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A New Model For The Geomagnetic Power Spectrum, With Application To Planetary Core And Dynamo Radius

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According to the so-called white noise hypothesis, the geomagnetic spectrum is expected to be independent or weakly dependent on the spherical harmonic degree at the core-mantle boundary. This property has been used to magnetically estimate the radius of the outer core of the Earth or more generally the radius of the dynamo region. However errors associated with this approach may be large (100s of kilometers), while some terms are found to be above or below this 'flat' spectrum line. Here we propose two new analytical forms to describe the Mauersberger-Lowes geomagnetic field spectrum at the core-mantle boundary. We find that two sub-families of the geomagnetic field exhibit a flat spectrum at the core-mantle boundary. The first family is the non-zonal spectrum (the non axisymmetric field). The second one is the quadrupole family (the symmetric field about the equator), We test our two fits using two approaches. First we estimate at the seismic core radius the agreement between the actual spectrum and the theoretical one. Second we estimate the magnetic core radius, i.e. what is the maximum depth from the Earth's surface at which the spectrum flattens. In both cases we show that the two sub-families offer a better agreement with the actual spectrum compared with previously proposed analytical expressions, while predicting a magnetic core radius within less than 10 km of the seismic core radius. These new fits supersede existing expressions to infer the core radius from magnetic field information because the low degree terms can be used. We apply these new methods on the magnetic field models of Jupiter, Uranus and Neptune, and obtain new estimates of their dynamo region radius. Our formalism may be also implemented to extrapolate the geomagnetic field spectrum beyond observable degrees.