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Planetary convection in fast rotating plain layer

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ABSTRACT

With the allowance for fast rotation, the system of equations for the convection similar to that taking place in the core of the Earth and other terrestrial planets is cardinally simplified in a plain layer. Here, my new key coefficient of similarity δ is scaled out from this simplified dimensionless system in the main order with fairly high accuracy. This small parameter δ ($\approx 2 \times 10^{-3}$ for the Earth) is equal to the ratio of the typical hydrodynamic size perpendicular to the rotation axis to the liquid core's thickness. The δ value that can be actually achieved on the present-day computers can successfully replace the Ekman number E ($\approx 10^{-15}$ for the Earth), which has been used for one century and which can barely be achieved in the computations in the foreseeable future. Even more old and extreme inverse Rayleigh number $1/Ra$ ($\sim 10^{-27}$ for the Earth's core) can be replaced in the similar way by the dissipation/generation ratio s suggested by me, which is $\sim 10^{-6}$ for the Earth's core. While for the fairly arbitrarily combined convection, I obtain a very large critical value of the dissipation/generation ratio: $s = 1200$. Thus, convection is very easily excited and is turbulent on the small scales. The correspondent turbulent s value on the large scales is limited from above by the value of ~0.04. The lower limit for s is still to be estimated; however, it cannot be too low. Here, I obtain that turbulent convection is not very much above its critical level, which is perhaps the main substantiation of the successful 22-year numerical modeling of the geodynamo-type systems. Wherein, turbulent transport coefficients are by several orders of magnitude higher than the corresponding molecular values. These features allow the strongly simplified numerical models to be used for the successful approximation of the geodynamo-like systems. Applications toward convection evolutions linked to the modern/past/future magnetism are suggested for the Mercury, Venus, Earth, Moon, Mars and Ganymede from the present theory.