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IRREGULAR VARIATIONS OF EARTH'S ROTATION VELOCITY AND ACTION OF SOLAR CORPUSCULAR STREAMS ON THE EARTH'S MAGNETOSPHERE

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ABSTRACT

The author attempts to explain the irregular variations of the Earth's rotation velocity by action of solar corpuscular streams on the Earth's magnetosphere, in particular on its tail, by discussing the position of the magnetosphere tail for various geomagnetic conditions, and then referring to the daily observation data collected between 1961 and 1963. A conventional parameter is computed on the basis of these data, and it is found that its behavior in all the cases considered was of same order, independently from the objectives of the current note. The main argument in favor of the hypothesis brought forth is the accounting for the noncoincidence in the direction of the magnetic field of the stream and of the geomagnetic field in the tail, which is characterized by a certain asymmetry due to universal geomagnetic anomalies.

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The irregular variations of the Earth's rotation velocity may tentatively be explained by the action of solar corpuscular streams upon the Earth's magnetosphere, and more particulary on its tail [1 - 3].

The latter are responsible for the creation of geomagnetic events, united in the notion of geomagnetic storm families [4]. The streams consist of a narrow axial part(jets), formed by a chain of M-elements [5], and of broad periphery. According to our own data the axial part has near the Earth's orbit a diameter $\sim 10^{12}$ cm and a periphery with diameter $\sim 10^{13}$ cm. According to [5], in the peripheral part the magnetic field is directed along the stream's isochron, generally to one side (for example, from the Sun), whereas in the axial part of the stream, having a more complex structure, the field is directed to the other side. This field H_m depends in the peripheral part of the stream on the distance $\underline{r}$ to the axial line, according to the law $H_m \sim r^{-2}$.

Under conditions, when there is no geomagnetic disturbance on Earth, the magnetosphere tail is disposed along the isochron of a quiet solar wind. (Note

* IRREGULYARNYYE IZMENENIYA SKOROSTI VRASHCHENIYA ZEMLI I VOZDEYSTVIYE SOLNECHNYKH KORPUSKULYARNYKH POTOKOV NA SHLEYF ZEMNOY MAGNITOSFERY.

that when this wind's velocity is $\sim 2 \cdot 10^7$ cm sec^{-1} the wind's isochrones form an angle of $\sim 70°$ with the line Sun-Earth). The geomagnetic field H in the tail is directed in the Southern part from the Earth, and in the Northern part toward the Earth. The northern and southern parts of the magnetosphere and of its tail are not entirely symmetrical because of the presence of universal geomagnetic anomalies. The tail's cross section by the "orbital plane" or the "orbital cylinder" (this cylinder has for directrix the Earth's orbit, and for generatrix a line perpendicular to the ecliptic plane) may be considered as a circle. If the length of this circumference is $L = 2\pi\rho$, the length L_1 of the arc in the northern part of the magnetosphere is $(2\pi + \beta)\rho$, and the length L_2 of the arc in the southern part is $(2\pi - \beta)\rho$, whereupon $\beta << \pi$.

When there appears a flux in the vicinity of the Earth, forces of the form $HH_m \sin\gamma$ emerge on the surface of the tail, where γ is the angle between the stream's isochrons and the quiet solar wind. If the tail is bounded by a cylinder of radius ρ and length l, the resultant of forces $HH_m \sin\gamma$ is $F = 2\beta\rho l^2 HH_m \sin\gamma$. Introducing this expression into the basic dynamics equation of a rotating body (assuming that the lever of the force is $l/2$), we have

$$\beta\rho l^2 HH_m \sin\gamma = I\frac{d\omega}{dt}.$$

Here I is the moment of inertia (practically equal to that of the Earth); ω is the angular rotation velocity.

It is possible to find the integral effect ε of stream's action on Earth's rotation. Taking into account that $\omega = 2\pi/T$ (T being the number of seconds in a day), $H_m = M'/r^2$ (M' being the magnetic moment per unit of length of stream's axial line), $\Delta\phi$ is the difference between the heliographic latitudes f the Earth and of stream's axial line, ω_0 is the stream's angular velocity relative to the Earth in a direction along its orbit, and denoting A.U. $\Delta\phi = r_\phi$, $r_0 = 2$ A.U., $r_1 = 19.5°$ A.U. (r_0 and r_1 are the radii of the axial part of the stream and of the entire stream on the orbital cylinder), finally, denoting

$$-\frac{\beta\rho l^2 H \sin\gamma T^2 M'}{2\pi I} = A,$$

we have

$$\varepsilon = \frac{2A}{\omega_0 r_\varphi}\left(\operatorname{arctg}\frac{\sqrt{r_1^2 - r_\varphi^2}}{r_\varphi} - \operatorname{arctg}\frac{\sqrt{r_0^2 - r_\varphi^2}}{r_\varphi}\right) - \frac{2A}{r_0^2\omega_0}\sqrt{r_0^2 - r_\varphi^2}.$$

If the Earth does not enter the axial part of the stream ($r_\phi > r_0$), we have

$$\varepsilon = \frac{2A}{\omega_0 r_\varphi}\operatorname{arctg}\frac{\sqrt{r_1^2 - r_\varphi^2}}{r_\varphi},$$

and if it passes exactly through the axial line of the stream ($\Delta\phi = 0$), we have

$$\varepsilon = -\frac{2A}{\omega_0 r_1}.$$

Part of expression A is constituted of quantities β, ρ, l, H. M', of which the numerical values are not known exactly. Combining them into a single comultiplier $f = \beta\rho l^2 HM'$, we shall obtain

$$A = -f\frac{\sin\gamma T^2}{2\pi I}.$$

Between January 1961 and June 1963, we disposed of daily values of ΔA_0 [1] and of the catalogue for storm families, in which the values of $\Delta\theta$ and Δt were available (Δt being the lag in days of geomagnetic events relative to solar events). This allowed us to compute f for a series of cases of stream action upon the rotation of the Earth. The order of f was reliably determined (10^{56} $cm^4 g \cdot sec^{-2}$). The same order for f was obtained at its determination according to the mean annual variations of ω (according to Brauer data; see [2]) by the formula

$$\Delta\Delta t = -365{,}25\frac{fT^3 \sin\gamma}{2\pi I r_\varphi^2},$$

in which mean annual values of γ, r_ϕ are introduced (Δt is the discrepancy in time [6], and $\Delta\Delta t$ is the variation of Δt from year to year).

The fact that the numerical values of f were found to be of same order in all the considered cases (daily as well as average yearly), and though they were actually determined by the quantities $\Delta\phi$ and Δt, found independently from the aims of the present note, is evidence in favor of the proposed explanation. The highlight in it is the accounting for the noncoincidence of the direction of the magnetic field of the stream with that of the geomagnetic field in the tail of the magnetosphere, which has a certain characteristic asymmetry on account of universal geomagnetic anomalies.

Let us note, moreover, that the proposed scheme validly explains also the 22-year cycle of Earth's rotation velocity [2], provided we account for the variations of polarities of active regions on the Sun in the neighboring 11-year cycles and the Shpoerer's law on the variation of latitude of active zones in them.

*** THE END ***

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(*) In transliteration