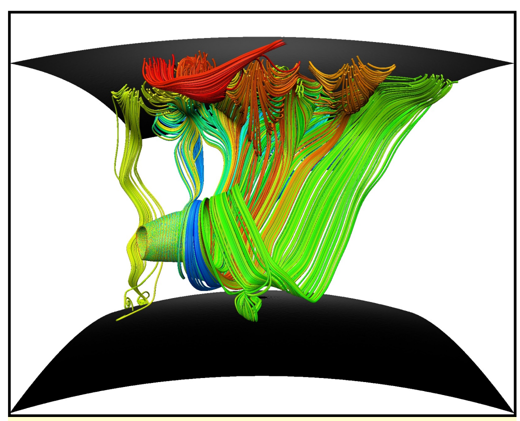
Summary of Involvement for the SPD Metcalf Travel Award

IAUS 328: Living Around Active Stars

October 17-21, 2016 Maresias, Brazil

Nicholas J. Nelson is an Assistant Professor of Physics at California State University, Chico. His research focuses on using 3D MHD simulations of convective dynamo action in solar-like stars to model fundamental physical mechanisms that drive differential rotation, dynamo action, and magnetic activity in stars. Nicholas received his PhD in Astrophysical and Planetary Sciences from the University of Colorado in 2013 where he worked with Juri Toomre and Mark Meisch. His doctoral research focused on simulating and studying the self-consistent generation of buoyant magnetic loops by solar-like convective dynamo models. He was a Nicholas C. Metropolis Postdoctoral Fellow at Los Alamos National Laboratory from 2013-2015, where he worked with Joyce Guzik on the interaction of convection and pulsations in gamma Doradus and delta Scuti pulsators.

My talk focused on how the evolution of dynamo action and flux emergence mechanisms over a star's main sequence lifetime play key roles in setting the stellar wind and space weather environment for potentially habitable planets such as our own. Stellar dynamo action results from turbulent convection of plasma, rotation, and stratification which combine to generate magnetic fields, emergent magnetic flux, and potentially cycles of magnetic activity. These processes are notoriously difficult to model, however continued advances in computational resources and massively parallel code development have provided global 3D convective dynamo simulations of sun-like stars which are beginning to access many of the key physical processes which yield stellar magnetism. Observationally young solar-like stars have been shown to at least roughly follow a Skumanich-type rotational evolution, while stars older than the Sun have recently been shown to exhibit anomalously slow spin-down. Here we present convective dynamo simulations of sun-like stars at a range of rotation rates and show that sun-like stars may undergo a "stellar midlife crisis" corresponding to a loss of rotational constraint on convective motions and a transition from solar-like differential rotation to what has been termed "anti-solar" differential rotation with super-rotating polar regions and sub-rotating low latitudes. This shift in differential rotation leads to significant changes in the strength, morphology, and variability of the resulting magnetic fields.



Volume rendering of velocity streamlines in a 3D ASH simulation of solar-like convection with a stochastic plume boundary condition, which shows a new path towards more realistic convective dynamo simulations.

IAUS 328 provided a valuable opportunity for both formal and informal discussions related to the differential rotation and dynamo action achieved in solar-like stars. Differential rotation is a key driver of dynamo action, which in turn leads to stellar magnetic activity, which in turns impacts exoplanetary space weather and space climate. The conference provided a venue to address the implications of my work on other components of the larger questions related to stellar activity and habitability.