DATA-DRIVEN MHD SIMULATIONS OF SOLAR ERUPTIONS

Chaowei Jiang\textsuperscript{1}, Xueshang Feng\textsuperscript{2}, Qiang Hu\textsuperscript{3}

\textsuperscript{1}Harbin Institute of Technology, Shenzhen 518055, China
\textsuperscript{2}National Space Science Center, Chinese Academy of Sciences, Beijing 100190, China
\textsuperscript{3}Center for Space Plasma and Aeronomic Research, The University of Alabama in Huntsville, Huntsville, AL 35899, USA

Although it is well recognized that solar flares/eruptions are driven by magnetic field of the Sun, why and how these phenomena occur are still open questions. Over the past forty years a variety of models have been proposed to explain the initiation mechanism of solar eruptions. Some researchers emphasize the importance of ideal magnetohydrodynamic (MHD) instabilities, in which, a magnetic flux rope emerges from the convection zone and is launched into the corona due to its kink or torus instability. Others stress the primary role of magnetic reconnection, and believe that without magnetic reconnection eruption can never happen even if the magnetic energy is excessively supplied. All these models are, however, idealized or hypothetical simplification of the realistic case that is much more complex and elusive in observation. In this presentation, we will show how the solar eruptions originate and develop in an unprecedentedly realistic way by using full MHD modeling driven directly by magnetic field data from observation without any kind of artificial configuration or constraint. We demonstrate that our model can reproduce the magnetic field and its evolution in an excellent agreement with the state-of-the-art EUV observation following the timeline from a long-duration quasi-static evolution (over days) to the fast eruption (in minutes), which is a typical evolution pattern of solar eruptions from its origin to onset. Our studied events represent a wide range of flares from the minor C-class to major X-class and include both the confined and eruptive ones, either typical two-ribbon flares or atypical ones such as circular-ribbon and X-shaped flares. We conclude that magnetic flux emergence and the resulted photospheric shearing motions play a primary role in leading to the solar eruptions and their triggers can either be magnetic reconnection or MHD instability, and how the solar eruptions occur, once being triggered, can be predicted by following evolution of the unstable pre-eruptive magnetic configuration.