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# RMS velocities and magnetic fields in the Earth's liquid core

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A hypothesis has been put forward and partially (based on order of magnitude estimates) confirmed that the integral power of the Lorentz magnetic force is determined by the square of the vector product of the magnetic field vector and the velocity vector of the electrically conductive flow in the liquid core of the Earth. In this case, we neglect the integrand of the alternating sign component of this power, which, when integrated, can practically be zeroed out, which still needs to be justified practically based on self-consistent 3D numerical models or proven theoretically if this is possible.

Integrals based on the equations of momentum and induction of the geodynamo is physically correctly simplified to a dynamic system of two ordinary differential equations for the rms convection velocity and the rms magnetic field in the Earth's liquid core. Convection and through it magnetism are generated due to the sufficient power of Archimedes' buoyancy force, which is given in integral form as, generally speaking, a function of time $a(t)$ based on the known and estimated heat and mass transfer in the outer liquid core of the Earth. Other parameters of the system are the magnetic diffusion time and kinematic diffusion time estimated from observations and theory. The last (fourth) combined parameter $L$ of the resulting system is determined by the ratio of the characteristic size to the typical sine of the angle between the velocity vector and the magnetic field vector. This parameter is an order of magnitude greater than the radius of the Earth’s core, which indicates the almost parallelism of convective currents and magnetic field lines. Accordingly, the geodynamo is a highly nonlinear system with the magnetic field energy significantly dominant over the kinetic energy.

The main stationary points of the system corresponding to a non-zero magnetic field are obtained. For them, with a typical stationary velocity of 1 mm/s and a magnetic diffusion time of about a thousand years, $L$ = 30 Mm. This, in addition to point 1 above, indicates a corresponding and very significant excess of the critical geodynamo level. With a typical geodynamo power $a$ = 0.3 pW/kg, I find that for the very existence of a significant stationary magnetic field, it is necessary that the kinematic diffusion time exceed a value of the order of one month. If, as is typical for a geodynamo, this condition is satisfied with a margin, then the rms magnetic field is quite large - about 10 mT (100 G), which corresponds to a geodynamo of a strong Braginsky field. At the same time, the relative geomagnetic energy is about $10^{-2}$ J/kg, which is significantly greater than the relative kinetic energy ~$10^{-6}$ J/kg.

It is shown that the specific power of the Archimedes force $a$ is usually large enough for the main stationary points to be stable and for small deviations from them the system returns to them, reducing the initial deviation by $e$ times in about a quarter at the parameter values accepted above. This extremely short time period of several months may well correlate with such a phenomenon as the well-known geomagnetic jerks, the physical nature of which still remains unclear. In this case, periodic oscillations occur with a period of about a decade, which are in excellent agreement with directly observed and well-known geomagnetic variations.

It was found that secondary stationary points with a zero magnetic field are stable in velocity, but under realistic conditions for a modern geodynamo, they are unstable in the magnetic field, moving away from the zero fields. However, with a rather low convection speed possible in the past, a tendency towards a stationary zero of the magnetic field could appear. These original manifestations of the geodynamo, apparently, can be associated with inversions and excursions, and possibly with a catastrophic zeroing of the geomagnetic field.