

Final report

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Studies in Nonlinear Problems of Energy

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We completed a successful research program on Nonlinear Problems of Energy, with emphasis on combustion and flame propagation. A total of 183 papers associated with the grant has appeared in the literature, and our efforts have twice been recognized by DOE's Basic Science Division for Top Accomplishment.

In our research program we concentrated on modeling, analysis and computation of combustion phenomena, with particular emphasis on the transition from laminar to turbulent combustion. Thus we investigated the nonlinear dynamics and pattern formation in the successive stages of transition. We described the stability of combustion waves, and transitions to waves exhibiting progressively higher degrees of spatio-temporal complexity. Combustion waves are characterized by large activation energies, so that chemical reactions are significant only in thin layers, termed reaction zones. In the limit of infinite activation energy, the zones shrink to moving surfaces, termed fronts, which must be found during the course of the analysis, so that the problems are moving free boundary problems. The analytical studies were carried out for the limiting case with fronts, while the numerical studies were carried out for the case of finite, though large, activation energy. Accurate resolution of the solution in the reaction zone(s) is essential, otherwise false predictions of dynamical behavior are possible. Since the reaction zones move, and their location is not known a-priori, we have developed adaptive pseudo-spectral methods, which have proven to be very useful for the accurate, efficient computation of solutions of combustion, and other, problems. Our approach is based on a combination of analytical and numerical methods. Our numerical computations built on and extended the information obtained analytically. Furthermore, the solutions obtained analytically served as benchmarks for testing the accuracy of the solutions determined computationally. Finally, the computational results suggested new analysis to be considered.

A cumulative list of publications citing the grant follows.

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## CUMULATIVE LIST OF PUBLICATIONS

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B.J. Matkowsky  
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