Deriving Movement of the Centroid of Coronal Holes from Long Term McA Data

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Features on the surface of the Sun and other layers of the atmosphere are constantly changing, due to its magnetic field. In 1964, Patrick Mcintosh, a scientist at NOAA's Space Environment Center, began creating hand-drawn synoptic maps of the sun's magnetic features and gathered nearly 45 years' (about four solar cycles) worth of these maps. To prevent these maps from being lost, most of these maps have been digitalized in the Mcintosh Archives (McA). This summer, we processed years' worth of this data to create stack plots, which are essentially plots of latitude bands stacked in time. This allows us to track the movement of solar features, particularly coronal holes. We calculated the centroids of the coronal holes at successive Carrington rotations, and estimated the slopes of these patterns as the coronal holes evolve. To calculate the centroids, we developed a new method using an algorithm and numerical tools in Mathematica. This method utilizes the Fourier Transform to find an approximation of any outline of coronal holes with a series of sinusoids in parametric form. These parametric equations are then plugged into line integrals to calculate the centroids. Our method of centroid calculations is accurate except when the coronal holes are too small. By estimating their velocities from these slopes, we found that the velocity is more prograde when the coronal holes are at low latitudes, and more retrograde at high latitudes, which isn't surprising due to the differential rotation. The velocity became zero at a lower latitude than expected based on where the Carrington rotation rate is defined at the photosphere. This implies, that the movement of coronal holes are being influenced by deeply rooted magnetic field lines below the surface. By superimposing differential rotation on coronal hole migration velocities and estimating the difference between the two, we can investigate what other factors influence coronal hole movement, such as Rossby waves. Learning more about these waves will tell us more about other forms of solar weather and could help us predict CMEs. This information could not only advance solar physics but also help keep our planet safe.