How to look into the solar interior

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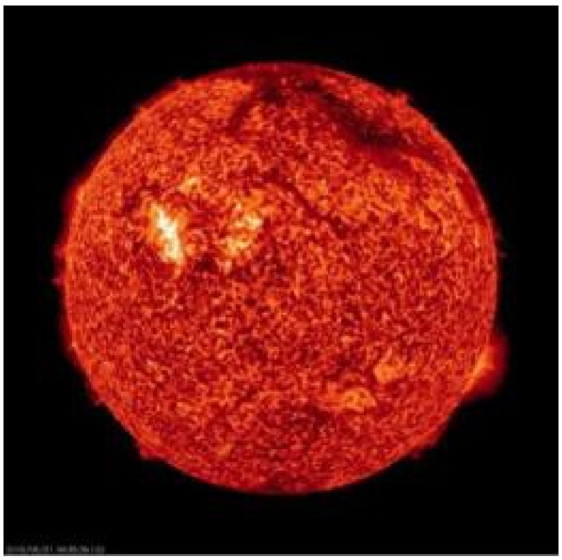

Image of sun courtesy of NASA.

An international group including one professor from the Moscow State University have proposed the first ever quantitative description of the mechanism responsible for sunspot formation and underlying the solar activity cycle.

Magnetic field helicity is one of the so-called motion invariants in magneto-hydrodynamics. It is a conserved quantity, like energy, describing the degree to which the field lines are "wrapped around themselves". During the last 20 years, scientists realized that conservation of this quantity is even more influential upon magnetic field evolution than energy conservation.

Chinese research lead by Hongqi Zhang considered magnetic helicity monitoring results for solar active regions. Using the data from the Solar Dynamics Observatory (SDO), they considered one particular active region (one area containing a number of sunspots) in the Southern hemisphere of the Sun. "These active regions do not emerge from nowhere, but float up from the solar interior and carry important information about the magnetic fields there. Considering these regions, we literally look into the bowels of the star," explains Dmitry Sokoloff, professor of the Physics Department of the Moscow State University.

Until recently, magnetic helicity spectrum (meaning the percentage of smaller and larger vortices found in active regions) successfully evaded all the scientists' attempts to measure it. "Axel Brandenburg and I understood how this spectrum may be calculated by scientific techniques, and Axel used a standard code to reconstruct the magnetic helicity spectrum using Fourier transforms," says Sokoloff. Observing a single active region on several different dates using different magnetogram types has shown this spectrum to be really stable, consistent with the scientists' expectations.

Authors say that magnetic helicity measurements on the Sun is an achievement of the last several years. Disentangling the processes of helicity distribution establishment is important for understanding the mechanisms controlling the 11-year solar activity cycle. "Ohm's law for solar matter includes the components absent in 'earthbound' electrodynamics. This is because solar convection lacks reflectional symmetry, hence local currents become parallel to magnetic fields rather than perpendicular to them. This is not of minor, but of key importance. And helicity itself is the measure of chiral, or reflectional, asymmetry," says Sokoloff. Results of the paper, accepted to *Astrophysical Journal Letters*, are expected to facilitate prediction of solar activity variations in future.

Understanding the role of magnetic helicity in solar activity will help the astronomers explain the nature of such phenomena as Maunder Minimum—a prolonged period in the end of XVIIth century characterized by very low sunspot numbers. "Helicity is definitely involved here, but it is difficult to check now because the data available for this period are only sunspot numbers. We do not possess any XVIIth century helicity measurements," says the russian researcher.

More information: Hongqi Zhang, Axel Brandenburg, and D. D. Sokoloff. "Magnetic Helicity and Energy Spectra of a Solar Active Region," 2014. *ApJ* 784 L45 DOI: 10.1088/2041-8205/784/2/L45

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