length M. .166 ; of the head, .035 ; to origin of ventral fin, .063 ; of anal fin .090 ; of second dorsal fin, .096 ; of caudal fin, .141.

Besides the generic characters mentioned, this species differs from the *Protistius semotilus* of the same region, in the larger number of soft rays, the smaller eye, narrower interorbital space, etc. The lateral line is better defined in this species, but is not continued beyond the anal fin ; a few isolated tubes occur on scales on other parts of the sides.

The color of the *Gastropterus archæus* is silvery, darker shaded on the upper surfaces, and without spots on the body or fins.

Two specimens ; coll. of 1874 ; obtained by Prof. Orton, at Arequipa on the Pacific slope at an elevation of 7500 feet.

Radiation and Rotation.

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Among the most interesting of the unsolved astronomical problems, are the questions as to the origin of solar radiation and of cosmical rotation. These two problems, as I have already shown, are intimately connected, at the centre of our system, by the ultimate equality which exists between the velocity of light, the limiting centrifugal velocity of solar rotation, and the velocity of complete solar dissociation.

It has been commonly assumed that physical forces tend to ultimate equilibrium and consequent complete stagnation. The imperfections of any plan which looks to such a final result, have led some writers to suppose that there may be some compensating provisions, hitherto undiscovered, for a renewal of activity. In the search for such provisions, the equality of action and reaction and the possibility that the compensation is continually furnished, by Him who is ever "upholding all things by the word of His power," seem to have been wholly overlooked.

If we assume the existence of a luminiferous æther, whether as a reality, or as a convenient representative of co-ordinated central forces, its undulations, when obstructed by inert centres, would necessarily lead to such phenomena as those of gravitation, light, heat, electricity, magnetism, etc. Confining ourselves for the present to the action of gravitation, it is well known that the limiting velocity of possible gravitating action and consequent centrifugal reaction, at any given point, is $\sqrt{2\,gr}$, the velocity varying as $\sqrt{\frac{1}{r}}$.

If, according to the hypothesis of Mossotti, each particle is provided with a definite æthereal atmosphere, the density of that atmosphere in a condensing nucleus, should vary as $\frac{1}{r^3}$. But according to Graham's law, $v \propto \sqrt{\frac{E}{D}}$. Therefore, in order to satisfy the conditions of gravity, the æthereal elasticity, within any nucleus which is either wholly or almost wholly gaseous, $\propto \frac{1}{r^4}$.

Since such is the supposed character of the solar nucleus, it seems not unlikely that the centrifugal radiations of any heavenly body being at all times equivalent to the centripetal radiations which it intercepts, solar and stellar light and heat are only the reactionary consequences, of such perpetual internal oscillations as the æther has first transmitted to the luminous orbs and then resumed. The fact that the reaction, which is shown in the centrifugal force of solar rotation, and the action which is shown in parabolic orbital velocities, find a common limit in the velocity of light, may perhaps be regarded as a crucial test of this hypothesis, which is further strengthened by the following considerations.

In the huge comet-like nebulosity which is indicated by the solar-stellar paraboloid, the interesting relation which has been pointed out by Stockwell,* between the perihelia of Jupiter and Uranus, and the many indications of normal "subsidence," which I have shown in previous papers, suggest the probability of an early ellipsoidal nucleus, with subordinate nucleoli; the major axis of the. nucleus being bounded by 2 ♆$_5$ (60.939) and 2 ♅$_5$ (41.358), and the Sun being in the focus. The *vis viva* of condensation would give velocities of incipient orbital separation at ♆$_5$ (30.470) and ♅$_5$ (20.679), and ♃$_1$ would then be in the centre of the entire system ($\overline{30.470-20.679} \div 2 = 4.885$; ♃$_1$ $= 4.886$), even as ⊕$_3$ is nearly in the centre of the secondary system ($\overline{♂_5 + ☿_1} \div 2 = 1.017$).

If we apply Gummere's criterion ($n = 11.656854$), we find that three prominent centres of "subsidence" were determined by this early ellipsoidal nucleus. For 2 ♆$_5$ $\div n = 5.228$, ♃$_3$ being 5.203; 2 ♅$_5$ $\div n = 3.548$, which is near the outer limit of the asteroidal belt, (107)$_3$ being 3.560; (♆$_1$ — ♅$_1$) $\div n = 1.022$, the centre of the secondary system being, as above stated, 1.017. The Earth is still in the centre of a "subsidence" ellipsoid, of which the sun is in one focus, while the outer asteroidal region (3.2028) and ♃$_3$ (5.2028) are at opposite apsidal extremities of the major axis. Moreover, 3.2035 is the extremity of an atmospherical radius which would move with the velocity of light, provided the sun's surface were moving with orbital velocity, or the velocity of incipient dissociation ($\sqrt{gr}$).

It seems probable that in consequence of subsidence, Jupiter, which, as we have already seen, was the centre of nucleal volume, may have been also the centre of nucleal mass, at the time of its complete orbital separation and that it was, therefore, the primitive Sun of the extra-asteroidal planets, before it became our Sun's "companion-star." For with the present mass of

*Smithsonian Contributions, 232, xiv.

the system, and with a mean radius vector $= \Psi_1 + ♃_1$ (34.4845), the orbital period of Neptune would be 73966 days. Two successive subsidences ($34.4845 \div n^2$) would bring the solar nucleal surface to about $\frac{2}{3}$ of $☿_3$, or 54.53 solar radii. The angular acceleration of rotation, due to subsequent nucleal contraction, would $\propto \frac{1}{r^2}$. Therefore, when the Sun had contracted to its present limits, its rotation period would be $73966 \div 54.53^2 = 24.88$ days.*

If this were the only coincidence of its kind we might, perhaps, have some good grounds for looking upon it as merely curious and accidental. But the bond of connection, which we have already found between rotation and revolution, in the limiting formative undulations which are propagated with the velocity of light, may prepare us for accepting evidences of a similar bond in the phenomena of nebular subsidence.

There are three other known systems of cosmical rotation, which may help us to judge as to the rightfulness of such an acceptance, viz.: that of the extra-asteroidal planets, with an estimated average period of about 10 hours; that of the intra-asteroidal planets, with an estimated period of about 24 hours, and that of the moon, with a synodic period of 29.5306 days. If these periods are dependent upon the same subsidence which led to the early belt formations, we may reasonably look for evidence of that dependence of a character similar to that which we have found in the case of the sun.

We have seen that the first subsidences from $2\,\Psi$ and $2\,♃$, account for the orbital ruptures of Jupiter and the Earth; secondary subsidences from points within the orbital belts, account for these three rotation periods. For $♃_5 \div n = 101.73$ solar radii and Jupiter's orbital revolution (4332.585 dy.) $\div 101.73^2 = 10^h.05$; $⊕_4 \div n = 19.66$ solar radii and Earth's orbital revolution (366.256 dy.) $\div 19.66^2 = 24^h.205$; $☽_4 \div n = 5.442$ Earth's radii and Earth's rotation $\times 5.442^2 = 29.619$ dy. In these accordances we have additional evidence of the equality of action and reaction.

The normal character of rotation is still further traceable, even after the formation of the subordinate planets in the two principal planetary belts. If we seek the point of incipient condensation, which would lead to such rotation periods as have been generally assigned by astronomers to the different planets, we readily find that Gummere's criterion, Newton's third law, and the law of equal areas, lead to the formula $n\left(\frac{T}{t}\right)^{\frac{1}{2}} = \frac{R}{\rho}$, in

*These relations may have an important bearing on Croll's hypothesis of the origin of solar radiation. In the stellar-solar paraboloid, of which traces still exist between Sun and *α Centauri*, there must have been frequent collisions. Some of Croll's critics have shown strange misapprehensions as to the possible velocity of collision. The limit of possible relative velocity, from the simple gravitation of two equal meeting masses, is $2\sqrt{2gr}$. This would be equivalent, taking the values of g and r at Sun's apparent surface, to $.01774\,r$, or more than 750 miles per second. If projection were added to gravitation, or if the two masses had small solid nuclei of great density, while the greater part of their volume was gaseous, or if there were a large number of equal masses, the limit of possible velocity might be largely increased.

which n = Gummere's criterion ; $\frac{T}{t}$ = number of planetary rotations in one orbital revolution ; R = radius of nebular contraction ; ρ = Sun's present radius. Taking Herschel's values for T and t we have

	$n\left(\frac{T}{t}\right)^{\frac{1}{2}}$		$\frac{R}{\rho}$ (1)		$\frac{R}{\rho}$ (2)
☿	110.4	☿$_5$	102.4	$\frac{1}{2}$⊕$_4$	111.1
♀	177.6	♀$_5$	166.4	$\frac{1}{2}$♂$_4$	176.6
⊕	223.1	⊕$_4$	222.2		
♂	361.8	♂$_2$	301.5		
③	445.4	③	427.1 to 719.4	2⊕$_4$	444.4
♃	1192.5	♃$_5$	1185.9		
♄	1829.5	♄$_1$	1876.7		
♅	3245.7			$\frac{1}{2}$♆$_4$	3258.9

It thus appears that :

1. All the points of incipient condensation, $\frac{R}{\rho}$ (1), are within Kirkwood's "spheres of attraction."

2. In the pair of extra-asteroidal planets which are nearest the asteroidal belt, the incipient points are near the *secular* aphelion of the inner, and the *secular* perihelion of the outer planet.

3. In the pair of intra-asteroidal planets which are nearest the asteroidal belt, the incipient points are near the *mean* aphelion of the inner and the *mean* perihelion of the outer planet.

4. The sum of the radii of nebular contraction, for the two principal planets of the solar system (1192.5 + 1829.5 = 3022), is almost precisely equivalent to the sum of the mean perihelion radii of the same planets (♃$_2$ 1069.6 + ♄$_2$ 1950.4 = 3020).

5. The secondary points of incipient condensation, $\frac{R}{\rho}$ (2), are all referable, through the simple accumulation of *vis viva*, to primary mean aphelia.

6. The significance of the fourth accordance is increased by Stockwell's discovery,* that "the mean motion of Jupiter's node on the invariable plane is exactly equal to that of Saturn, and the mean longitudes of these nodes differ by exactly 180°."

7. Gummere's criterion confirms the theory of Democritus, that the evolution of worlds was due to a vortical movement, which was generated by the descent of the heavier atoms through the lighter.

* Loc. cit.

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