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The origin of the main field

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Early in the twentieth century Einstein described the problem of the origin of the earth's magnetic field as being one of the five most important unsolved problems in physics. Since then, major advances have been made and it is now generally accepted that the main field originates from some form of dynamo process taking place in the earth's outer core. However, the 'dynamo problem' has not yet been solved and remains one of the most challenging mathematical problems ever formulated. Significant progress was made during the 1950s and 1960s with the nearly axisymmetric model developed by Braginsky and the mean-field concept instituted by Krause and Radler. Since then dynamo theorists have continued to search for ways to simplify the mathematics.

In the dynamo problem, the core which is fluid and a good conductor of electricity, is considered to be in motion and so by motional electromagnetic induction generates and sustains its own magnetic field. Also the core material must be considered to be equally good at conducting in all directions, so that particular insulated paths for the flow of electricity (as occur in the common dynamo of electrical engineering) are not allowed, and the dynamo is described as 'homogeneous'. The details of the process must change with time, to explain the observed secular variation of the earth's magnetic field and particularly its reversals over geologic time, known from paleomagnetism.

Energy must be continually supplied to such a dynamo to maintain its electric currents and magnetic fields. In the case of the earth's dynamo, possible sources of this energy are thermal energy in the core, gravitational energy released by heavy material sinking and light material rising, and the energy of the earth's rotation.

Observations of changes of the main geomagnetic field with time are providing valuable information in the search for details of the dynamo process. These changes are evident in the secular variation over the last several hundred years, and on longer time scales, in archeomagnetic and paleomagnetic data.