Project Details

ROSES ID: NNH06ZDA001N
Selection Year: 2007
Program Element: Focused Science Topic

Topic: Understand how Flares Accelerate Particles near the Sun (i.e., through Shocks and/or Reconnection) and how they Contribute to Large SEP Events

Project Title:
Stochastic particle acceleration in solar flares

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Summary:
The acceleration of particles to energies exceeding 50 MeV in solar flares is a long-standing problem and one of the Focused Science Topics of NASA's 2006 Living-With-a-Star (LWS) program. This proposal addresses one of the leading theories for particle energization in flares, namely stochastic particle acceleration. In this theory, turbulent waves are excited in the flaring region by magnetic reconnection and the ideal fluid motions that arise as the magnetic field relaxes to a new configuration. The energy in these waves undergoes a turbulent cascade to small scales, resulting in high-frequency waves that accelerate particles to high energies through resonant wave-particle interactions. If the power spectra of these waves have the right properties, stochastic acceleration can explain many of the observed features of flares, including the acceleration time scales, the energy spectra of different particle species, and the highly enhanced abundance of helium-3 relative to helium-4 in the accelerated particle population. However, there is still no predictive theory for the turbulent power spectra of waves on the Alfven/ion-cyclotron and fast-magnetosonic/whistler branches of the dispersion relation in flaring regions. The determination of these power spectra is the most important unsolved problem for the stochastic-acceleration model, and is the focus of this proposal. Building on previous work by the PI and co-I, we will carry

out weak turbulence calculations and direct numerical simulations to determine the power spectra of the above-mentioned waves for solar-flare conditions. A notable feature of this turbulence research is its extensive use of analytic theory in addition to numerical simulations, which will lead to highly detailed quantitative results, a theoretical framework that can be applied by other investigators, and a clear physical picture of the energy cascade mechanisms. We will use these power spectra to determine the acceleration times and energy spectra of different particle species as a function of the overall turbulence amplitude (i.e., the rms velocity at the largest scales) using quasilinear theory to treat the particle-acceleration process. We will then compare our results to x-ray, gamma-ray, and in-situ particle measurements. By determining the power spectra of the different wave modes in solar-flare conditions, our work will provide key missing information that is essential for assessing the importance of stochastic acceleration in solar flares, and for determining the contribution of flare-accelerated particles to large solar-energetic-particle (SEP) events observed at Earth.

Publication References:

Summary: no summary

Reference: Chandran, B., "Strong Anisotropic MHD Turbulence with Cross Helicity," Astrophys. J., 685, 646, 2008.

Summary: no summary

Reference: Pongkitiwanichakul, Peera; Chandran, Benjamin D. G.; Karpen, Judith T.; DeVore, C. Richard; (2012), The Effects of Wave Escape on Fast Magnetosonic Wave Turbulence in Solar Flares, The Astrophysical Journal, Volume 757, Issue 1, article id. 72, 6 pp, doi: 10.1088/0004-637X/757/1/72