(8) or by (7) it is possible to describe satisfactorily elastic π^+p scattering through 90° at sufficiently large energies by means of the contribution of the Δ_δ trajectory.** The angular distribution of the cross section

$$\frac{d\sigma}{d\Omega} = |f(s,z)|^2 + \sin^2\theta\,|\tilde{f}(s,z)|^2 \quad (11)$$

also agrees near 90° with the experimental values for energies $P_{lab} \gtrsim 3.5$ GeV/c (Fig. 3). (In the forward hemisphere, the contribution of the t-channel is large.) We note the following important circumstance: At high energies, in spite of the presence in formulas (2) and (3) of Legendre functions with oscillating real and imaginary parts, the π^+p scattering angular distribution corresponding to the contribution of one Δ_δ Regge trajectory is described on the whole by a smooth curve which is symmetrical with respect to $z = 0$, and which has a minimum at this point. The presence of a minimum at $z = 0$ is characteristic of experiments at $P_{lab} \geq 3.5$ GeV/c [8], i.e., in the region where the plot of Fig. 2 agrees with the experimental data.

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* A similar idea was used recently by Desai et al. [2] to describe the polarization occurring during the charge-exchange process $\pi^-p \to \pi^0n$. The authors became acquainted with a preprint of this paper after completing the present work, and are grateful to K. A. Ter-Martirosyan for supplying this preprint.

** Estimates show that if the Δ_β trajectory exists and if its residue decreases with energy more rapidly than the residue of the Δ_δ trajectory, then the contribution of the Δ_β trajectory to the cross section of the process can improve the agreement between theory and experiment at medium energies, without making the agreement worse at high energies.

MAGNETIC-GRAVITATIONAL ANALOGY AND THE POSSIBLE CONSEQUENCES FROM GENERAL RELATIVITY IN COSMOGONY

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The tensor nature of the gravitational field leads, even in the linear approximation, to additional forces that act on a moving particle and which in principle are absent in

Newton's gravitation theory.

A few years ago Abdil'din [1] advanced certain hypotheses concerning the influence of these forces (which are analogous to the forces in a field with a Lense and Thirring metric [2]) during the formation of the solar system. These forces, were identified, in particular, as the reason why the planets all orbit in approximately the same plane. In [1] are given general formulas of higher approximations, obtained by methods developed by V. A. Fock [3].

Without ascertaining the causes of the complanarity of planetary orbits, it is of interest to estimate the perturbations caused by general relativity effects in the planet parameters.

We propose to start in the calculations not from the Langrangian of the system of the gravitating bodies, but using the magnetic-gravitational analogy. Such an analogy between electrodynamics and linear approximations in general relativity was indicated by Smorodinskii [4]. Further proof is afforded by the gravitational Zeeman effect, indicated by Ya. B. Zel'dovich [5]. The author and Guseinov [6] have shown that when the core of a star rotates in the same direction as its shell, an additional attraction is produced between the shell and the core, similar to the attraction between two parallel currents.

Inasmuch as the periods of the planets in their orbits are much shorter than the characteristic times of variation of the orbit inclination, the mass of each planet can be regarded as uniformly distributed over its orbit. Consequently the force due to the rotation of the other planets per unit orbit length (assuming that the orbit is a circle) is

$$\vec{f}_{gr} = \left[\frac{mv}{2\pi R}\, rot\, c\mathbf{g}\right]. \tag{1}$$

If the field were to be produced only by a central spherically-symmetrical body with angular momentum $\vec{M}$, then

$$\vec{g} = \frac{2G}{c^3 r^3}[\vec{r} \times \vec{M}]. \tag{2}$$

This formula certainly does not apply in our case, since the sun has a much smaller angular momentum than the planets, and the latter determine the effect in question.

With the aid of formulas (1) and (2) we can determine the rules for the transformation from magnetostatic quantities into gravitational ones. Indeed, the force per unit length of a conductor with current I is

$$f_M = \left[\frac{I}{c}\, rot\, A\right], \tag{3}$$

where the vector potential A is given by the expression [7]

$$A = \frac{\vec{M} \times \vec{r}}{r^3}. \tag{4}$$

Here M is the magnetic moment of the current generating the field.

From a comparison of (1) with (2) and of (3) with (4) we get the following rules for the transformation from magnetostatics to gravitation:

$$I/C \to a\frac{mv}{2\pi R}, \quad M = -\frac{1}{a}\frac{2G}{C^2}M, \quad a = \frac{2\sqrt{G}}{C}. \tag{5}$$

In (5) we have introduced a coefficient α for the purpose of mutual reconciliation of the indicated transitions, since $M = IS/C$ where S is the area encompassed by the circular current.

Having established the transformation rules, the problem of interest to us can be considered in the magnetostatic formulation, after which we transform to gravitation.

Let us consider, for example, the motion of the orbit of Mercury (M) under the influence of the rotation of Jupiter (J) - the planet having the largest orbital angular momentum in the solar system, namely M_J.

Since $M_M/M_J \approx 4.9 \times 10^{-5}$ and $R_M/R_J \approx 7.7 \times 10^{-2}$, the orbit of Mercury can be represented as a "trial loop with current" in the quasihomogeneous "magnetic field" of Jupiter. According to the rules of magnetostatics [7], the torque acting on a current-carrying coil in such a field is

$$K_M = \dot{M}_M = [M_M \times H_J]. \tag{6}$$

For the "magnetic field" generated by the revolution of Jupiter in the region of Mercury's motion we have in accordance with [7], in an approximation that is permissible by the ratio of the radii of the two orbits, $H_{Jz} \approx 2\pi I_J/CR_J$, $H_{Jr} = H_{J\varphi} = 0$. We have introduced here a cylindrical coordinate system connected with Jupiter's orbital plane.

Now, transforming to gravitation in (6) with the aid of (5), we get

$$\frac{dM_M}{dt} = [(\frac{2G}{C^2}R_J^{-3}M_J) \times M_M]. \tag{7}$$

This equation signifies that M_M precesses around M_J with an angular velocity

$$\Omega_{pr} = \frac{2G}{C^2}R_J^{-3}M_J; \qquad |\Omega_{pr}| \approx 6 \cdot 10^{-20}\,\mathrm{sec}^{-1}. \tag{8}$$

The complete revolution of the vector M_M (assuming the parameters of the planets in question to be constant) lasts 3.3×10^{12} years. We note that this is longer than the age of the solar system, 10^9 - 10^{10} years.

Allowance for the influence of other planets decreases the foregoing time by not more than one order of magnitude.

In the case of the precession of the orbit of Mercury due to the sun ($\odot$) (the metric of Lense and Thirring), we have

$$\Omega_{pr} = \frac{2G}{C^2}R_M^{-3}M_\odot .$$

This is smaller by about one order of magnitude than the precession under the influence of

Jupiter.

Let us consider further the precession of the proper angular momentum of the earth (E) under the influence of its own orbital motion ("spin-orbit interaction").

According to the magnetic analogy we have for the torque acting on the earth

$$K_E = \dot{M}_E = [M_E \times H_E]. \tag{10}$$

Here H_E can be represented as the intensity of the magnetic field produced by a linear current whose direction coincides with the velocity of the orbital motion v_E.

From (10) it follows with the aid of (5) that M_E precesses with an angular velocity

$$|\Omega_{pr}| = \frac{2G}{C^2} \frac{m_E V_E}{\pi R_E r_E} \approx 8{,}8 \cdot 10^{-17} \text{ sec}^{-1}. \tag{11}$$

Here R_E is radius of the earth's orbit, and m_E and r_E are the mass and radius of the earth.

According to (11), the axis of the earth tilts ~0.06" per century. Such quantities can be measured in principle, but the situation is aggravated by the relatively large precession of the earth in accordance with Newton's laws (50.24" per year) under the influence of the attraction of the moon, sun, and the planets.

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ABSORPTION AND SCATTERING OF LIGHT BY EXCESS ELECTRONS IN LIQUID HELIUM

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An investigation of the mechanism of charge motion in liquid helium has shown that a cavity of approximate radius 20 Å is produced in the helium around an excess electron. To the electron, the cavity represents a potential well of approximate depth 1.3 eV. Such a well can accommodate several (~10) electron levels. If a beam of light passes through liquid helium containing excess electrons, effects connected with transitions of the electrons between the levels, namely absorption of resonant frequencies and scattering, can be observed. Some ideas concerning the optical properties of excess electrons in helium were already