Magnetic Reconnection

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Magnetic reconnection is a phenomenon that drives solar flares and Coronal Mass Ejections on the sun's surface. A strong enough CME is capable of damaging electrical equipment, disrupting communication, and harming astronauts in space. In my project, I wrote a Python program to simulate magnetic reconnection. According to a standard model of magnetic reconnection called the Sweet-Parker model or a current sheet, in order for a reconnection to happen, the flow of plasma needs to be stable and a thin current sheet needs to be formed. For the main objective of the project, I performed a parameter study on the current sheet to find the conditions where magnetic reconnection is more likely to occur. I found that a higher strength of magnetic field and a higher electrical resistivity of the plasma stabilizes a current sheet and leads to magnetic reconnection. The observations of the vorticity profiles clearly demonstrated this qualitatively but also the norms of the vorticity profiles confirmed this quantitatively. The analysis of the simulations showed the dependency of magnetic energy (of the current sheet) on the initial magnetic field strength; having a higher magnetic energy means more energy is released during magnetic reconnection and the associated phenomena are stronger. In summary, a higher magnetic field strength and a higher resistivity increase the stability of the current sheet and consequently facilitate magnetic reconnection. A higher magnetic field strength also increases the energy released and the strength of the solar flare or CME. My Python program helps understand the dynamics of how solar flares and CMEs form and leads to predictive models that will mitigate the catastrophic damages caused by solar flares and CMEs.

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