Simulation of the Birth of a Solar Active Region

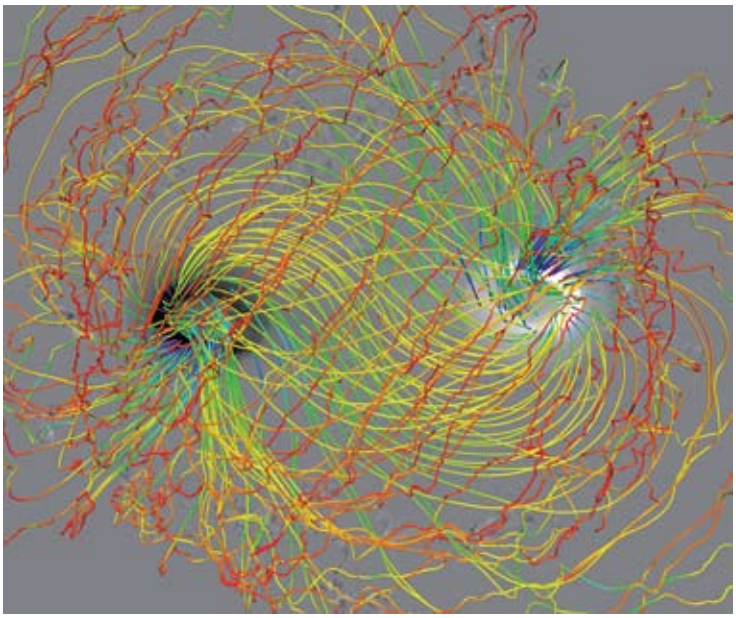
The solar surface is ever evolving and full of intense magnetic fields that are responsible for solar storms. The most spectacular manifestations of magnetic fields on the Sun's surface are in the form of Active Regions (ARs). These ARs are a consequence of the emergence of buoyant magnetic flux bundles from the solar convection zone into the solar atmosphere.

Recent observations from the Solar Optical Telescope (SOT) onboard the Hinode spacecraft, an international mission to study the Sun, have unveiled the intricate dynamics of these emerging flux regions in unprecedented detail. By performing realistic numerical simulations of emerging flux regions, we are able to reproduce and explain the various observational properties of how ARs form and evolve.

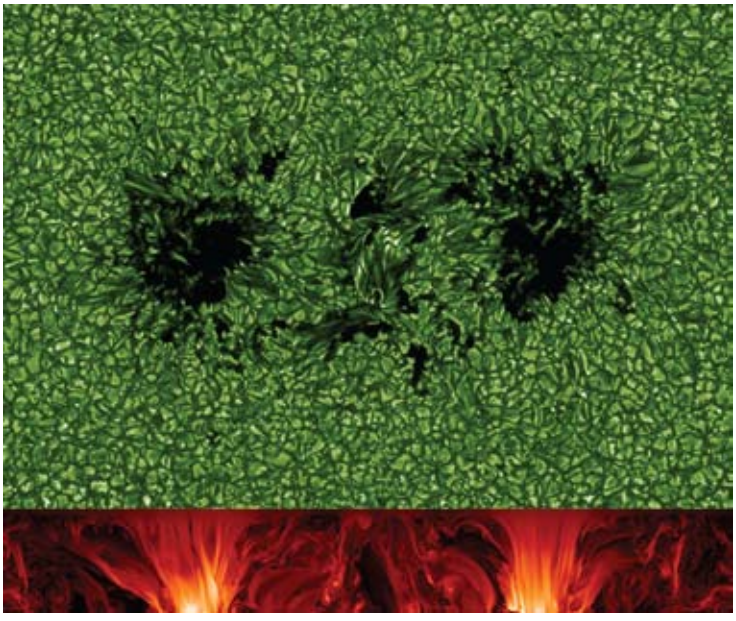
The numerical simulations carried out during this project allow us to better interpret the observations from the Hinode spacecraft. A better understanding of emerging flux regions will also help us better use observations from NASA's upcoming Solar Dynamics Observatory and Interface Region Imaging Spectrograph (IRIS).

Use of the Pleiades and Columbia supercomputers located at the NASA Advanced Supercomputing facility at Ames Research Center has allowed us to run simulations at unprecedented scales. The availability of thousands of processors for a single simulation run was crucial and allowed us to study how:

- Magnetic field rises over ten pressure scale heights in the top layers of the solar convection zone
- Expansion of rising magnetic flux drives near-surface horizontal flows
- Small-scale flux emergence events occur in succession leading to the build-up of coherent concentrations of magnetic field that becoming spots in an active region
- Light bridges inside sunspots form and disappear
- Light bridges, umbral dots, and penumbral filaments have a common magnetoconvective origin
- Physical properties of active regions translate into their observed appearance



Field lines show the twisted structure of the magnetic flux bundle as it rises towards the solar photosphere, the lowest layer of the Sun's atmosphere.



Brightness intensity of the active region at the solar photosphere (upper panel) and vertical cross-section through the central portion of the region showing the magnetic field distribution in the convection zone and photosphere (lower panel).

http://www.lmsal.com/~cheung

Mark Chun Ming Cheung, Lockheed Martin Solar & Astrophysics Laboratory, cheung@lmsal.com