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Miriam A. Forman, Principal Investigator
SUNY Stony Brook, Department of Physics and Astronomy
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Past year accomplishments:

1. Talks and presentations
I presented papers on my approach and progress, at the American Geophysical Union Fall and Spring meetings. I gave an invited talk on the history and evolution of cosmic ray transport theory for the heliosphere at the COSPAR Colloquium on the Outer Heliosphere, in Potsdam Germany in July 2000, and attended the ACE symposium in January 2000. At no cost to the grant, I worked several weeks at Imperial College London with Tim Horbury to begin unravelling the 3-D structure of magnetic turbulence in the solar wind. This needs to be done to fully accomplish the objectives of this grant, and the final result cannot be found without it. I reported our considerable progress at a colloquium at Queen Mary College.

2. Scientific summary of accomplishments
The science problem I have tackled in this grant, is the derivation of the diffusion tensor of energetic particles in turbulent magnetic fields, with a sensible mean field. The new approach was to use quasi-linear theory with a consistent treatment of those scattering terms leading to diffusion perpendicular to the mean magnetic field; and, to use modern data and formats for three-dimensional turbulence.

The full problem is mathematically very tedious, at least until the final insight is achieved.

As a start, I have redone the theory of diffusion parallel to the mean field. I have discovered and reported in talks that power in the magnetic turbulence spectrum at an infinite family of semi-discrete wave vectors all over k-space contribute to both parallel and perpendicular diffusion. (They are discrete in k_z, but have finite width in the k_x and k_y directions.) I discovered that the problem with the early theories which assumed "slab" turbulence, was that method picked up only a single member of this family of resonances, for both parallel and perpendicular diffusion. The improvements made to diffusion theory by the Bartol group in the last decade pick up some of the largest additional resonances, but not all of them.

I have been using the forms described by Oughton, *et al.*(Phys Rev E, **56**,2875-2888, 1997) for the correlation and power spectral tensors for three-dimensional (3D) magnetohydrodynamic (MHD) turbulence. They showed that MHD physics implies that each of the nine elements of the tensors, is a linear combination of just four scalar functions of the wave vector, and tensor forms made from the direction cosines of the k-vector. The scalar functions are the fundamental descriptors of MHD turbulence, and thus of the utmost importance to diffusion theory.

My theory will eventually describe scattering and diffusion of energetic particles completely by the power in Oughton's scalar functions at families of semi-discrete wave vectors.

I have also discovered that the heliosphere turbulence community does not know how to reliably deduce these scalar functions from spacecraft data. Thus, to make useful progress on my problem, I have been working with Tim Horbury (Imperial College, London) to use his Ulysses magnetic field data to deduce the four scalar functions.

3. Plans for the future

I will continue work on the tedious algebra of the perpendicular diffusion of energetic particles in magnetic turbulence. Simultaneously, I will work on characterizing the underlying anisotropy of the power spectrum tensor of magnetic turbulence in the heliosphere, because it is required for the diffusion theory, and because it is interesting for its own sake and could be an important result from Ulysses.

Following the NASA/ROSS 2000 competition, I was awarded a new grant to continue this work. The details of future work are described in detail in the successful proposal is attached.