Preliminary Results

Nathan

The experiment is divided into two separate methods of analysis. One approach is using a computer code and the other is using a visual observations.

The IDL code has so far been developed into a fully automated sunspot tracking algorithm, successfully detecting the boundaries of the umbra and penumbra. The code generates and stores the two dimensional coordinates of both the umbra and penumbra boundaries. These are used to calculate a centre for the sunspot and then this point is used to measure the rotation of the sunspot. The angular velocity will then be plotted against time and wavelet analysis will be performed. Figure 1 shows an output of the IDL program, displaying the sunspot in the different stages of analysis within the program. Firstly the raw data obtained from the solar dynamics observatory satellite is plotted, giving the full solar disk (top left). The data is then passed through several mathematical operations in order to locate the sunspot and plot it on a much smaller scale (top right). Many cross sections are taken through the darkest pixel of the sunspot and a intensity profile is produced (middle) for each cross section. The umbra and penumbra boundaries are identified as minimum and maximum peaks (bottom). These are then over-plotted onto the sunspot image.

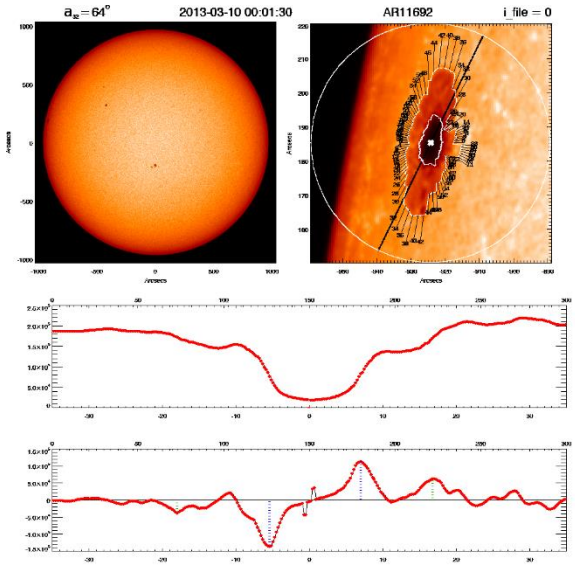

Figure 1 – A sample of the IDL program output, showing the sunspot located on the solar disk, zoomed in with boundary contours plotted, the intensity profile along the cross section and the derivative profile of the intensity.

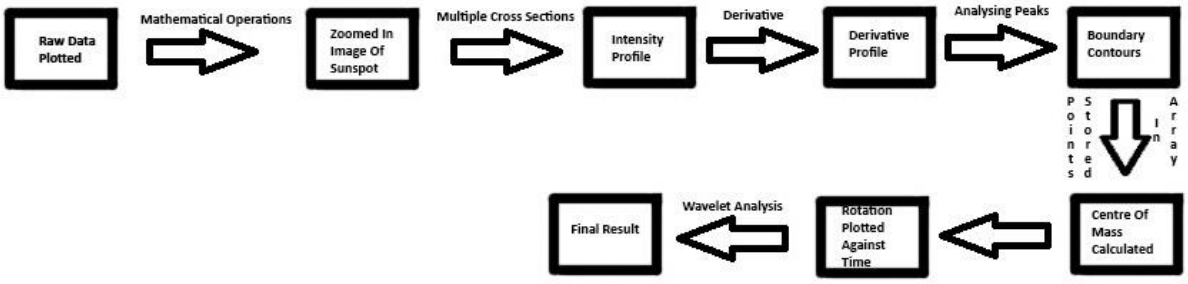

Figure 2 – Flow chart of the various processes within the IDL Code.

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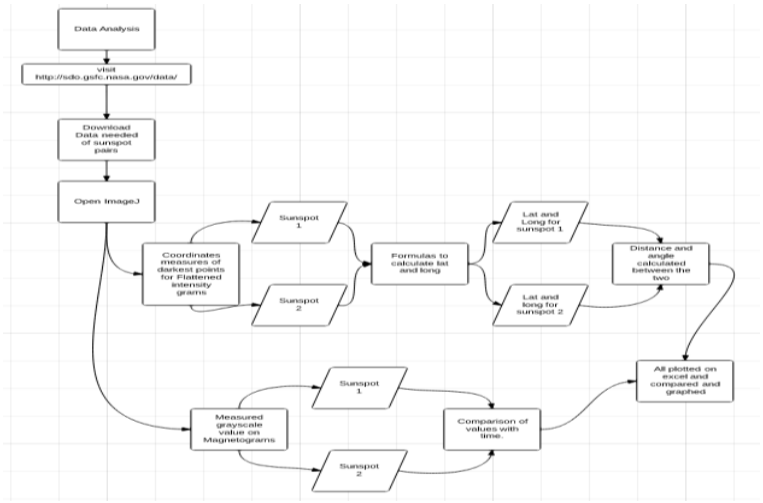

Figure 3 – Flow chart showing steps required to analyse a sunspot pair

A sunspot pair has been analysed using the flow chart shown in Figure 3. The sunspot pair was analysed for the duration of their lifetime using a cadence of approximately 90 minutes. The results were imported into excel and two graphs were plotted. The first graph was angle vs distance for both sunspots and is shown in Figure 4. The plot shows that the sunspots are rotating about one another and the angle between them decreasing. Figure 5 shows the plot of the latitude and longitude as the sunspot pair travel across the central (longitude = 0°) axis of the Sun. The sunspot positions can be seen to increase in latitude to this point and then decrease thereafter. It is believed that this is due to the tilt of the Sun relative to Earth's orbit. This will be taken into account with further refining.

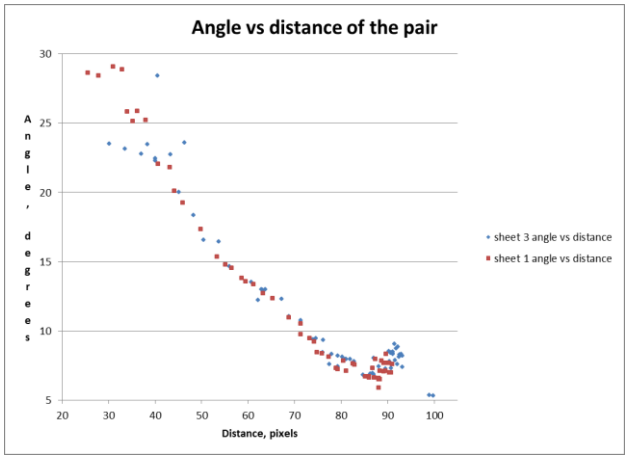

Figure 5 – Plot of sunspot pair Angle Vs Distance

More sunspot pairs will be analysed using the same process but improving upon certain aspects, such as the tilt of the Sun, the cadence, and analysis using magnetograms. The intensitygrams and magnetograms will be compared for any correlation and studied to find the effect of changing magnetic field on the geometry of the sunspot pairs.

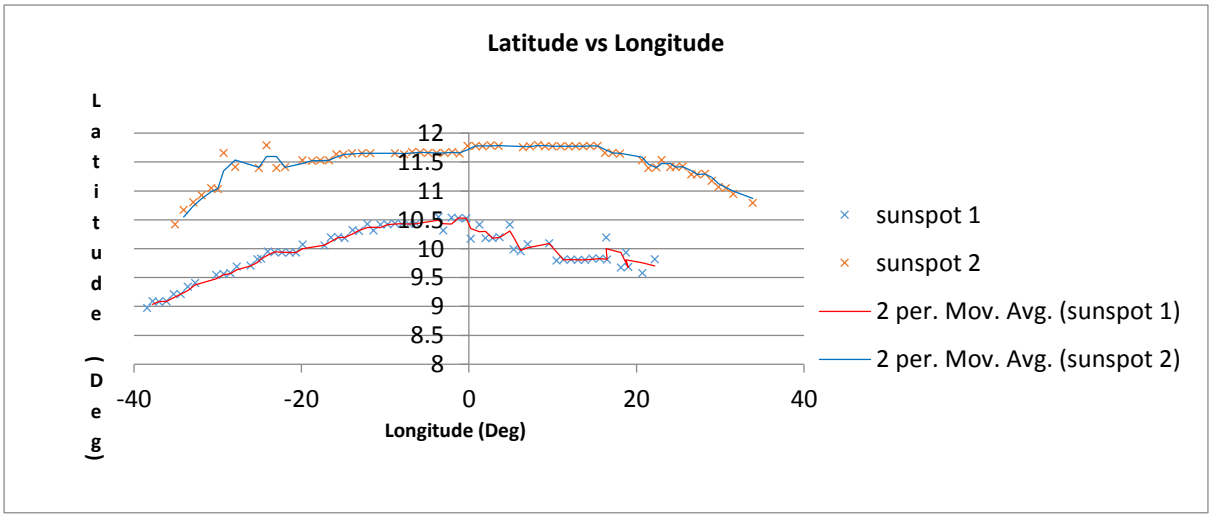

Figure 4 – Plot of sunspot pair Latitude Vs Longitude