Project description for general public

Project title: Buoyancy driven magnetic dynamo.

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The main goal of this project is determination of magnetic field characteristics generated by buoyancy effects – the magnetic buoyancy in the context of the Solar interior and thermal and compositional buoyancy in the Earth's core context. In the former case the aim is to consider all the fundamental effects determining the dynamics in the Solar tachocline, i.e. strong toroidal field strengthening with depth, thermal effects including conduction, fluid's resistivity and viscosity, velocity shear and density stratification to determine the main spatial and temporal characteristics of the magnetic field dynamics in this region. These will be used to derive an effective system of dynamical equations governing the magnetic field evolution in the tachocline and capturing the crucial characteristics of solar magnetic field dynamics. Such an effective set of equations will constitute a very useful tool for modeling the time variation of the Solar magnetic field and the magnitude of the field at the surface, thus allow for much more detailed modeling and understanding of the Solar activity.

Previous works concerning the nonlinear evolution of the magnetic buoyancy instability and the dynamo generated by this instability, such as e.g. Kersalé *et al*. 2007, *Astrophys. J.* **663**, L113 or Davies & Hughes (2011), *Astrophys. J*. **727**, 112 etc. did not identify the major length and time scales in the analysed dynamical process and hence did not profit from the knowledge of the manner in which the dominant physical effects enter the dynamics. The possible ground-breaking gain of describing the physics of the Solar tachocline and detecting the right spatial and temporal variation scales in that region has serious practical implications since it gives solid grounds for understanding the solar activity, and in that sense is related to predicting intense activity periods and thus forecasting magnetic storms on the Earth. The magnetic storms caused by violent eruptions on the Sun's surface during intensified activity periods, which themselves result from relaxation of energy accumulated in magnetic field deformation in Sunspots, have a profound impact on plasma dynamics in the Earth's magnetosphere and ionosphere. The main effects include heating up the atmosphere and thus influencing significantly the atmosphere dynamics and weather, interruptions in the HF communication and in satellite motion and in the case of strong storms even destruction of electronic equipment on satellites and temporary decrease of the Earth's large scale magnetic field.

The intensity of disturbances in the cosmic environment associated with the Solar activity is typically described by the solar activity indices, such as the relative Sunspot number (Wolf number) R describing the total number of sunspots and spot groups and dark spot characteristics or the index F10,7, which describes the intensity of Solar radiation of frequency 2800 MHz, expressed in units 1022 W/(m2Hz). Those indices reveal a large spectrum of oscillations in the dynamical evolution of the Solar magnetic field, in particular exhibit the well-known 11-year Solar cycle. The results of the project concerned with the fundamental aspects of Solar magnetic field's evolution will allow for a detailed understanding of the physics and effective modeling of the Solar dynamo thus setting grounds for a more precise space weather forecast.

Finally, the second goal of the project is concerned with the Terrestial dynamo process, induced by convection, with a possible contribution from the so-called MAC (Magneto-Archimedean-Coriolis) waves in the iron liquid core and in the context of social impact is tightly linked to the first of the project's goals. In particular MAC waves are likely to generate measurable oscillations of the planetary magnetic field and length of day variations (as demonstrated e.g. by Braginsky 1999, *Phys. Earth Planet. Int*. **111**, 21 and Buffett 2014, Nature, **507**, 484). The magnitude and dynamics of the Earth's magnetic field affect the amount of energy from the Sun reaching the Earth's environment. Therefore the geomagnetic field dynamics can strongly influence the global energy cycle in the Earth's atmosphere and hydrosphere and through that influence the Earth's climate on large time scales. Moreover, the planetary field by controlling the amount of Solar wind particles that reach the Earth's surface can also have an impact on satellite systems and the biosphere.