David Pham
PHY 482

Project – Starting an annotated bibliography

The topic for this project has narrowed down to magnetohydrodynamics of stellar object (mainly the Sun), with applications to 3D modeling. Additively, there are two more articles read, published by EDP Sciences and the American Astronomical Society.

The key findings from "Observationally driven 3D magnetohydrodynamics model of the solar corona above an active region" by Bourdin, Bingert, and Peter was the thermal structure of the plasma and of the magnetic field in the coronal structures. Prominently, these findings are important as the description sets the pressure of the coronal structure within the limitations of the spatial resolution in the models computed. Initially, the models cannot resolve the actual dissipation length scale based on precision, but it does takes into account the energy input, redistribution, and radiative losses to get a proper coronal energy balance. Specifically, the coronal energy balance is the redistribution of energy by *heat conduction along the magnetic field*. Also, these assisted in the comparison of observations to test the field-line braiding mechanism. Routinely, what led to this finding is that the implementation of the field-aligned heat conduction together with the optically thin radiative losses allows the researcher to properly describe the energy cycle between the chromosphere and corona.

What is necessary to understand the matter is Ohmic heating, which is a process wherein electric current is passed through materials with the primary purpose of heating them. Mathematically, Ohmic dissipation of induced currents is $E \cdot E$. How they initialized the magnetic field configuration with a potential field extrapolation is from the observed photospheric magnetogram. A magnetogram refers to a photographic representation of the spatial variations in strength of the solar magnetic field. An interesting notion to run the numerical experiments is utilizing the Pencil Code, due to its modular structure. The Pencil Code are codes utilized to solve partial differential equations and prominent in magnetohydrodynamics.

To summarize, the central idea behind this study is to compare synthesized emission from a forward 3D magnetohydrodynamics coronal model driven by photospheric observations to actual coronal observations. The goal was to employ a 3D magnetohydrodynamics model to model the corona in an observed solar active region.

The key findings from "Three-Dimensional Magnetohydrodynamics of the Emerging Magnetic Flux in the Solar Atmosphere" by Matsumoto, Tajima, Shibata, and Kaisig was that nonlinear instability does not exist in the pure interchange instability and that the pure interchange instability alone cannot create emerging magnetic loops. The figure that supports these key findings was by studying the three-dimensional nonlinear evolution of the magnetic buoyancy instability, a concept by which magnetic fields from within the Sun might come to the surface and contribute to its magnetic activity.

Significantly, there is much to learn before delving into this article. This article is a follow-up on their previous paper on two-dimensional magnetohydrodynamic code and 2.5D simulations, a necessary read. To state, 2.5D means that we include the vector components in the third dimension, but removes the variation in the third direction. The main aspects to take into account when thinking of the magnetic components from this article are two ideas. The rise velocity of the magnetic field saturates in a short time when it reaches the Alfvén speed evaluated at the initial conditions. If an isolated flux tube has the same temperature as the external medium, it cannot be in magnetostatic equilibrium. In discussion, they use the term "collimated expansion" for an expansion in the x – z plane but which is restricted in the y-direction.

To summarize, the study is towards the case in which the unperturbed magnetic flux tube is in magnetostatic equilibrium with the external medium that has the same density distribution. "The overall nature of the magnetic flux expansion is characterized by the properties of the undular mode."

David Pham
PHY 482

References

Kaisig M, Matsumoto R, Shibata K, Tajima T 1993 Three-Dimensional Magnetohydrodynamics of the Emerging Magnetic Flux in the Solar Atmosphere

Bingert S, Bourdin A, Peter H 2013 Observationally driven 3D magnetohydrodynamics model of the solar corona above an active region