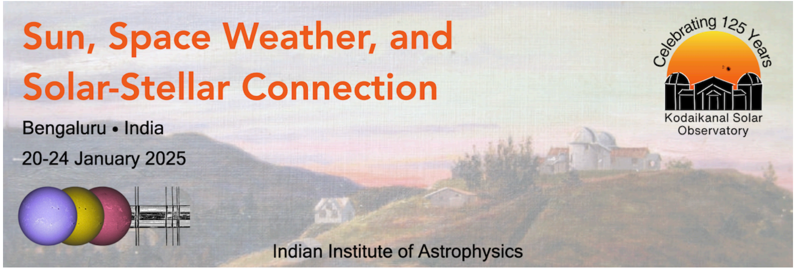

Contribution ID: **31** Type: **Poster**

Investigation of Plasma Relaxation in Solar Flares Using Data-Constrained MHD Simulations

Solar flares are transient events occurring over a time scale of minutes to hours, characterized by a sudden release of magnetic energy in the form of heat and kinetic energy of the plasma. These events are believed to be the manifestations of the magnetic reconnection process. We have explored the effects of 3D reconnection in solar flares, focusing on (a) magnetofluid dynamics from the perspective of plasma relaxation theory (b) reconfiguration of magnetic geometries such as null points, QSL, and HFT (c) spatiotemporal evolution of magnetic energy, current density, and related quantities namely twist and magnetic field gradient. A novel research problem exploring effects of two competing extrapolation techniques on the study of flare dynamics in data-constrained simulations is formulated. The novelty is in recognizing that reconnection is dissipative, which suggests its implications to be nearly independent of the used extrapolation model. The numerical model EULAG-MHD is used for the simulations, initiated using three different initial conditions constructed using nonlinear force-free and non force-free field extrapolations. Both models produced similar null point and HFT geometries. The dissipated free magnetic energy and changes in field line connectivity because of reconnection were also similar in all simulations. Further, a null point topology generated spontaneously and disappeared in each case near HFT. During its existence, its fan plane exhibited slipping reconnection, which is found to be indicative of having plausible contribution in the investigated flare. The key conclusions are (a) both extrapolation models are suitable for initiating data-constrained MHD simulations and (b) short lived magnetic structures may also be relevant in the overall energetics of flare dynamics. The release of magnetic energy in transients leads to the expectation that magnetic field should relax to a lower energy state. Therefore, it is natural to consider the feasibility of known relaxed states in the post-transient state of magnetofluid. Notably, the Taylor's state is of immediate interest because it minimizes magnetic energy and hence relates directly to the transients. In this regard, earlier studies focused on analytical magnetic fields or observations, but to account for the complexity of active-region magnetic fields, simulated dynamics of an actual flare is investigated. Taylor's theory assumes conducting walls but since the solar corona is an open system, three integration volumes of different sizes are envisaged to navigate through this challenge. The study revealed an important result: to realize magnetic energy decay and hence relaxation, the size of the chosen relaxation volume needs to be large enough such that energy transfer due to Poynting flux is small. In absence of physical resistivity, Poynting flux is estimated using ideal MHD and the problem of validating it in various regions of the computational box is tackled by calculating the deviation of the induction equation from its ideal form. The analysis of angular alignment between current density and magnetic field showed evolution toward force-free state but relaxation is not enough to achieve the Taylor's state. The key conclusion from this study is that flare energetics may have a bearing on the extent of relaxation. To explore further, three energetically different flares are analyzed and it is found that from the viewpoint of energy decay, relaxation extent is in concurrence with the general relation between the energy classes of chosen flares. However, an interpretation of change in angular alignment in the context of relaxation extent is found to be non-trivial. An interesting finding of the work is a parameter based on reconnection morphologies that may predict the strength of solar flares and hence might prove useful in space-weather applications.

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Theme

Energetic Phenomena

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