Extending the Medium-l Program to HMI

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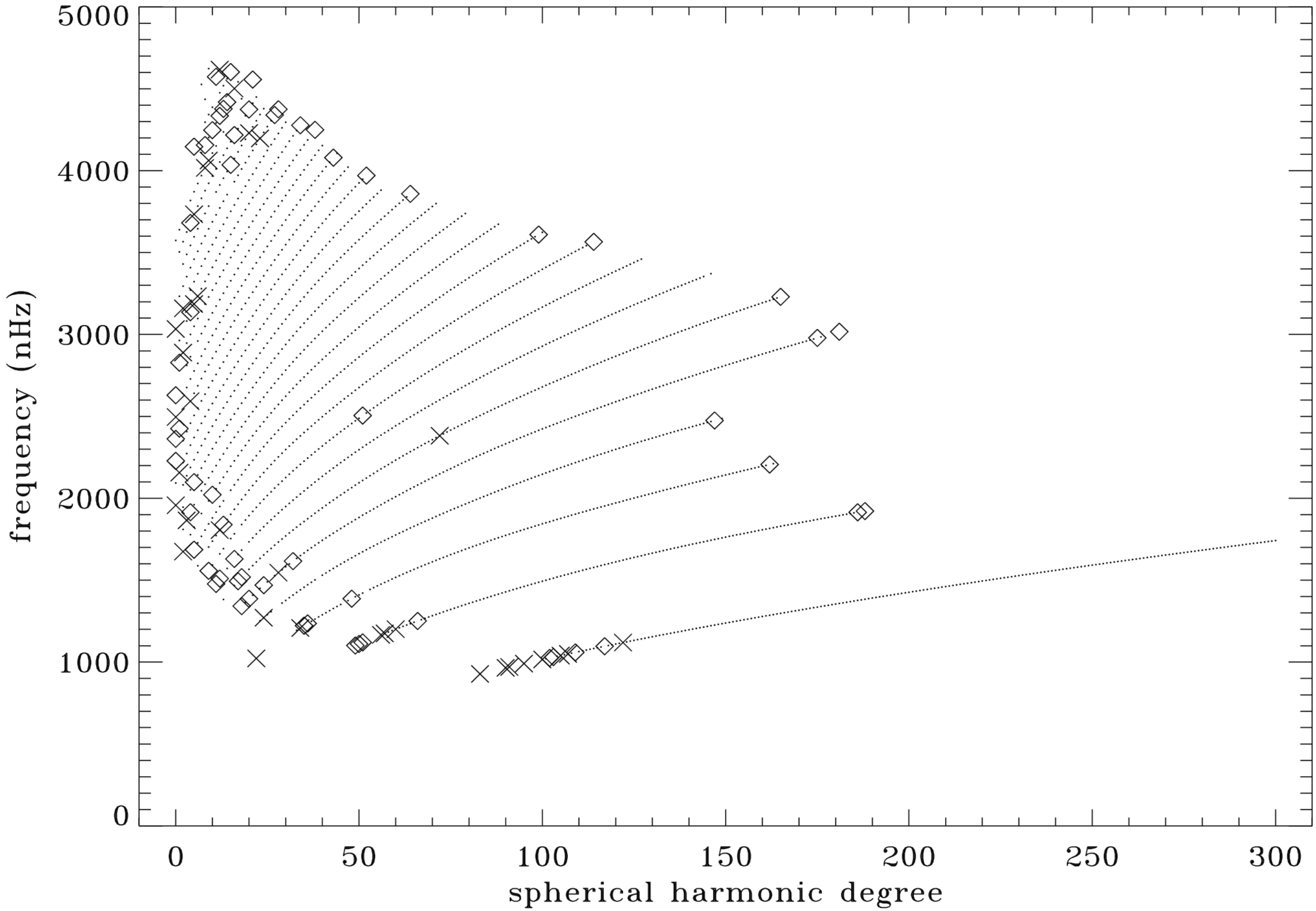
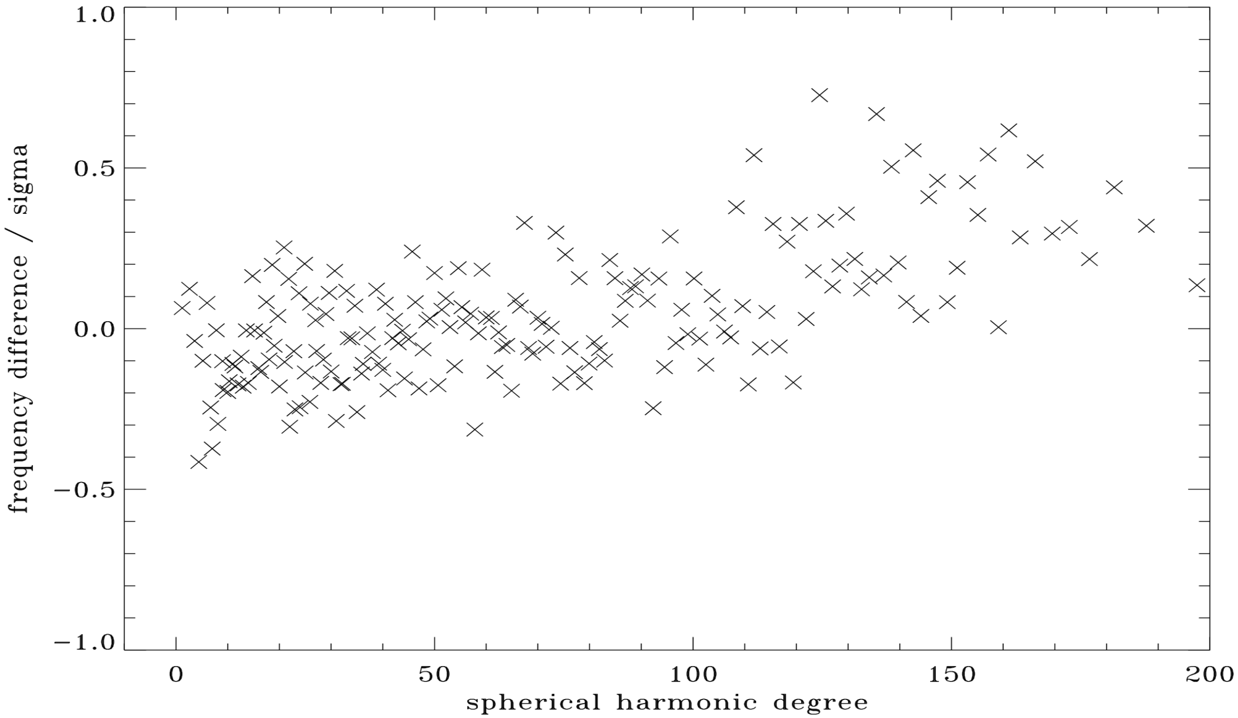
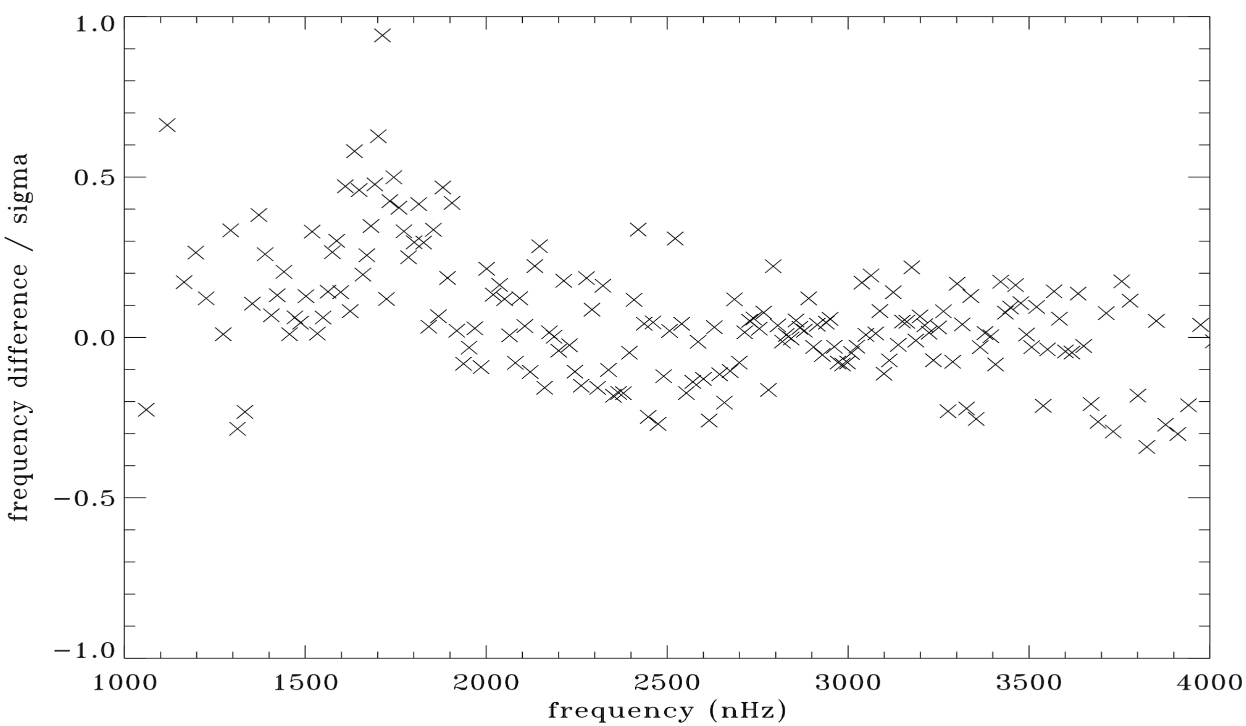
As we approach a full year of regular observations from HMI, the MDI project draws to a close. In this poster we discuss a continuation of the MDI Medium-l Program using data from HMI. While agreement between the two instruments is generally quite good, HMI provides an opportunity to finally unravel some of the systematic errors we found in the analysis of MDI data. To that end, we recompute the leakage matrices with different resolutions, apodizations, and point spread functions and compare the resulting mode parameters obtained during the last MDI Dynamics run with contemporaneous results from HMI.

The l-nu diagram below shows the mode coverage for the last MDI dynamics run. Dots represent modes fitted in both MDI and HMI data, X's were fitted only for MDI, and diamonds were fitted only for HMI.







The plots to the left show frequency differences between HMI and MDI in units of standard deviation. The sense of subtraction is HMI – MDI. Points have been binned by a factor of 10 for clarity.

The top plot seems to show a positive slope with a zero crossing in the middle, implying that for low l HMI systematically sees lower frequencies than MDI and for high l it sees higher frequencies.

Does the bottom plot have a feature around 1700 nHz? We do not yet know its origin.

Overall, however, agreement is quite good. Out of 1988 common modes, only 6 differed by more than 2 sigma. 122 modes differed by more than 1 sigma.

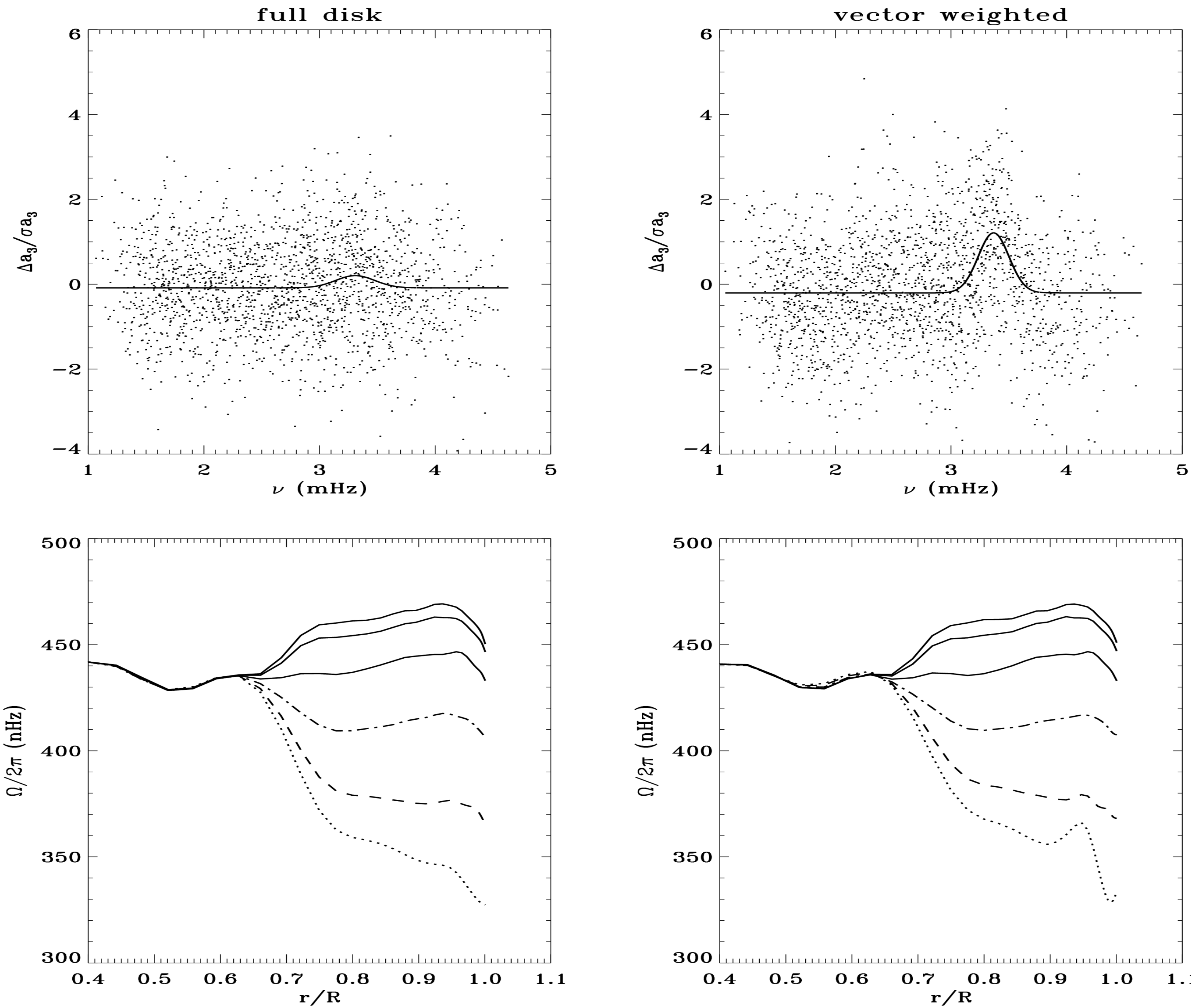
So what are we worried about? The comparison plots above are all comparing HMI with MDI full disk data. Unfortunately, the usual input to the MDI Medium-l Program is not full disk data but rather vector weighted data, so called because it has been convolved with a gaussian "vector". It is also subsampled by a factor of 5 and highly apodized. Although the full disk data is generally of higher quality, it is only available a few months out of the year. Because we have the vector weighted data for almost the entirety of the MDI mission, that is the dataset that we would like to have continuity with HMI.

Unfortunately, and as the plots below show, we are not even able to bring the two MDI datasets into agreement with each other. The top plots below show the normalized residuals for one of the a-coefficients. If the model is a good fit to the data, we would expect for these to be normally distributed around zero. The feature seen in the vector weighted data at 3.4 mHz is an unexplained deviation from this, but it is almost completely absent in the full disk data.

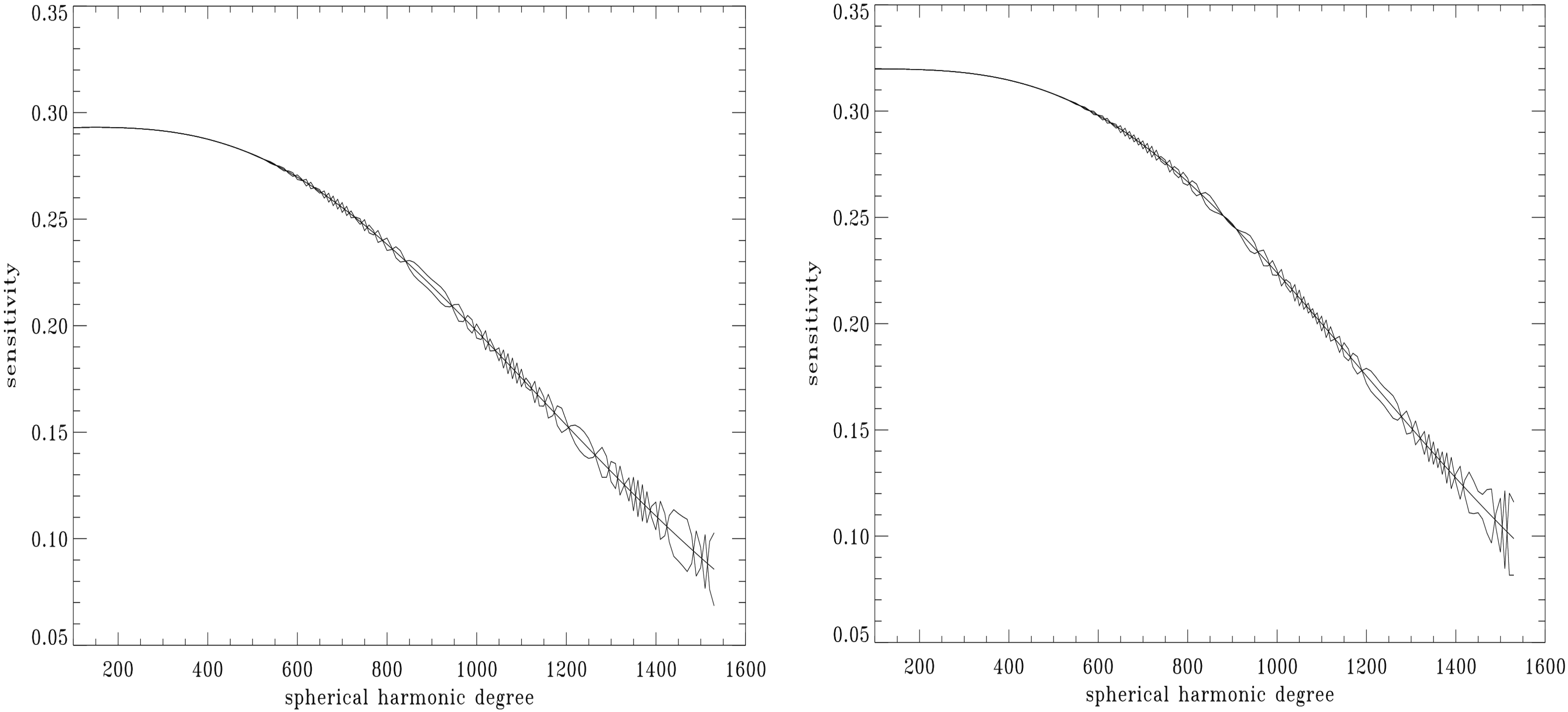
The bottom plots below show rotation profiles obtained from RLS inversions. Again, the vector weighted data show a spurious feature, the polar jet. And again, it is absent in the full disk data.

Our previous investigations have revealed that both of these features depend more strongly on the apodization of the data rather than its resolution. We therefore began to suspect that there could be errors in the leakage matrix.

The Problems



Left panel shows the effect of offsets in x0 for m=l. Right panel shows the effect of offsets in y0 for m=0. Plotted are 0 offset, 0.5 pixel offset, and their average.



Left panel shows effect of changing the p-angle for m=0. Plotted are 0 degrees (as in right plot above) and 0.5 degrees. The latter is smooth with no averaging. The effect on m=l was negligible.

Right panel shows the effect of changing the observer distance, or equivalently the radius of the solar image, for m=0. Plotted are 0.984 AU (top line), 1.016 AU (bottom line), and an average over these and 7 points in between. The average is smooth only until about l=1300. The effect on m=l was similar.