NOTES ON METEORITES.[1]

VI.

Comets are Meteor-Swarms which have entered the Solar System some time or other.

THESE swarms, then, are comets. The final demonstration, as we have seen, we owe to the labours of Newton, Adams, and Schiaparelli chiefly. But long before their time the connection between shooting-stars (and even meteorites) and comets had been suspected on various grounds.[2]

Many shooting-stars pass through the air with a trail. This appearance is certainly suggestive of a very rapid comet. Hence, perhaps, it was that such an appendage, often noticed in the case of bright meteors, was sometimes in ancient records described as a comet. It is known that Cardano described as a comet the great meteor from which fell 1200 stones on the territory of Crema on September 4, 1511.[3]

Not only, as we have seen, Kepler (1600) regarded shooting-stars as akin in nature to meteorites, but he held that both had the same origin as comets:—"Falling stars are composed of inflammatory viscous materials. Some of them disappear during their fall, while others indeed fall to the earth, drawn by their own weight. Nor, indeed, is it improbable that they have been formed into globes from feculent materials mixed with the ethereal air itself, and thrown from the ethereal region in a straight line through the air like very small comets, the cause of the motion of both being hidden."[4]

Halley (1700) though he thought that the phenomenon of shooting-stars[5] was produced by a material disseminated through celestial space falling upon the sun and meeting the earth in its passage, did not associate it with cometary phenomena; but Maskelyne (1765) held that meteors were of celestial origin, and was inclined to assimilate them to comets. He wrote as follows in a letter to the Abbé Cesaris, the astronomer at Milan, about December 12, 1783:—"Freely accept, I pray you, this map, which I have lately published in order to stir up learned men rather than the unlearned, to observe more keenly the phenomena called fire-balls. In all probability they will turn out to be comets. . . ."[6]

To Chladni belongs the credit of having broached the theory which modern observations have established.

We have already seen that Chladni formulated the view, in 1794, that space is filled with matter. In 1819 he extended it by stating that both shooting-stars, meteorites, and comets were but different manifestations of it.[7]

Chladni made a step in this matter of which, as pointed out by Schiaparelli, only to-day are we able to appreciate the importance. In suggesting the cosmical hypothesis, he regarded two possible cases: either the meteors were formed of masses of independent materials which had never formed part of the larger celestial bodies, or they are the result of the destruction of a celestial body previously existing. Chladni held the second hypothesis as possible, but held to the first as more probable. He stated that we could not doubt the existence in the celestial space of small bodies endowed with movement, which are now and then visible by passing before the sun.

He held, therefore, that the small masses which appear under the forms of bolides and falling stars do not differ essentially from comets. It is also probable, he says, that comets consist of clouds composed in great part of masses of vapour and dust, which are kept together by mutual attraction. That this attraction is not enough to sensibly disturb the planetary movements is a proof of the exceeding tenuity and dispersion of the materials in such clouds, through which, however large, it is possible, to observe the fixed stars.[8]

In 1839 the Abbé Raillard suggested a connection between luminous meteors and comets and the aurora,[9] and Dr. Forster noted that the years marked by the appearance of a large comet are remarkable also for the abundance of falling stars, especially of white ones.

Perhaps the first to give a more solid support to the cometary theory of falling stars on geometric grounds was Boguslawski, who conceived the idea of representing by means of parabolas the apparent orbits observed in some of the August meteors of 1837.[2]

For the next important advance in thought upon this subject we have to come down to 1858, in which year Baron Reichenbach published a most important memoir[3] attacking the question from an entirely new point of view. Reichenbach, accepting as proven by the then knowledge the most intimate connection between meteorites and falling stars, reasoned in the following manner, that both were connected with comets. He first recapitulated the facts then accepted with regard to comets:—

(1) Comets, both tail and nucleus are transparent.

(2) Light is transmitted through comets without refraction; hence the cometary substance can be neither gaseous nor liquid.

(3) The light is polarized, and therefore borrowed from the sun.

(4) Comets have no phases like those of moon and planets.

(5) They exercise no perturbing influences.

(6) Donati's comet (which was then visible) in its details and its contour is changing every day—according to Piazzi, almost hourly.

(7) The density of a comet is extremely small.

(8) The absolute mass is sometimes small (von Littrow having calculated very small comets, tail and all, as scarcely reaching 8 pounds).

From these data the following conclusions might be drawn:—

(1) That a comet's tail must consist of a swarm of extremely small but solid particles, therefore granules.

(2) That every granule is far away from its neighbour—in feet, so far that a ray of light may have an uninterrupted course through the swarm.

(3) That these granules, suspended in space, move freely and yield to outer and inner agencies—agglomerate, condense, or expand; that a comet's nucleus, where one is present, is nothing else than such an agglomeration of loose substances consisting of particles.

Hence we must picture a comet as a loose, transparent, illuminated, free-moving swarm of small solid granules suspended in empty space.

The next step in Reichenbach's reasoning was to show that meteorites (of which he had a profound knowledge) were really composed of granules.

He pointed out that these granules (since called chondroi) formed really the characteristic structure both of irons and stones, so that both orders were chiefly aggregates of chondroi—stony ones in iron meteorites, iron ones in stony meteorites.

In some irons, such as Zacatecas, they exist as big as walnuts, firmly adherent, but they can be separated; inside these are balls of troilite, often firmly embedded, so that on breaking the meteorite they will divide, but in other cases so loose that they fall out, and they are smooth enough to roll off a table.

Sometimes chondroi have smaller ones sprinkled in them, sometimes dark chondroi have white earthy kernels.

In some cases these chondroi are so plentiful as to form nearly the whole mass of the meteorite. They are often perfectly round, but not always, and they are often so loose that they tumble out and leave an empty smooth spherical cavity.

The stones chiefly consist of such chondroi and their *débris*.

He adds that each magnesic chondros "is an independent crystallized individual—it is a stranger in the meteorite. Every chondros was once a complete, independent, though minute meteorite. It is embedded like a shell in limestone. Millions of years may have passed between the formation of the spherule and its embeddal."

He then goes on to remark that the chondroi of meteorites indicate a condensation of innumerable bodies such as we see must exist in the case of comets; further, that they have been formed in a state of unrest and impact from all sides. Many meteorites are true breccias; they have *many times* suffered mechanical violence. He then shows that in comets we have precisely the conditions where such forces could operate, and

[1] Continued from vol. xxxviii. p. 605.

[2] For many references in what follows I am indebted to the historical notice in Schiaparelli's "Stelle Cadente."

[3] Humboldt, "Cosmos," iv. p. 587 (Otté). Cardani, "Opera." Lugdani, 1663, t. iii. p. 279. See also Schiaparelli, "Stelle Cadente."

[4] Kepler, "Opera," ed Frisch, vol. vi. p. 157.

[5] Coulvier-Gravier et Sargey, "Introd. Historique," p. 5.

[6] *Memorie della Società Italiana*, vol. iii. p. 345, Verona, 1786.

[7] "Ueber Feuermeteore, und ueber die mit denselben herabgefallenen Massen" (Wien, 1819). See also "Ueber den Ursprung der von Pallas gefundenen Eisenmassen," p. 24.

[8] "Feuermeteore," p. 395; see Kaemtz, "Meteorologie," vol. iii. p. 316.

[9] *Les Mondes*, t. xii. p. 649, et t. xiii. p. 656.

[1] "Essai sur l'Influence des Comètes," &c. (Bruges, 1843).

[2] Coulvier-Gravier et Sargey, "Introd. Historique," p. 103.

[3] *Poggendorff's Annalen*, vol. cv. p. 438.

hence arrives at the view that "comets and meteorites may be nothing else but one and the same phenomenon."[1]

This was in 1858, eight years before Schiaparelli's discovery. Newton, as we have seen, referred the comet of 1862 to the largest meteorite in the August swarm.

We may assume from the work which has already been done that Reichenbach's view is more probably the true one, and that the head of a comet is merely the denser part of the swarm. Whether that denser part is at the end or at the beginning of the long line to which reference has been made, it does not very much matter, but where that is there we shall have the appearance of a comet presented to us in the heavens. That being so, we are able to apply everything that we have learned about comets to the movements of meteorites in space; in the case of meteors and falling stars we were limited to what took place in our own air.

The Appearances presented by Comets away from the Sun.

When a comet first becomes visible, it appears in the telescope as a round misty body, and moves very slowly in consequence of its still great distance from the sun. At this time, too, its light is very feeble. Its appearance under these conditions strikingly resembles that of a nebula, and in fact comets have often thus been mistaken for nebulæ.

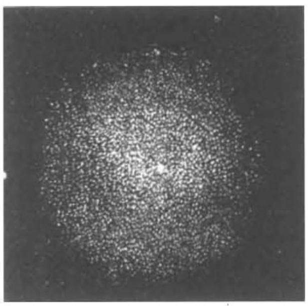

FIG. 12.—A comet near aphelion.

Occasionally the appearance put on is that of a planetary nebula in small telescopes and a globular one in larger ones.

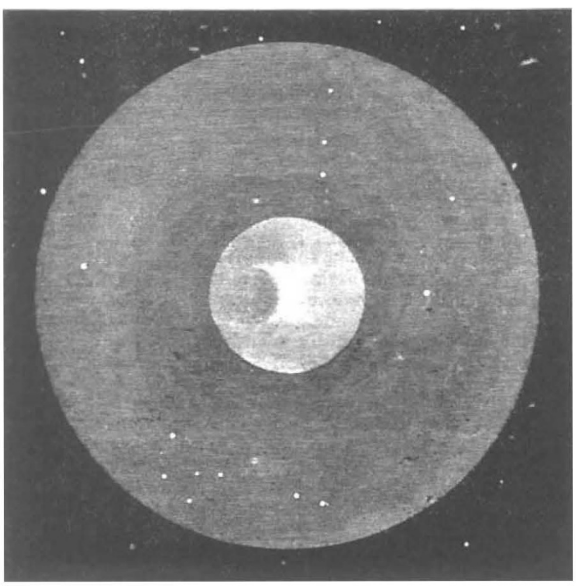

FIG. 13.—The Pons-Brooks comet, January 13, 1884 (Thollon).

The globular form, after a time, gives way, and the concentration of light is now a star-like concentration at one end of an elliptic patch.

In the next phase, both the star-like object and the elliptic patch lengthen, and the appearance becomes more like what is ordinarily recognized as a comet.

As the comet approaches nearer the earth, so that observations of its several portions may be seen, we get a still greater differentiation of the phenomena.

FIG. 14.—The first beginnings of a tail.

Fig. 16, which is a representation of Donati's comet as it appeared in 1858, will serve to illustrate the main characteristics of comets. The brighter part is called the *head* or *coma*, and sometimes there is within this a still brighter and smaller portion called the *nucleus*. The *tail* is the dimmer part radiating from the head, and this varies greatly in different comets; it may be long or short, straight or curved, single, double, or multiple. The comet of 1744 had six tails, that of 1823 two. In others the tail is entirely absent. The tail of the comet of 1861 was 20,000,000 miles in length, and that of the comet of 1843 was 112,000,000 miles long.

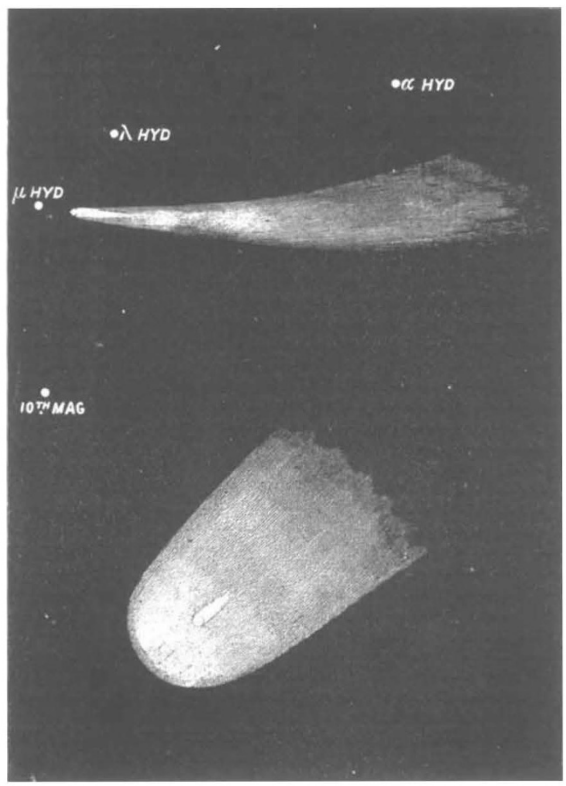

FIG. 15.—The lower portion represents the elongation of the star-like luminosity; the upper one, the concomitant extension of the whole comet (Comet 1882 October 25, Seabroke).

[1] For this analysis of a part of Reichenbach's memoir, I am indebted to my friend Mr. L. Fletcher, of the British Museum.

Both head and tail are so transparent that all but the faintest stars are easily seen through them. The star Arcturus was seen through the tail of Donati's comet in 1858 at a place where it was 90,000 miles in diameter.

As a comet approaches the sun its velocity, like that of the planets, increases, and it gradually gets hotter and gives out more light.

When the comet gets sufficiently hot, *aigrettes* or *jets* make their appearance; these are so called because they seem to shoot

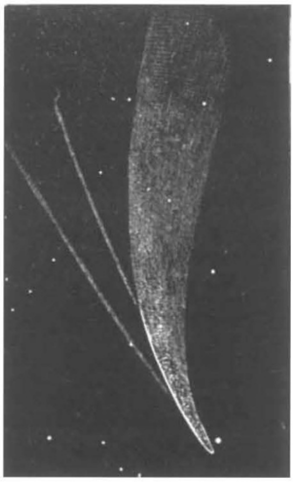

FIG. 16.—Donati's comet (general view).

out from the nucleus like sparks shoot out from a squib. The jets rapidly change their positions and directions, and the tail is formed, apparently at the expense of the matter of which the head was in the first instance built up. The tail is always turned from the sun, whether the comet be approaching or receding.

Drawings of a comet, as seen at different times, show how the jets vary in appearance and direction. Instead of jets, some comets present phenomena of a very different character, called envelopes, which are thrown off concentrically from the nucleus.

FIG. 17.—Comet with single nucleus (Cruls's comet, 1882, Riccò).

These are among the chief physical peculiarities about the heads of comets; and we see at once that we have something perfectly distinct from the planets, and that some comets are at first sight different from others. The envelopes have been observed to rise from the nucleus with perfect and exquisite regularity in exactly the same way that the jets swing backwards and forwards.

The enormous effect produced by a near approach to the sun may be gathered from the fact that the comet of 1680, at its perihelion passage, while travelling at the rate of 1,200,000 miles an hour, in two days shot out a tail 60,000,000 miles in length.

We must now enter somewhat more into details with regard to some of these cometary characteristics.

First of all, it must be pointed out that the meteoritic swarms

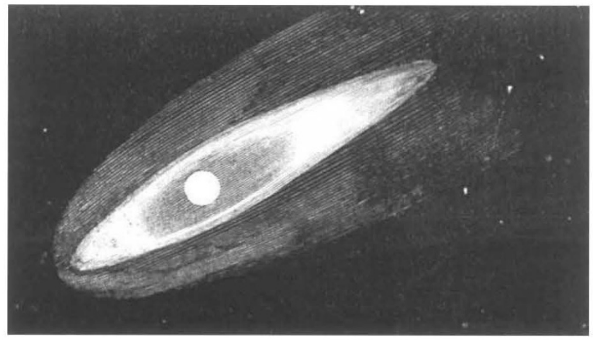

FIG. 18.—Nucleus surrounded by ellipsoidal head (Comet 1882 October 25, in Washington refractor).

are not always single, for in some comets the nuclei are double or triple.

In the case of single nuclei the nucleus may be the origin, and lie in the brighter region the extension of which forms the

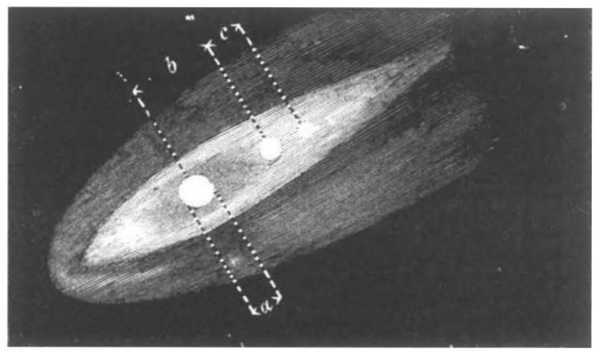

FIG. 19.—Compound nucleus (same comet November 5).

tail. But this is not invariable: the nucleus may be caught forming part of an elliptic head (Fig. 18) before any very great extension of the tail begins to take place, owing to reasons which will be stated further on.

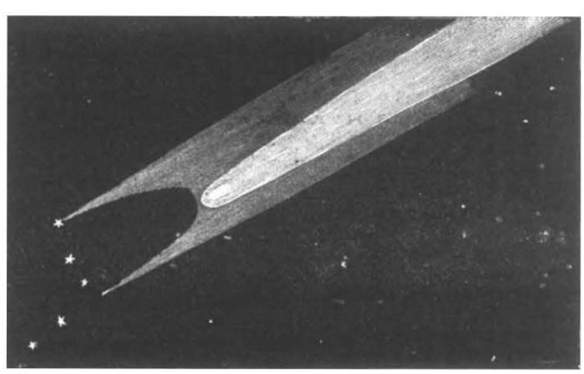

FIG. 20.—Commander Sampson's sketch of the great comet, 1882, October 10.

In the case of double or multiple nuclei we have a clear indication of the existence of more than one chief meteoritic swarm, whether they be enveloped in the same atmosphere or give rise to the same tail (Fig. 19). But it would seem that, in some cases, different nuclei may give rise to separate tails; such would seem a possible explanation of Commander Sampson's observation of the comet of 1882 (Fig. 20).

J. NORMAN LOCKYER.

(*To be continued.*)

THE ANNIVERSARY MEETING OF THE ROYAL SOCIETY.

THE anniversary meeting of the Royal Society was held on Friday last, St. Andrew's Day. The President read the anniversary address—a copy of which has not yet reached us—and presented the medals. Prof. Huxley received the Copley Medal, and Mr. Crookes the Davy Medal in person. Prof. Osborne Reynolds was also present to receive one of the Royal Medals. The other Royal Medal was received on behalf of Baron von Mueller by Sir Graham Berry, Agent-General for Victoria, and the Rumford Medal, which had been awarded to Prof. Tacchini, was received on his behalf by the Chevalier Catalani, the *Chargé d'Affaires* at the Italian Embassy. The Society next proceeded to elect the officers and Council for the ensuing year. The selected names we have already published.

In the evening about 175 Fellows and guests dined together at Willis's Rooms. Among the guests were eminent representatives of the English Government, of foreign nations, and of art and literature. Sir Frederick Leighton, in proposing "The Royal Society," said :—

"A great honour is done to me in intrusting to my hands the toast which I have risen to propose, for it is the toast round which the chief sympathies of those who sit at this table are centred, be they hosts or be they guests—namely, prosperity to that ancient and honoured body, the Royal Society. It is, indeed, a toast favoured in this—that no inadequacy of presentment could rob it of your warm reception, but it is one, also, which, in one sense, the individual now before you is so little fitted to propose that I could almost suspect you, Sir, of a little prompting of humour in your selection. I do not mean because the bodies with which you and I have respectively the honour to be connected are now, in Piccadilly, as they were in former days in Somerset House, next-door neighbours, and because it is not habitually to one's next-door neighbour that one looks in life for a kind word; but on this other and more cogent ground—that the subject on which you bid me speak is one in regard to which I am entirely ignorant, and that my attitude is therefore not free from ludicrous aspects in the face of a body to which grasp and accuracy of knowledge is the one thing needful, and precision of statement the first duty of man; and this, Sir, certainly not least in the day of your headship. And yet, on closer view, it is not knowledge, perhaps, that you require of the proposer of this toast so much as respectful sympathy; and that you find in me to the full. No, gentlemen, you do not demand in me knowledge beyond that of the average ignoramus who watches you in wonder as you sound with divining eyes the realms of the heavens above and of the earth beneath and of the water under the earth, and lay bare before us the very beat of the life-pulse of Nature. You demand in me, I say, rather, some sympathetic sense of your magnificent missions, some adhesion to the faith that you profess, and for these you do not look to me in vain. It happens to me, Mr. President, from time to time to have to acknowledge words of recognition of the services of the great institution to which I am bound in a like capacity with your own; and, knowing how earnestly that body is bent on the worthy discharge of an arduous task, such words are deeply grateful to me, but in every such case I see in my inner mind, behind and above the institution which I serve, the sweet and serene countenance of our divine mistress—of Art herself; and so, also, in offering this toast to the acclamation of your guests and to the acceptance of your flock, I am thinking less of the noble services of your renowned Society, less of the many names which are its high adornment at this time and our country's pride, than of your mistress beneficent and supreme, the scatterer of darkness—Science. All of us walk in the daylight of her illumination, the humblest layman can bear witness to her, and the most ignorant concerning the paths she treads may yet not unbecomingly declare his gratitude to her ministers, and express, as I now express, the hope that they and their successors may in the bond of this constituted brotherhood long continue to tend the flame and feed the increasing splendour of her sacred inextinguishable lamp."

The President of the Royal Society responded in a short speech, in which he compared the Royal Society to a wave of light moving onward through space, conveying intelligence from one portion of the universe to another far-distant portion. The molecules which it set in motion had but a brief existence, but the wave moved ever onward.

SCIENTIFIC SERIALS.

THE *Journal of Botany* is still largely occupied with the discussion of points connected with botanical nomenclature, in which English, American, and Genevan botanists take part. The October number contains also a description of a new genus of Berberidaceæ by the Japanese botanist Tokutaro Ito.—In the November number are papers on the genus *Carex*, by Mr. L. H. Bailey; on Ferns from West Borneo, by Mr. J. G. Baker; on South Derbyshire plants, by Rev. W. R. Linton; and on the Desmids of Maine, by Mr. W. West. Mr. W. H. Beeby records the interesting fact that of the two very nearly allied species of valerian, *Valeriana Mikanii* and *sambucifolia*, one is very attractive to cats, while to the other they are quite indifferent.

IN the *Botanical Gazette* for September, Mr. C. Robertson completes his essay on zygomorphy and its causes, summing up the results of his observations. The remainder of the number is largely occupied by abstracts of botanical papers read at the Cleveland meeting of the American Association for the Advancement of Science.—In the October number are two important anatomical papers, by Miss Emily L. Gregory on the development of cork-wings on certain trees, and an illustrated one by Mr. W. H. Evans on the stem of Ephedra. Mr. G. Vasey contributes an interesting article on the characteristic vegetation of the North American desert.

THE number of the *Nuovo Giornale Botanico Italiano* for October 1888 is entirely occupied by reports of the papers read before the annual meeting of the Botanical Society of Italy held at Florence in September, many of which are of considerable interest.—Sig. C. Massolongo describes the germination of the spores of three new species of Sphæropsideæ—*Phyllosticta Bizzozeriana*, *P. Aristolochiæ* and *Phoma Orobanches*. He maintains that the only difference between pycnidia and spermogonia is that the sporules (stylospores) contained in the former are capable of germinating directly, while those formed in the latter (spermatia) have no such power.—Sig. A. N. Berlese adds to the very numerous fungus-parasites of the vine two new ones, *Greeneria fuliginea*, S. et V., and *Ascochyta rufo-maculans*, Berk.—Sig. G. Gasperini has investigated the nature of the organisms which bring about the fermentation of the palm-wine known to the Arabs under the name of "*legbi*." He finds it to be due to *Saccharomyces cerevisiæ*, which is always accompanied by *Bacillus subtilis*. On the surface is also commonly found a pellicle of *Saccharomyces Mycoderma*.—Prof. A. Borzi describes a new species and genus of Ascomycetes—*Eremothecium Cymbalariæ*, found on half-ripe capsules of *Linaria Cymbalaria*.—The little-known germination of the seeds of the water-lily, *Euryale ferox*, is described by Sig. G. Arcangeli, the chief peculiarity being the almost entire suppression of the elongation of the radicle.—Prof. L. Macchiati claims to have discovered an entirely new substance, which he calls *xanthophyllidrin*, as a constituent of the green colouring-matter of plants. It is crystallizable, and altogether distinct from xanthophyll and from the pigment of yellow petals.—Prof. A. Borzi describes the mode in which *xerotropism* displays itself in some ferns—*Ceterach officinarum*, *Notochlæna Marantæ*, *Asplenium Trichomanes*, and several species of *Cheilanthes*; understanding by this term the mechanical contrivances by which an organ protects itself against excessive desiccation.

SOCIETIES AND ACADEMIES.

LONDON.

Royal Society, November 22.—"The Waves on a rotating Liquid Spheroid of finite Ellipticity." By G. H. Bryan, B.A. Communicated by Prof. G. H. Darwin.

The hydrodynamical problem of finding the waves or oscillations on a gravitating mass of liquid which when undisturbed is rotating as if rigid with finite angular velocity in the form of an ellipsoid or spheroid, was first successfully attacked by M. Poincaré in 1885.