Investigating a chromospheric spiral structure using SST CRISP.

Yash Saneshwar[1], Eamon Scullion[1], Gert Botha[1]
y.b.Saneshwar@northumbria.ac.uk
Northumbria University[1]

Northumbria University NEWCASTLE

High resolution ground-based observation from SST

In this project, the goal is to study an observation taken from the ground based Swedish 1-m Solar Telescope (SST). This observation of interest is a giant spiral structure in the solar chromosphere in the vicinity of a magnetic null point.

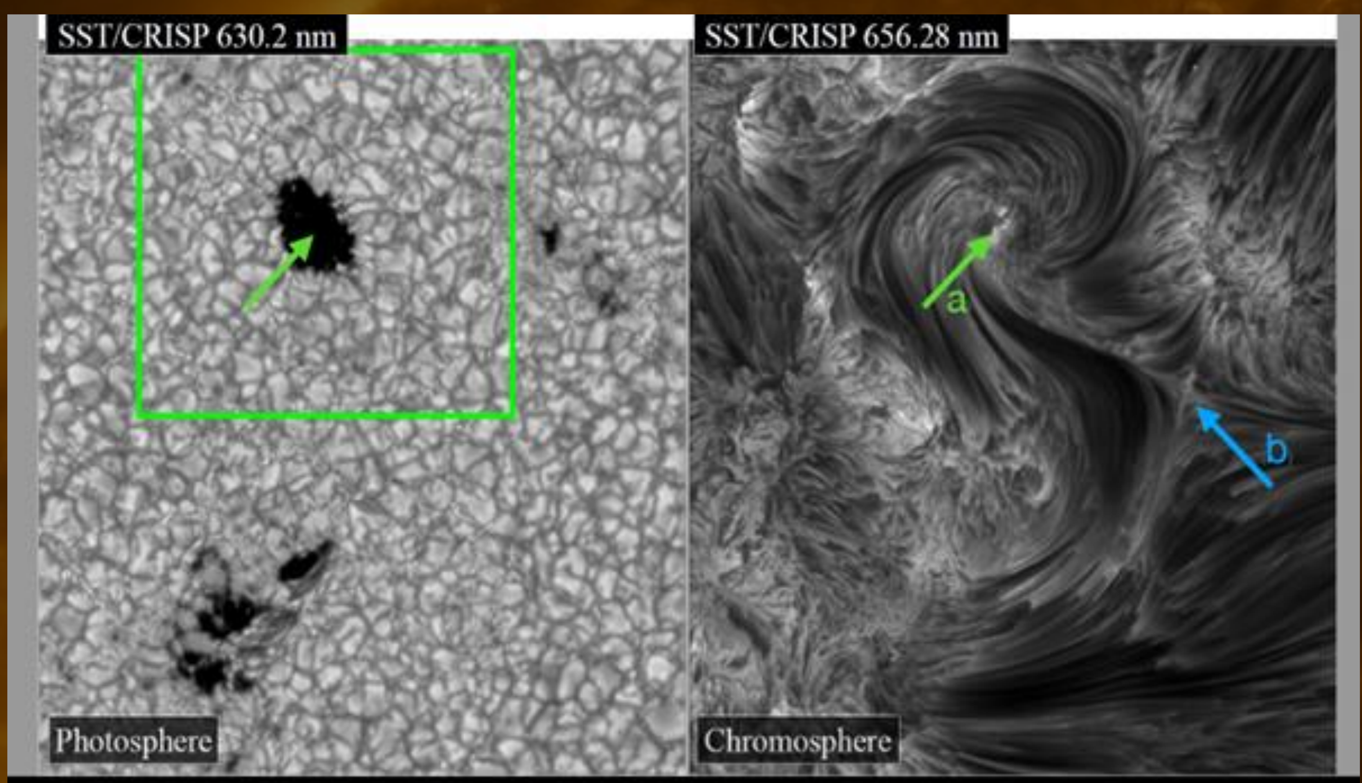


Fig 1: The observation was taken in two different wavelengths; this gives us the ability to look at both the photosphere and the chromosphere. The arrow a points at the center of the giant spiral. The green box is indicative of the area of the spiral in the chromosphere above the photosphere. This is also the location of the pore. The arrow b is the location where we believe there is a magnetic null point.

Automated detection of the spiral arms

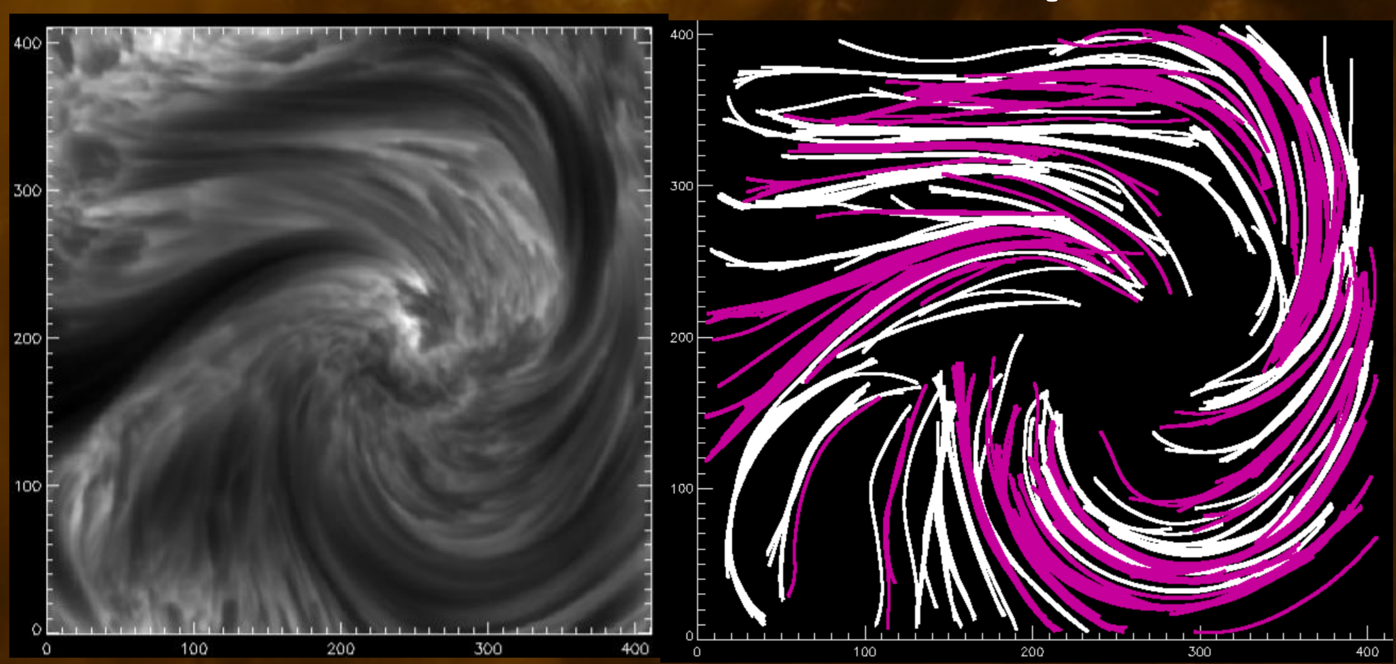


Fig 2: An example of loop tracing capabilities of OCCULT2 code on the SST observation of the spiral

OCCULT code is used to for automatic loop detection. OCCULT2 (Oriented Coronal Curved Loop Tracing) is an algorithm developed for closed loop tracing in coronal loops. It is an automated pattern recognition code that is particularly well suited to extract one-dimensional curvi-linear features from two-dimensional digital images [1]. The OCCULT dataset had to go through multiple sets of filtering for data reduction.

Tracking of traced loop over time and statistics

A code was developed that tracked the evolution of loops over time. This code tracks loops that exists for more than 1 timestep. Tracking the loops enable the study of the evolutions of loop structure over time. Studying the XT cut of these evolving loops will give an insight into what is causing these loops to deform. Below is an examples of these tracked loops:

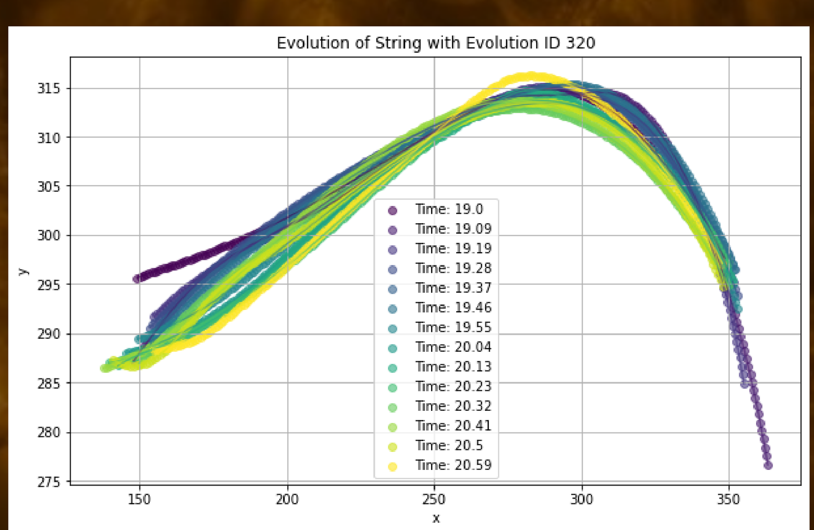


Fig 3: This image shows the superposition of the same loop as it was observed over many timesteps. Here we illustrate the long duration of a single loop and the large-scale drifting or potentially swaying of the entire loop structure. The loop lasts for at least 122 seconds, as a result of the long duration of this activity we can explore the correspondence between the swaying motion and the presence of waves and flows along the loop structure

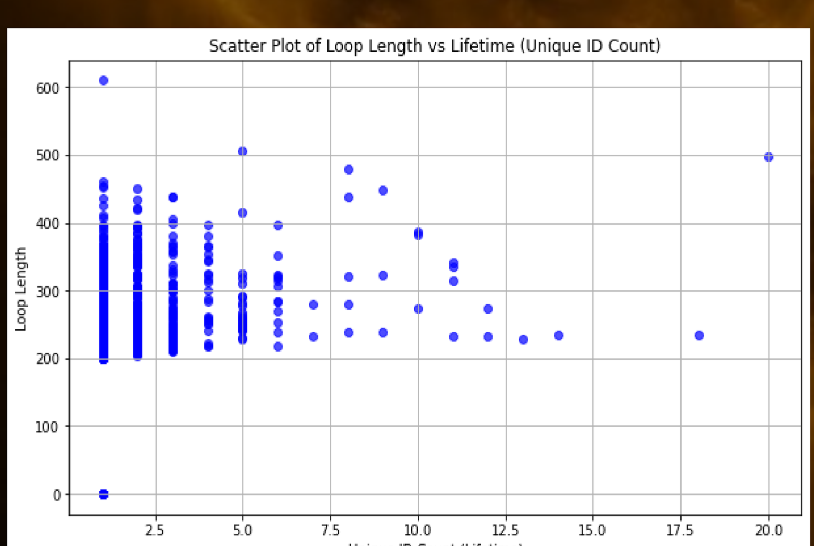


Fig 4: This scatter plot illustrates the relationship between the loop length of solar magnetic field structures and their lifetime, quantified by the number of unique identifiers observed. Each point represents a unique magnetic loop, highlighting trends and variability in loop stability and longevity."

Evolution in a single loop struct

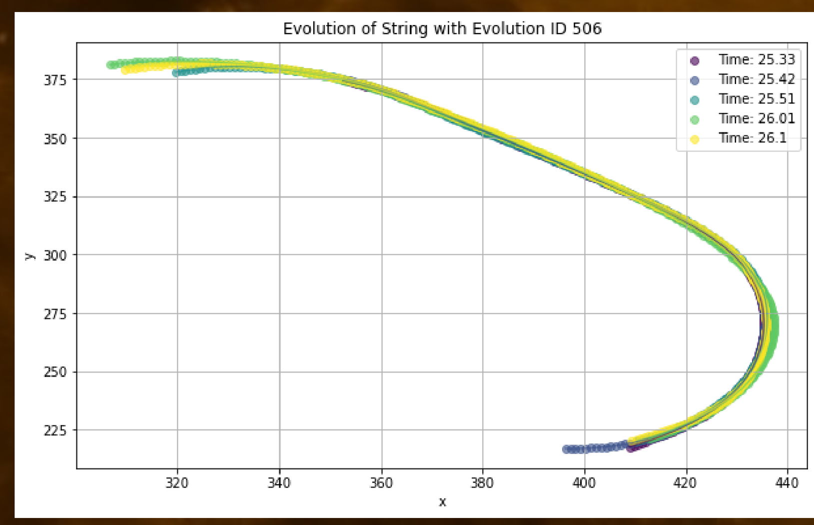


Fig 5: This image shows the superposition of the same loop as it was observed over multiple timesteps. Each timestep is identified with different colours. Two highlights of this example show: I) Deformation of the loop are detected down to the image scale of the telescope(43Km). II) Large scale perturbation of loop are present indicative of large-scale twisting or sheering of the loop structure.

Flow of plasma in single loop structure

From the loops above a single loop is selected and is plotted below along side its xt cut to study the properties of plasma inside the loop as well as the effect of plasma on the loop structure itself. The periodicity of the flow changes as it travels along the loop. This is because the loop rises into the atmosphere and then falls back and reconnects with the surrounding.

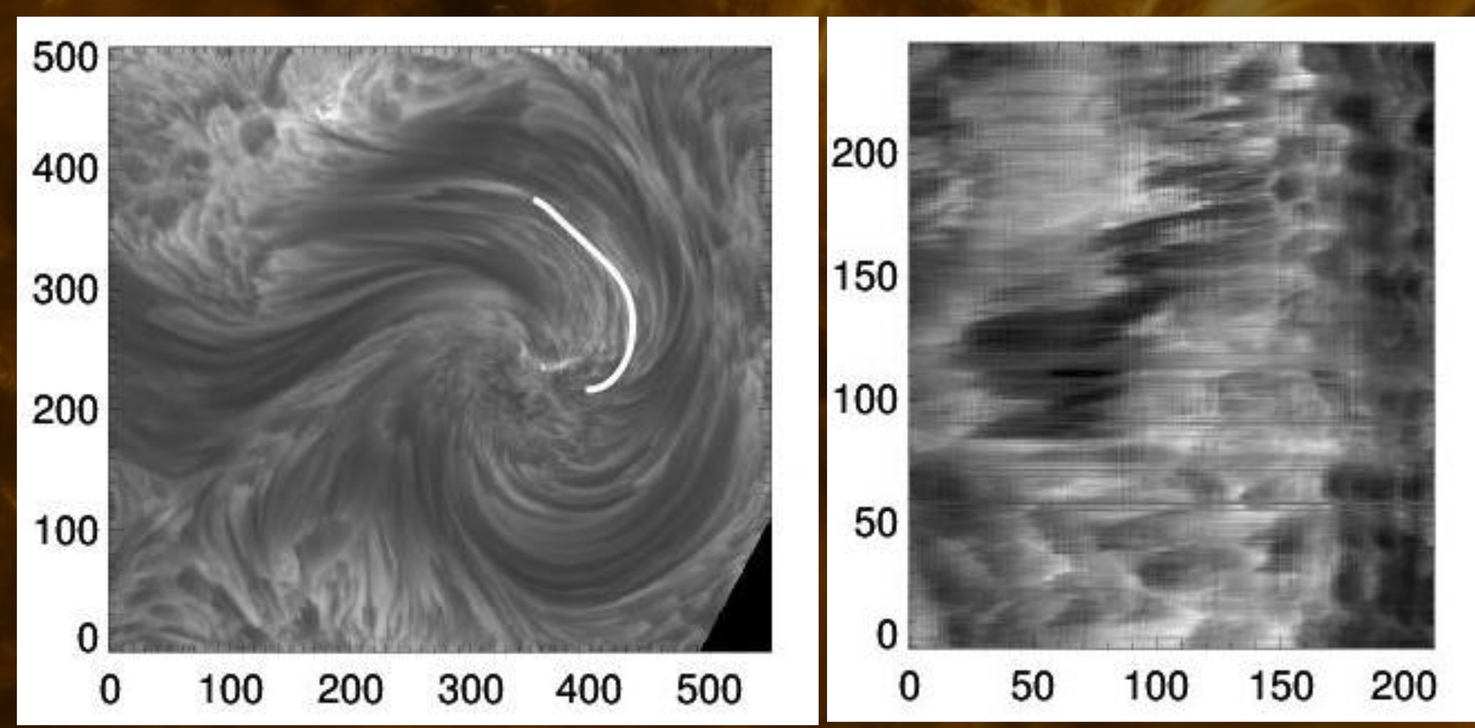
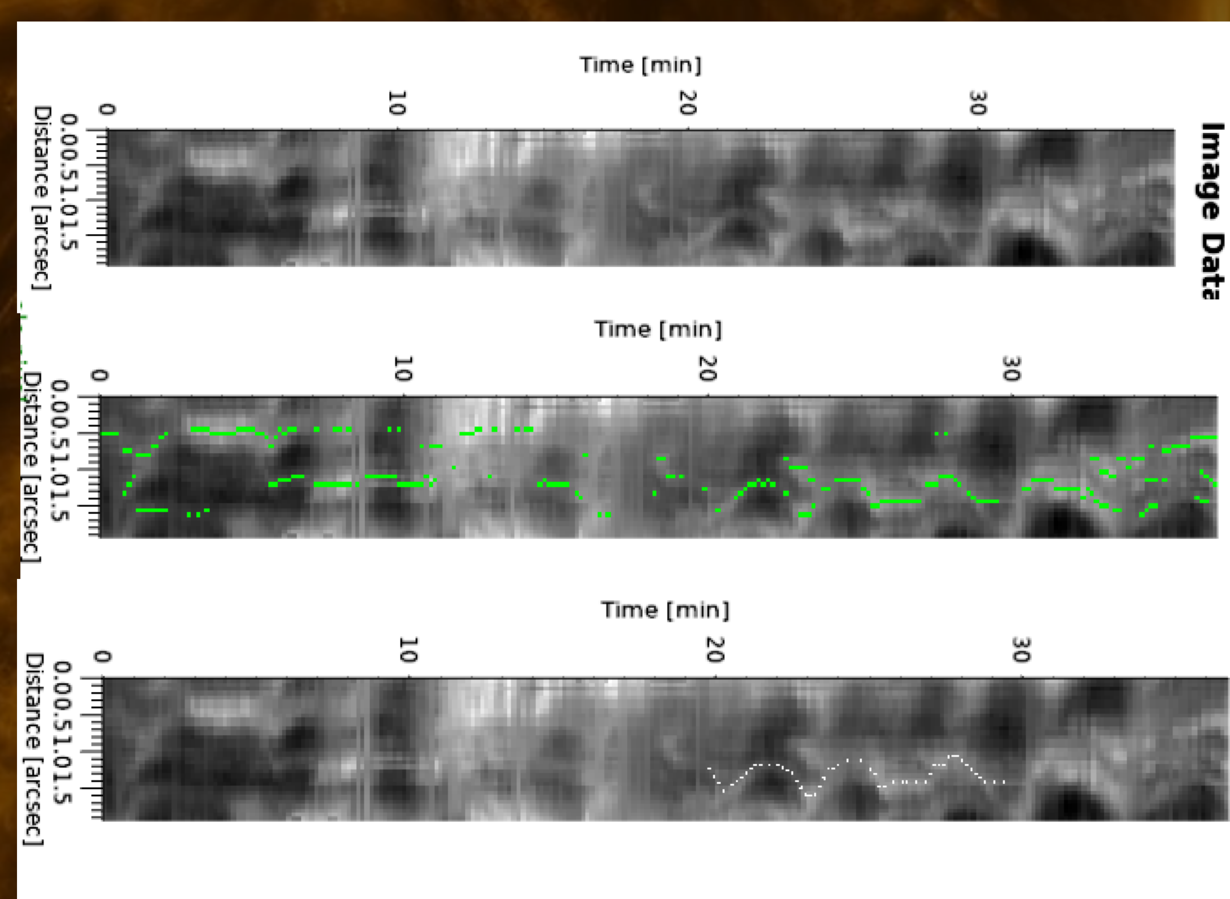


Fig 6: For this loop in the XT cut it is observed that there is signature of flows towards the beginning and the end of the loop. The beginning of the loop sees flows from the center of the pore and as the pore rises it can be seen that the periodicity of the flow changes. As it turns from ~3-minute to ~ 5-minute oscillation

Analysis of plasma flows

From the loop above a small section is selected to study the flow of plasma near the centre of the pore and the following statistics are extracted using a program called NUWT



Period	**3.25 mins**
Amplitude	132.85 Km
Peak PSD	4.405x10^6 Km^2 s

Fig 7: This is an example of using NUWT for wave detection. The NUWT code automatically detects multiple wave signatures and provides additional information of the detected flows and waves.

NUWT is used to analyse the XT cut and it automatically detects flow signatures in the XT cut. NUWT which analyses transverse waves along curvilinear features in time-distant diagrams of solar data [2]. The output from NUWT is used to understand the properties of these detected flows such as the time-period, frequency, amplitude, etc.

CONCLUSION

As magnetic loops rise and move away from the centre of the pore into the solar atmosphere, smaller oscillations shift to larger ones due to decreasing acoustic cutoff frequencies with height, which allows lower-frequency waves to pass and filters out higher frequencies. This study highlights the influence of curvature changes on plasma flow and tracks how these flows alter the shape of the loops.

References:

1. Aschwanden, M., Pontieu, B. & Katrukha, E. Optimization of curvi-linear tracing applied to solar physics and biophysics. Entropy 15 (2013).
2. Morton, R. J., Verth, G., Fedun, V., Shelyag, S. & Erd´elyi, R. Evidence for the Photospheric Excitation of Incompressible Chromospheric Waves. 768, 17 (2013). 1303.2356.