Re: Report on the Doctoral Thesis "Two dimensional spectropolarimetry of a sunspot" by Jan Jurčák.

This is an excellent thesis based on one of the data sets with the best spatial resolution spectropolarimetric data that can be achieved nowadays. The instrument LPSP (La Palma Stokes Polarimeter) attached to the old 0.5m SST (Swedish Solar Telescope), located in the island of La Palma, was used. The author analyses two maps taken in the umbra of a complex spot, including penumbral and umbral regions, as well as two well defined light-bridges.

The thesis is well written, structured, and motivated. Adequate and up-to-date references are given where necessary. Figures are inserted in the appropriate places, except for the large number of them that are placed at the end of the thesis, showing maps of the different quantities derived during the course of the analysis. This exception is justifiable in view of the large number of parameters studied. Chapters 2 and 3 give an overall description of the present knowledge about sunspot structure and of the observational setup and data acquisition, respectively.

The basic ingredient used for the analysis is the inversion code SIR. Chapter 4 is devoted to describe the formalism used by the code to derive, in an iterative manner, a model atmosphere capable of describing the input polarized spectrum of the observed spectral lines. Special emphasis is given to the physical meaning of the response functions, the true heart of the code, to the reliability of the inversion process and to the ranges of heights where the results are trustable, in the different retrieved atmospheric quantities. A critical input parameter, such as the number of nodes for each derived magnitude is adequately discussed and justified.

The remaining chapters show the results of the analysis for the observed umbral, penumbral and light-bridge regions. The results obtained of the two umbral cores show the expected behaviour known from previous works: (i) almost vertical magnetic fields, slightly deviating from the vertical as one moves from the centre to the external parts of the umbra; (ii) zero velocities (although the wavelength calibration procedure is not explained in the manuscript). The study of the penumbral parts is more complex, since they are highly structured well below the spatial resolution of the observations. The analysis done, based on a single magnetic component in each resolution element, makes it difficult to extract information on the individual mixed components that, with all certainty, give rise to the observed penumbral Stokes spectra. Nonetheless, the uncombed penumbral structure is confirmed in this work, favouring the rising flux tube model by Schlichenmaier, and the return flux by Westendorp Plaza et al.. Some results contradict previous studies (v.g, weaker magnetic fields are obtained in brighter areas) and deserve attention in future works. The results obtained from the light-bridges that cross the two umbral cores are much more interesting, since a smaller number of works have been devoted to their study up to the present. Of special importance is the derivation that the light-bridges seem to disappear in high layers, as if the magnetic field from the neighbouring umbral cores merges up in the atmosphere. In the deepest layers, there are even regions that can be considered as almost field-free, while the magnetic field strength increases with height. This explains why the 630.1 nm line has a considerable larger amplitude in circular polarisation than the companion 630.2 nm line, as shown by Fig. 32 of the thesis. The larger Landé factor of the latter makes it compatible only with the retrieved magnetic field stratification. The discussion of the

stray-light effect on these results is very illustrating and demonstrates the reliability of the magnetic field gradients obtained in these structures.

In summary, this is an outstanding work, based on an excellent data-set, taken at one of the best solar telescopes in the world, with one of the best instruments for spectropolarimetry. The analysis is based on an excellent inversion code, which allows the user to disentangle the intricate non-linear relationship between the observed spectra and the atmospheric parameters. The results confirm, to a large extent, the picture of a cool umbra at rest and an uncombed penumbra, with large pixel-to-pixel variations, compatible with the existence of more or less horizontal flux tubes embedded in a less inclined background. The scenario where light bridges may be field free photospheric intrusions up to a certain height is very attractive. With all these arguments, I consider that the thesis is ready to be defended before the corresponding committee, with my full recommendation that the candidate obtains the PhD degree, with the highest mark.

La Laguna, July 24th, 2006

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