the newcomers' squad are placed in the fourth class. At once they begin to participate in the regular routine and drill, embracing artillery, gymnastics, school and signals, infantry, boats, seamanship, gunnery, bags, hammocks, sewing and mending. Saturday is devoted to general cleaning of the whole building, recreation, and music. In the examinations, conduct record is the basis of determination of promotion in classes. When a boy is well versed in the subjects taught in the fourth class, able to keep himself and his clothing clean and neat and lay out his hammock for inspection and stow and lash it in the proper manner, he is promoted to the third class, and so on up to the first. Extra privileges are given to the apprentices who are first-class in studies and in conduct and who are out of debt—such as the liberty to visit Newport on Saturday afternoon once in two weeks.

The day's work begins at the training station at 5:30 A. M., when the bugle sounds reveille and the boys leap from their hammocks, which are rolled up and lashed and carried to their places. Every one is served with a bowl of hot cocoa and then the bugles sound "turn to," when for an hour there is cleaning and scrubbing all over the place. Each boy is his own laundryman and must wash his clothes, hammock, covers, bags, etc., at allotted times in the course of the day. They are dried by steam on long racks in a drying-room, and occasionally outside on sunny days. Breakfast formation is sounded at 8 o'clock, when the boys march into mess hall. These young boarders of Uncle Sam's are well and bountifully fed, the bill of fare varying according to the day.

After breakfast comes the sick call, followed by quarters and prayers. From then on till 12 o'clock, dinner time, is given up to a period of instruction, which continues, after a recess of an hour, until supper, at 5:45. After this the boys can enjoy themselves as they please, until the hammocks are piped down.

At 8:35 the bugle sounds for the piping down of hammocks. The boys sling their hammocks, arrange bedclothes and prepare their sleeping places. At 9 o'clock "taps" are heard, the day's work is done, and the four hundred apprentices spring into their hammocks. These are swung one above the other in the same fashion as between the decks of a man-of-war, and the sailor lads prefer their comfortable swinging bed to any other.

It has been said by competent experts that the battalion infantry drill as seen at the Newport Training School is equal to and even ahead of that at Annapolis. This is due largely to the efficient work accomplished by the drillmasters, notably of John R. Daly, U. S. N., instructor in infantry, sword, and bayonet exercise. Mr. Daly exercises superior control over the whole battalion and has succeeded in getting it through the most difficult evolutions in unison and with almost clocklike precision. One of the most interesting of the open-air maneuvers is the physical rifle drill with music. The whole battalion takes part in this, usually in the morning, some two hours after breakfast. This is probably the most fascinating to the onlooker of all the open-air spectacles. On a raised platform the instructors, with rifle uplifted, face the squad of apprentices, lined up in rows. At the word of command, eight hundred hands rise in the air, with rifle high above head, then lowered front and back, to and fro, quick and slow, keeping time to the music. In seamanship a typical masthead, set in the ground, with the ropes, sails and rigging, etc., of a seagoing vessel, affords the young mariners the novel and practical place to limber up their muscles in climbing and to perform other routine work. Filled from topmast down with a hundred or more of the white-clothed tars, it presents an animated sight. The U. S. S. "Hist," attached as station ship, takes some fifty boys for a week's cruise in nearby waters for instruction in practical seamanship, gun drills, signaling, etc.

Marksmanship is popular and small-arm target practice on the ranges with a service revolver is indulged in with a deal of energy and enthusiasm. There is much rivalry and competition among the boys to be the best shot. Every day a squad is taken to the ranges for practice. Each apprentice is allowed to fire a limited number of times. As an extra inducement, prizes are offered for the best scores. A boy qualifying as a first-class marksman gets a cash prize of $1.50; as second class, $1; as third class, 50 cents. Those having the highest score at each quarter get $1 additional in prize money, provided they have passed as first-class marksmen. Boxing and wrestling are favorite pastimes when off duty. A good rough and tumble wrestling bout is sure to wind up some day's recreation period, drawing a gallery of enthusiastic onlookers. Lectures, concerts, and entertainments are given on frequent evenings each month.

Apprentices of unusual ability, just after they have left the training school, are sent to the ordnance school at Washington and to the torpedo station at Newport, where they can become proficient in electrical engineering and torpedo work and qualify as divers. Those who desire to make diving in the navy a particular study enter the seamen gunners' class. Here the men are taken out morning and afternoon in a specially equipped diving boat and each one is sent down to the bottom for a limited time. After six months' work at the training school and passing satisfactory examinations, the apprentices are sent on their first cruise on one of the training ships and shipped as third-class seamen. In course of this voyage instruction in practical seamanship and gunnery is further pursued. On return they are advanced to second-class apprentices upon examinations, with increased pay of $15 a month. A transfer is then made to a regular man-of-war, and after qualification they are advanced to the grade of first-class apprentices, with pay of $21 a month, serving a year's cruise.

Upon the expiration of the enlistment of an apprentice he will, if recommended, be handed an honorable discharge and upon re-enlistment within four months from date of discharge, he will receive as a bonus four months' extra pay, a continuous service certificate and an addition of $1.36 per month to his pay.

Ex-apprentices are given the preference in the selection of petty officers with pay ranging from $17 to $30 per month and from $1,200 to $1,800 with retirement at the age of 62 years on three-quarters pay for life. This remuneration, considering that the boy gets quarters, rations, and continuous employment, with no losses or waste time, opens a satisfactory career to the determined and aspiring lad in the navy, which is not so bad financially and socially, for in fact the salary is higher than many shore positions in civil life.

Gold from Sea Water Once More.

Sir William Ramsay recently has announced that the old problem of extracting gold profitably from the sea can be successfully solved.

Newspapers of repute have given much space to explanations and interviews thereon, and even the staid Spectator devotes two columns to a consideration of its possible success and the effect thereof on the world's economy.

There are some ridiculous calculations based on alleged results. One critic solemnly asserts that 5,000,000,000 tons of solid gold await successful prospectors. The bubble has not yet been pricked, though it has been contracted in its dimensions. The weightiest authorities, speaking with gravity and becoming dignity of the exalted promoters, have expressed disbelief in the theory that it will pay to extract the gold.

The syndicate interested in the scheme is said to have employed Sir William Ramsay professionally, but seem to share with him the fear of eventual ridicule, for on a recent exposure they and he alike hastened to make statements "with a view," as they said, "of stopping possible speculative dealings by the public." At that time Sir William Ramsay wrote:

"The process is still in an experimental state. Needless to say I do not hold shares in the syndicate."

The inventor of the process by which it is hoped to make a corner in the world's gold is H. J. Snell.

We question very much whether Sir William Ramsay has stated more than the fact that sea water contains a certain percentage of gold, a proposition that no chemist will deny. Probably upon this utterance of Sir William's the London syndicate has built its extravagant claims.

Velocity Potential of the Universe.

BY EDGAR L. LARKIN.

If a hole be drilled entirely through the earth, passing through its center, and a stone be let fall into it, the stone will move to the opposite side and return to the starting point. And if air could be removed, it would oscillate to and fro so long as the earth endures. It would be a pendulum. The velocity of the falling body on arrival at the center would be 4.91 miles per second; and of the rising body, on arrival at the other side, zero. Imagine that the entire earth should be mined, removing all matter save a small mass here and there; and let all these be supported by timbers extending from mass to mass, to prevent falling to the center. Remove 99 per cent of the matter; and the stone would move with greatly reduced speed, still acting as a pendulum. Now remove all the timbers, and at the same time expand the earth to a diameter of, say, many million miles. Gravity exerted by the small masses upon each other would be weak; no supports would be required. But the stone would keep up its oscillation from side to side of the expanded swarm of earth masses, with velocity reduced in proportion to the expansion, and consequent weakened gravity.

THE UNIVERSE IS SO EXPANDED.

A remarkable computation made by Prof. Simon Newcomb (page 499, "Popular Astronomy") is based on a mass of the sidereal structure equal to that of 500,000,000 suns like ours. These are conceived to be spread out into a disk-shaped universe, whose diameter is such that the time required for light to move across it, with the velocity of 186,000 miles per second, is 30,000 years. From the known laws of gravity and motion, he shows that a stone that has been falling forever, or as he words it, "falling from an infinite distance," will on arrival at the center of the disk be moving at a rate of 25 miles per second. It is known that the force required to be imparted to a falling body to double its velocity must be quadrupled; and nine times the force is necessary to give it three times the quantity of motion. Then to cause the motion to be increased to eight times, sixty-four times the quantity of force must be exerted. Suns in space correspond to the small blocks of earth after mining out; and distances between them take the places of the timbers. The stone is represented by any flying sun. A sun may start on one side of the universe, fall through the center of gravity, pass to the other side, and return. For the purposes of this note, the quantity of matter in existence is imagined to be finite, and distributed in the shape of suns, nebulæ, and dark worlds throughout a space having a diameter of 30,000 light years, or 176 quadrillion miles. And it is imagined to have a boundary.

POTENTIAL.

If a sun could be observed near the center of this stellar structure, supposing that the center can be discovered, to be in motion with a speed of say 200 miles per second, then this would be the true velocity potential of the entire mass. Some suns now seen to be moving, are thought to have this rate. If these suns have fallen from an infinite distance, then the mass of the sidereal structure is equal to 500,000,000 × 64, or thirty-two billion times that now in our sun. The number of bodies giving light enough to impress a sensitive plate is estimated at about one hundred million, a quantity so insignificant in comparison with 32,000,000,000, that it is scarcely worth mention. However, suns starting from the periphery of the cosmical sphere would in many cases be drawn into orbits around others, and fail to become pendulums, or, in rare cases, two might collide. This would result simply in change of direction of the debris. Two suns drawn into orbits around their centers of gravity would still move on in some direction. There does not seem to be anything to prevent some suns from reaching opposite sides of the structure and then returning. According to this, it does not appear that it is necessary for an entire finite universe of worlds to be in rotation to set up centrifugal tendency to counteract collapse at the gravitation center. To accurately compute the quantity of matter, find the center of gravity of nature, its distance from the earth, and the velocity of any sun near it. That is, to find a mass that cannot be exceeded on the assumption that the moving sun has arrived in from an infinite distance.

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