Summary of Involvement for the Thomas Metcalf SPD Travel Award

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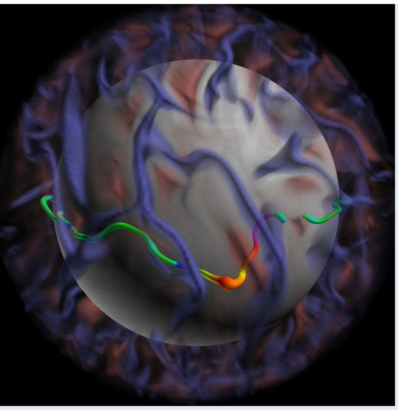
Maria A. Weber

Maria is a post-doctoral researcher at the University of Exeter, Exeter, UK working with Dr. Matthew Browning on convection and magnetism in lower mass stars. She is an expert regarding flux emergence in the interior of the Sun and solar-like stars, knowledge she gained as a graduate student working with Dr. Yuhong Fan and Dr. Mark Miesch at High Altitude Observatory/NCAR. Maria received her Ph.D. from Colorado State University, Fort Collins, CO in 2014. Her love of the Sun began in the summer of 2007 while she was an REU student at NSO, Sac Peak.



Active-region-scale magnetic flux tube evolving in turbulent, solar-like convection. Image generated by NASA NAS.

Contribution – Magnetic Flux Tubes in the Turbulent Solar Interior: Toward Linking Fibril Magnetic Fields with Active Regions

Active regions are observable manifestations of solar magnetic fields, thus providing a photospheric link to the deep-seated dynamo mechanism. However, the manner by which magnetic fields traverse the convection zone to eventual emergence at the solar surface is not well understood. We study the dynamic evolution of active region progenitors by embedding thin magnetic flux tubes in a rotating spherical shell of turbulent, solar-like convection. Utilizing the thin flux tube approximation, we track the evolution of an effectively 1D flux tube while circumventing the problem of artificial diffusion suffered by 3D MHD models.

Our simulations bring us to a more comprehensive understanding of the flux emergence process in the bulk of the convection zone, and compliment results from recent 3D convective dynamo simulations. We find that convective flows have a non-negligible effect on most of the flux tubes in our study. Strong downflows pin portions of the flux tube to the base of the convection zone, while strong upflows can accelerate rising flux loops toward the surface, promoting flux emergence (see figure). Furthermore, large convective structures present in our simulation referred to as giant cells organize flux emergence into distinct longitudinal spans with significant North/South alignment. Including the effect of radiative heating on flux tube evolution causes an increased buoyancy of the tube in the lower convection zone. As a result, 10^{22} Mx flux tubes of $\leq$60 kG have footpoints that are no longer able to anchor in the stably stratified convective overshoot region. The distribution of tilt angles calculated from our flux tubes once they have reached the simulation upper boundary ($0.97R_\odot$) agrees well with what is observed on the Sun. Helical upflows help tilt the apex of rising flux tubes toward the equator, contributing to the Joy's Law trend of observed active regions.

Maria is grateful for support she received from the Thomas Metcalf Travel Award to attend the Flux Emergence Workshop (FEW) as a Metcalf Lecturer, also making it possible to attend the Solar Dynamo Frontiers Workshop in Boulder the week prior to FEW. Maria enjoyed many fruitful discussions with attendees of FEW, initiating multiple collaborations particularly in regard to comparing her results to solar observations. New insights gained from observations and simulations at the workshop will help guide Maria as she continues to study flux emergence and convective dynamo action in lower mass and solar-like stars.