Project Title:
Methods and Tools for Studying Magnetic Field Structures and Dynamics Inside the Sun by Local Helioseismology

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Project Information:
The goal of this proposal is to develop tools for investigation of magnetic field effects in the Sun's interior by methods of local helioseismology and, in particular, by time-distance helioseismology (or acoustic tomography). The key questions are: How strong is the magnetic field at different depth in the convection zone? What is the topology of the emerging magnetic structures? Where are the magnetic stresses and twists that cause flares and mass ejections generated? How does the magnetic field interact with convective flows, rotation and meridional circulation? What is the depth at which the internal flows control the surface magnetic field? Developing local helioseismology tools to answer these questions is absolutely essential for making further progress in our understanding the physics and dynamics of the solar activity and short- and long-term magnetic variability, solar cycle, and irradiance variations. The previous helioseismic diagnostics are focused on flows and a combined sound-speed signal caused by temperature variation and magnetic pressure. These methods are currently being developed and are at various stage of refinement. They have provided spectacular images of the sound-speed structures beneath sunspots, and emerging active regions. However, they also posed major questions: What are the relative contributions of magnetic field and temperature variations associated with the changes of the convective energy flux in these structures? How does the magnetic field affect helioseismic inferences? Currently, the magnetic field affects represent a central problem of helioseismology and the physics of the Sun's interior. Their investigation is very important to for developing MHD theories of sunspots and active regions, modeling magnetic configurations in the corona, and global dynamics of the heliosphere. We propose to make the next major step in developing local helioseismology methods and tools by studying explicitly magnetic effects for the whole helioseismic procedure, from measurements of the Doppler shift through helioseismic inversions. The proposed work is mainly focused on time-distance helioseismology which currently is the most advanced local helioseismology technique. However, the new methods and tools will be also applicable to other techniques, e.g. the ring-diagram analysis and holography, thus providing a major advancement in the field.

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Citations: