Title: **Helioseismic inversions of plasma flows and sound-speed perturbations**

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The submitted thesis is about constructing and validating reliable measurements of the dynamics and (sound-speed) structure of the solar interior. Sound waves are stochastically excited at the surface of the Sun and propagate through the solar interior. The author greatly enhances the time-distance analysis, a local helioseismology technique. This method is based on measuring the travel times of sound waves and then inverting them to derive vector flows and sound-speed perturbations. Time-distance analysis has been used successfully to determine horizontal flows in the solar interior. However, attempts to derive vertical flows have met with limited success and attempts to derive the structure (especially below sunspots) have led to contradictory results.

The author implemented and validated two crucial improvements over the “standard” time-distance technique: (i) the minimization of cross-talk between the signal of horizontal flows and that of other components and (ii) the simultaneous inversion for vector flows and sound-speed perturbations. Among the new scientific results, the author showed that these improvements are necessary to derive vertical flows and sound-speed perturbations. The inversion results are highly contaminated when either one of the two modifications is neglected. The presented work is vital for improving the understanding of subsurface structures below active regions, which has made little progress in the last decade. In addition, this approach makes it possible to derive vertical flows in near-surface layers and not just their spatial variations, as in previous studies.

The author applied the improved technique to solar observations. First, the author analyzed SDO/HMI Dopplergrams with the new technique and compared its results with those of the standard HMI pipeline. Second, the author derived flows under an erupting filament finding an increase in velocity magnitude before the filament erupts. Third, the author confirmed the existence of strong divergent flows in the centers of supergranules and showed that these flows decrease in strength with increasing depth in agreement with theoretical models. These three applications help to validate the technique and, at the same time, indicate areas of solar-physics research that might benefit from this technique.

The author introduced new travel-time measurement geometries consisting of one-sided arc geometries. The author validated the technique performing consistency checks with regard to (i) standard geometries (annulus and e-w and n-s ones) and (ii) a snapshot of a simulation of the convection zone. Wave interactions in the vicinity of strong inclined magnetic fields make it difficult to interpret seismic measurements in active regions. The novel approach has the potential to greatly advance the study of active regions because it can be used to minimize the effects of magnetic fields on helioseismic inversions.

The submitted thesis is well-written. The thesis flows logically from one step to the next. After an introduction into waves and helioseismology, the author focused on time-distance analysis and explained the processing pipelines and their applications to solar observations. The author concluded with a concise summary of the new results and pointed out several other objects in our solar system that might be explored with seismic techniques.

The submitted thesis is excellent and clearly shows that the author is able to produce creative scientific work.