Laboratory work 13
Solar image processing to determine the angular velocity of EUV coronal wave

Performance - Tuesday, May 17, 2016
Due to submit a performance report – Friday, May 20, 2016

The objective of this laboratory work is to apply gained skills during the term to determine angular velocity of EUV wave in the solar corona by processing solar images. This problem is very important for space weather applications.

This laboratory work is performed in the class by students as in teams of 2 on May 17, 2016 and the team will submit one document reporting about the performance till May 20, 2016. Within your group, you may discuss all issues openly, and discuss and debate until you reach a consensus.

Here is the recommended procedure:

1. Download data from canvas needed for the laboratory work.

2. Load polar coordinates ρ, ϕ of all the pixels, center of the coordinate system is located in the eruptive center. ρ - distance from eruptive center to a pixel, ϕ – polar angle.
   Files: ro.mat, phi.mat

3. Load four difference images that demonstrate coronal mass ejections followed by EUV coronal wave propagation
   image1.mat – 4:50 utc
   image2.mat – 5:07 utc
   image3.mat – 5:24 utc
   image4.mat – 5:41 utc

4. Plot images
   Use command imshow, limits [-100 300], colormap jet

5. Load boundaries of EUV wave front for every image. Boundaries are given in pixels.
   Files:
   borders1.mat for image 1
   borders2.mat for image 2
   borders3.mat for image 3
   borders4.mat for image 4

6. Select all pixels that belong to EUV wave front from the whole image using given boundaries for every image. Select also polar angles corresponding to determined EUV wave front. Sort determined polar angles in ascending order from 0 to $2pi$ (from 0 to ~6.28 radians). Sort also pixels belonging to EUV wave front according to sorted polar angles.

7. Plot dependence of intensity of a pixel belonging to EUV wave front on angle for every image.

8. Make smoothing of the dependence obtained in item 7.
   How to do?
   Each pixel is replaced by the sum of all pixels of length $\frac{\pi}{8}$ centered on the considered point. It means that you should use running angular interval $[-\frac{\pi}{16};\frac{\pi}{16}]$.

   At the beginning $[0;\frac{\pi}{16}]$ and end $[N-\frac{\pi}{16};\mathrm{N}]$ of interval please sum up whatever you have on these intervals.

9. Remove pixels from the analysis that correspond to polar angles from 2 to 4 radians. This corresponds to direction toward northwest. There is no propagation of EUV wave front toward this direction due to interaction with coronal hole.

10. Replace all negative intensities of pixels by zero as we need to analyze only bright intensities corresponding to EUV wave front.

11. Calculate the coordinate of intensity center for every image.

12. Determine the polar angles for estimated intensity center. Plot obtained polar angles for every image. Analyze the dynamics of polar angles depending on time. Make conclusions whether the rotation of EUV wave front is detected.

Performance report

1. Performance report should contain all the items listed

2. The code should be commented. It should include:
   - Title of the laboratory work, for example
       % Converting a physical distance to a grid distance using least-square method
   - The names of a team, indication of Skoltech, and date, for example,
     %Tatiana Podladchikova, Skoltech, 2016
     Main procedures also should be commented, for example
     %13-month running mean
     …here comes the code

3. If your report includes a plot, then it should contain: title, title of x axis, title of y axis, legend of lines on plot.