Report on the thesis

Velocity fields in the solar photosphere

by Mgr. Michal Švanda

Michal Švanda investigates horizontal velocity fields applying the technique of local correlation tracking (LCT). Because high spatial resolution and constant good seeing conditions, as they can be obtained only from space or with adaptive optics systems, are mandatory for this technique, it became only recently a frequently used method in solar physics. In the present work, LCT is applied to Doppler velocity measurements with the Michelson-Doppler Imager (MDI) on board the Solar and Heliospheric Observatory (SoHO). The Doppler velocity measurement and the determination of horizontal motions are complementary. As a second method, Michal Švanda applies the recently developed time-distance helioseismology (TDH) and compares the results. An immense amount of data is treated in a careful and critical way in order to investigate a variety of important scientific questions.

Horizontal motions play an important rôle to shear magnetic fields and to build up magnetic twist. Twisted and sheared magnetic fields cause reconnexions which appear as dramatic events like flares and coronal mass ejections (CMEs). A good knowledge of the system of meridional motions and magnetic flux transport is of large importance to improve theoretical models of the solar dynamo.

The thesis is written in a clear language, and it is well structured. The reliability of the results from used method is demonstrated by an application on artificial data which were obtained from a numerical model of the supergranulation. From these investigations the optimum time lag as a compromise between the needed time difference and the development of the supergranular structures is found. A comparison of the application of LCT and TDH to MDI-data shows that the results are similar.

Long term variations are investigated confirming the torsional oscillations. Indications of periodic variations of 1.8 years in the meridional motions and 4.7 years for the rotation rates are found, although further work is needed to confirm their reality. A search for variations in the order of the rotation period is presented. Michal Švanda demonstrates that the rotational speed is higher around the leading polarity of a new active region, and it slows down within a few days.

For the case of an erupting filament Michal Švanda could show that there was a high speed shear motion near the filament before the eruption. After the event, this motion disappeared. Such findings are important to understand the eruption process.
Finally magnetic butterfly diagrams are used to determine the speed of the meridional magnetic flux transport. Generally this speed is in agreement with the meridional motion, but it is pointed out that local flows around active regions influence the mean meridional flow. This is significantly relevant for dynamo models.
In the appendix, Michal Švanda demonstrates the high potential of LCT applied to stellar surface maps. At the present time, only a few such maps are obtained with the Doppler imaging technique, but their number and quality will increase rapidly in the near future. Then LCT will be a well suited method to investigate velocity fields at the surface of stars.
Concerning Section 6, I have some questions. I have the impression from Figure 31, that the "fast" rotation falls mainly into the summer half-year, while more "slow" phases occur in the winter half-year. Such an effect, although perhaps not in this order of magnitude, is produced by the variable speed of the L1-orbit around the sun (same angular velocity as the Earth). The higher angular speed in the winter half-year leeds to a lower synodic rotation rate and vice versa in the summer half-year. Is this effect taken into account, and are there additional effects of the SoHO-orbit around L1? Is it possible to plot the obtained rotation rates versus the phase of the Earth's orbit (perhaps ecliptic longitude)? Inspecting Figures 32 and 33, I cannot recognize that there is an alternation with the Carrington period. Could this be demonstrated in a more convincing way?

In total, Michal Švanda presents an excellent thesis, in which he demonstrates his ability for creative scientific work. I strongly recommend that he obtains the PhD degree after a successful defense of the thesis.

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