Introduction
The coronal heating issue causes investigation of the heating mechanisms of the chromosphere and corona, in which temperatures increase multiple orders of magnitude over a few thousand kilometers above the photosphere. A proposed mechanism for the increase in thermal activity in the chromosphere is Cowling heating, namely the Joule heating due to dissipation of electric currents perpendicular to the magnetic field lines by Cowling resistivity. We plan to investigate the contribution of Cowling heating within the solar active region atmosphere corresponding to NOAA AR1224 on 2014-07-27 from 14:02 to 17:58 UT (as a first analysis to investigate the presence of Cowling heating, we analyze at 14:12 UT), in particular over a sunspot light bridge (LB). Cowling heating has been observationally shown to heat an LB in Louis et al., 2021. Yalim et al., 2023. In this work, we analyze the Cowling heating as heating mechanism of a second sunspot LB towards the generalization of the results we obtained for the former.

Methods
The model used for calculating Cowling heating is defined by Yalim et al., 2020, in which the generalized Ohm’s law relation takes multiple plasma parameters:

\[ \mathcal{Q} = \mathcal{Q}_n + \mathcal{Q}_c + \mathcal{Q}_{\text{Cowling}} \]

where \( \mathcal{Q}_n \), \( \mathcal{Q}_c \), and \( \mathcal{Q}_{\text{Cowling}} \) are the Joule heating due to plasma collisions, perpendicular currents, and Cowling heating, respectively.

Data
We observe a light bridge within NOAA AR12121 in Figure 2. We obtain the plasma parameters from tabulated data of semi-empirical Maltby M model (Maltby et al., 1986) that models sunspot umbra, and magnetic field from the application of non-force-free field (NFFF) magnetic field extrapolation technique (Hu & Dasgupta, 2008) to SDO/HMI vector magnetogram data measured at 14:12 UT (see the dashed box in Figure 1, which corresponds to the AR 12121 in Figure 2).

Results

Discussion, Conclusions, and Further Study

- The obtained values for Cowling resistivity, perpendicular currents, and the resulting Joule heating all show enhancement (a decrease in resistivity, and an increase in the other two parameters) in the LB with respect to its surroundings.
- Plots of the heating parameters across the LB show an increase/decrease to significant levels relative to the LB’s surroundings. The visualization of perpendicular current, and Cowling resistivity on a vertical cut across the width of the LB (Figures 9, 11) shows a substantial increase & decrease in their values, respectively compared to the region outside the LB, but still within the target AR.
- In the case of Cowling heating, the maximum observed values in the target region of Figure 4 were found within the LB. This indicates, in addition to Louis et al., 2021, that Joule heating is a significant contributor to the overall heating of the LB atmosphere in a second LB which is an important step towards generalization of the results in the former. However, the two LBS still behave differently when it comes to the heating and its parameters due to the differences in magnetic field topology between the two LBS (see Figures 9-11).
- The nearly exclusive presence of perpendicular currents directly corresponding to the location of the LB indicates that the subsequent dissipation due to Cowling resistivity is most likely to occur in regions where LBS are prevalent: highly inclined magnetic fields with interactions between ions and neutrals.
- Considering the plasma parameter values discussed here come from tabulated solar atmosphere models (except for \( B \), constraining our model by observational temperature data will be an important next step. Observed spectral data from instruments like the Interface Region Imaging Spectrometer (IRIS) can be inverted to reveal 3-dimensional temperature data, so that fewer measurements of the chromospheric plasma parameters rely on tabulated model values.

References

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