EXPLANATION OF THE EMPIRICAL TERMS OF THE MOTION OF THE MOON BY ASSUMING GRAVITATIONAL EXTINCTION IN THE EARTH'S INTERIOR

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In his tract "On the application of the fundamental natural laws of the universe,"[2] Geheimrat von Seeliger says in his critique of the Newtonian Law of Universal Gravitation: "The placement of a third body between two others in question may affect the mutual attraction between the latter, and thus may cause deviations from the Newtonian formula, which can perhaps be described as 'absorption' of gravitation. Such deviations appear reasonably plausible and thus to have a good change of discovery. They would be, in the final analysis, observable in the movement of the moon; and probably only there."

It was on this initiative that I undertook this investigation. Below I present its main points and results. The basic study, including the documentary material and more detailed interpretation will be published soon.

In every lunar eclipse, the earth enters the space between the moon and the sun. On their way to the moon, the "gravitation rays" from the sun must pass through the earth. It was here assumed that the expected extinction [of gravitation] would be proportional to the penetrated mass (of the earth). The effect would manifest itself as a repulsive force aligned along the earth-sun line, essentially along the radius vector of the moon's orbit. Furthermore, if we assume that the integral over time of the repulsive force can be represented as an impulse,[3] then the mean period should show the effect (which is the only effect considered here), and that can be easily be detected by the method of varia-

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[1] This article, originally published under the title "Die Erklärung der empirischen Glieder der Mondbewegung durch die Annahme einer Extinktion der Gravitation im Erdinnern," appeared in the *Astronomische Nachrichten*, **191**, No. 4568, Cols. 147-150, 1912. The translation was done by Gunther Wolf.

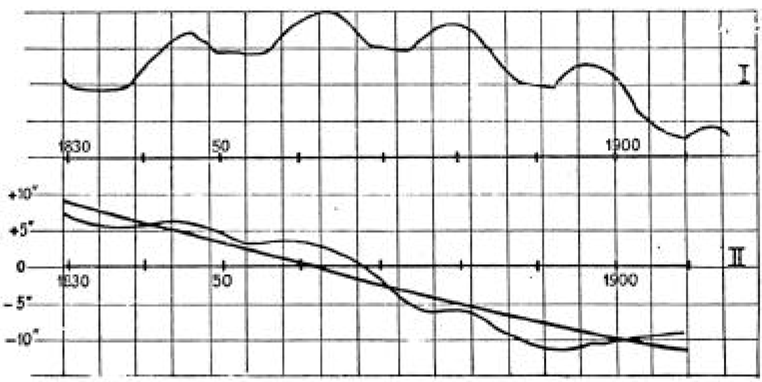
[2] von Seeliger, G., 1909. "Über die Anwendung der Naturgesetze auf das Universum," *Sitzungsberichte der Kgl. Bayr. Akademie der Wissenschaften*, p. 12.

[3] Many know that the rate of change in position (derivative) is called velocity, and that a change in velocity is called acceleration. The corresponding change in acceleration is called "Impulse."

tion of orbital elements. The impulse is a function of the magnitude of the eclipse, which depends then only on the density distribution of the earth's interior. I took the distribution of Prof. Wiechert, its rendering being the most convenient for computation, where for simplification, the sun and moon are assumed point masses. The perturbation to be observed is then obtained as the sum of the perturbations of all preceding eclipses.

In this way, I computed the history of the perturbation for all eclipses, both partial and total, from 1830 until 1913.

In his article published in the *Monthly Notices of the Royal Astronomical Society*, 69, entitled "Unexplained Fluctuations in the Mean Motion of the Moon," S. Newcomb reported on an extensive investigation into the empirical terms in the moon's orbital motion. I compared my computations to his empirical results.



The above figure shows the deviations of the observed mean lunar nodal longitude from the computed ones. Curve **I** follows my computation, which assumes absorption of gravity, and curve **II**, follows Newcomb. Note that there is an almost complete match of all minima and maxima from 1830 to 1895. One is thus immediately led to the conclusion that the true cause has been found, at least for these short-period fluctuations. Nevertheless, the absence of my computed maximum [centered on 1895–*Ed*.] in Newcomb's curve remains unexplained. This can hardly be invoked as an argument against the theory since in the calculations, various effects (especially the density distribution of the earth's interior) are uncertain, and, therefore, the shading function also.

If one then assumes the absorption as the cause of Newcomb's terms, one derives a value for the attenuation of a ray of gravity (passing through the center of the earth). That value is 1/60,000. By comparison, the absorption coefficient in the cgs-system for an earth made entirely of water is $\lambda = 3 \cdot 10^{-15}$.

A foremost check of this hypothesis could be effected by confirmation of this result by another researcher in the field and/or through, perhaps, somewhat different assumptions. Also, the Martian moon Phobos might be suitable for such an investigation since the latter also experiences lunar-type eclipses. According to my estimates, the respective perturbation may amount to perhaps 10° to 20° of apsidal longitude.

Also, the component of the absorption-induced perturbation perpendicular to the orbital plane might exhibit this attenuation of gravitation. But this must await the availability of more sensitive instrumentation (as I noted in *Astronomische Nachrichten* 4550). Using the absorption coefficient just determined, these fluctuations would amount to:

$$\mathbf{I} = 0''.001 \sin 2z$$
$$\mathbf{II} = 0''.0004 \sin z.$$

For a more detailed justification of these expressions, I must refer to the exhaustive study to be published later.

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