Summary of the 29 March, 2019, videcon

Attendees were:

Jørgen, Kiran, Jesper, Rachel, Rafa, Sarbani, Sushant, Shukur, Sergei, Sasha, Savita, Sylvain, Angela

Most discussions were based on the files uploaded by Sarbani and Sasha.

Sarbani and Antia uploaded inversion results using 2D RLS method for the 5-year splitting data provided by Sylvain prior to the meeting and these can be accessed at

https://www.dropbox.com/home/Rotation%20Inversions/HMA_SB/2019March27

Sarbani mentioned that the inversion results uploaded prior to the February meeting (https://www.dropbox.com/home/Rotation%20Inversions/HMA_SB?preview=HMA_SB_GONG.ps)

are good for outer layers; however inversions for the core rotation were not carried out at that time. Since core inversions are heavily dominated by the smoothing parameters, it is more appropriate to use forward modeling for this region. This was done by assuming a certain value of the core rotation. They also calculated residuals and chi-square, and finally looked at the systematic effects in residuals to see if these are systematically distributed. This process was repeated for several values of the turning point radius, r_c. The results are available in https://www.dropbox.com/home/Rotation%20Inversions/HMA_SB/2019March27?preview=probcor.ps

Detailed summary of their work can be found in the text file

(https://www.dropbox.com/home/Rotation%20Inversions/HMA_SB/2019March27?preview=Core_rotationnote_HMASB.txt)

Here is an extract from this file:

"*We find that the inversions by themselves are not likely to constrain the rotation rate in the solar core, and hence we combined forward modelling with inversions. For this purpose we assumed that the rotation in the core (r<r_c) is either constant or a linear function of r. For linear case \Omega is continuous at r=r_c, while in constant case there is a discontinuity by \Delta\Omega. We used different values of r_c. For the specified core rotation, the rotation outside the core is determined by the same 2D RLS inversion. The inverted profile is used to calculate splitting coefficients, which are then compared with the observed splittings. For modes that have turning point in the core we calculate the average deviation from the observed value, the deviations are normalized by the observed uncertainty. This should quantify the difference between modified rotation profile and the actual solar rotation. The figure shows the*

mean deviation for 3 cases. For the constant core rotation case we use r_c=0.20 Rsun and r_c=0.15 Rsun, while for the linear profile we use r_c=0.4 Rsun. The mean deviation is essentially a linear function of \Delta\Omega or the gradient and this can be used to put limits on these deviations. The figure also shows horizontal lines at 3 and 5\sigma.

We also tried to combine the low degree (l<3) splittings from LOI which have smaller errors with GONG/HMI splittings at higher l. Since LOI splittings have lower error we expect to get higher significance for the same difference in the rotation rate. This is true, but there are some systematic differences between the GONG and LOI splittings at the level of about 1 \sigma. When we try the best fit with constant core rotation with r_c=0.15Rsun, the GONG data gives \Delta\Omega=-43 nHz, while with LOI data combined we get \Delta\Omega=248 nHz. The results using these data combination are also included in the figure.

It was noted that the results are essentially consistent with a constant rotation rate in the core. However, Sarbani and Antia also calculated limits on the g-mode splitting within the 5\sigma range of their results, for comparison with the g-mode claims by Fossat et al.

Post-meeting note: LOI splitting up to \ell=1-3 were uploaded by Thierry Appourchaux in December 2017 and are available at https://www.dropbox.com/home/Solar%20Splittings?preview=splitting_LOI_2017.txt

Since the core rotation obtained from the LOI splittings are different from GONG for r_c=0.15R_Sun, it was suggested to include low-degree mode splittings from other data sources, e.g., BISON, GOLF etc. Sarbani recalled that Antia did look at the BISON splittings (perhaps from Anne-Marie), however the errors were too large. They are planning to use splittings produced by Rachel in future work.

Rafa reported timing anomaly in low-degree modes observations as per his discussion with Pere Palle, perhaps of the order of 20-30 sec. He suggested to wait until he collects more information from Pere.

Post-meeting note: Time differences between various data sets are given in Table A.1 of the following paper,
http://adsabs.harvard.edu/abs/2018A%26A...617A.108A

In connection with the analysis of the core rotation and the possible g-mode results a recent paper on solar rotation is relevant:
A Critical Evaluation of Recent Claims Concerning Solar Rotation by Phil Scherrer and Douglas Gough (http://adsabs.harvard.edu/abs/2019arXiv190402820S)

Sasha and Sylvain uploaded 5 data files before or just after the meeting, to https://www.dropbox.com/home/Rotation%20Inversions/Kosovichev/20190329

1. splits-6400-all-36-hmi-32x.jsBo=0.dat - observed splittings, from HMI data
2. sgk_hmi3.dat - mean mode frequencies (*l, n*, nu, error)
3. cs_sgk_hmi6400-32x_err3_1.eps - sound-speed inversion of mean frequencies against Model S, no *l* = 0 modes included
4. splits_sgk_hmi3_test1.dat - test splittings without errors (*l, n, m*, nu, dnu)
5. splits_sgk_hmi3_test1_err.dat -test splittings with errors (*l, n, m*, nu, dnu, sdnu)

4. and 5. are artificial data obtained by using a rotation model to calculate splittings for the mode set in 1. 4. Includes no errors, while normally distributed errors with the standard deviations from the observed mode set are included in 5. For inversion of both mode sets these standard deviations should be used. Since the videocon Sylvain and Sasha have provided *a* coefficients based on the splittings, which have been uploaded to https://www.dropbox.com/home/Rotation%20Inversions/Kosovichev/20190414

Sasha may produce more artificial data, if needed.

Sasha also studied the distribution of errors as a function of turning point and obtained a smooth variation.

There was a consensus that everybody should use these sets of data in various inversions.

Again, there was a discussion on how to combine results from different methods. It was suggested to rewrite all output files (ASCII) from different inversion codes to a common format. It looks more reasonable rather than changing the output format of inversion codes. This approach will make it easier to compare results in a simple way.

Dates for the conference to honor Michael Thompson's contributions to Helioseismology have been finalized. The meeting will be held in Boulder during September 24 -26, 2019. Since the meeting the conference has been announced by mail and will be announced in different newsletters. The conference website is now open at https://www2.hao.ucar.edu/MJTWorkshop2019.

Next meeting will be at the end of April.