An Alternative Approach to Measuring Solar Velocities on the Solar Dynamics Observatory (SDO)

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Abstract
Aboard the Solar Dynamics Observatory (SDO), the Helioseismic and Magnetic Imager (HMI) measures the velocity of the Sun's magnetic fields. However, there is a calibration issue causing an artificial 24h periodicity. The SDO spacecraft's velocity leaks into the solar velocities data.

The spacecraft’s velocity is much greater than the solar velocities and causes inaccurate data. I compared the current HMI Method results with a Gaussian Fit Method, that could bypass the calibration error and avoid the leak of spacecraft velocity on the solar data. By plotting the Sun's spectra at six different wavelengths, I could use a Gaussian fit to calculate the distribution at each pixel.

After noticing trends in the two methods, I can claim the Gaussian Method works better at calculating solar velocities. However, it can be sensitive at identifying the wavelengths at Sunspot locations, varying only slightly from the original HMI data. This would give the most accurate results for solar velocities and limit the need for calibration.

Introduction
- From the Earth’s line of sight, the Sun rotates on an axis in the approaching and receding motion.
- Due to the Sun rotating faster around the equator and slower around it’s poles, the Sun’s magnetic fields get tangled.
- Sunspots are regions where the magnetic fields lines have become so tangled the field lines pierce through the sun surface.

The HMI instrument measures solar rotation and magnetic field velocity at all regions of the Sun. The current HMI Method uses ratios of 6 wavelengths to find a weighted velocity and requires a calibration curve that assumes how the spectral line looks at each pixel. The current HMI method is causing a leak of the spacecraft velocity on the solar data.

The Gaussian Method calculates solar velocity at all regions of the Sun. The current HMI Method uses to calibrate the Data. However, there is a calibration issue causing an artificial 24h periodicity. The SDO spacecraft's velocity leaks into the solar velocities data.

Results
- The figures show the results of the solar velocity plotted over 24 hours using the Gaussian fit, robust HMI method before calibration and after calibration, at different locations on the Sun.
- The HMI method incorporated a calibration in attempt to calculate accurate data. However, the use of calibration on the HMI data is unneeded when calculating the solar velocity in quiet inactive regions and caused the spacecraft's velocity to leak into the solar velocities.
- The HMI Method after calibration may produces accurate results in active region of the sun.
- The Gaussian method produced accurate solar velocity results at both active and inactive regions without the need for calibration.
- The lack of data with sunspots given, makes it difficult to determine what is happening in Fig. 8.

Conclusions
- The Gaussian Method produces more accurate results among both active and inactive regions.
- The HMI’s calibration error in inactive regions indicate the leak of the spacecraft velocity in active regions as well.
- To produce accurate results the HMI method would need to correctly identify when calibration is needed, if it is needed at all.
- Further research is needed to determine consistency in each of the methods.
- Future work would entail calculating the magnetic- field strength, Fe I line width, line depth, and continuum intensity using the Gaussian Method.

References

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