FINAL TECHNICAL REPORT

Project Title: *Shedding New Light on Exploding Stars: Terascale Simulations of*
                        Neutrino-Driven Supernovae and Their Nucleosynthesis
PI: Dennis C. Smolarski, S.J.
Performance Period: May 15, 2003 – May 14, 2004
Funds Awarded: $68,000

This award continues the ongoing development of software as part of the Terascale Supernova Initiative. The first year of funding for Smolarski's effect on this project was through a subcontract issued on TSI-DOE Grant 1528746, award to the University of Illinois Urbana-Champaign. Dr. Anthony Mezzacappa is the Principal Investigator on the Illinois award.

1. Smolarski continued his work with Doug Swesty (SUNY-SB) in developing and revising code for various "striped" SPAI preconditioners for the V2D code developed by Swesty and Eric Myra, traveling to SUNY-SB in November 2003 and again in January 2004 for extended periods of consultation. While Smolarski and Swesty were at the Copper Mountain Conference on Iterative Methods together in March – April 2004, additional discussion took place. Some revision of code of some preconditioners was necessitated by the updated versions of the Swesty-Myra V2D code.

2. The technical report, *On the Performance of SPAI and ADI-like Preconditioners for Core Collapse Supernova Simulations in One Spatial Dimension*, by R. Balakrishnan, E. D'Azevedo, J. Fettig, B. Messner, F. Saied, P. Saylor, D. Smolarski, F.D. Swesty (Univ. of Illinois, Dept. of Computer Science, Technical Report UIUCDCS-R-2003-2335, June 2003), was revised in January 2004 and initially submitted to the *Journal of Computational and Applied Mathematics.* It was again revised with the help of B. Messer and D. Swesty, most recently, in December 2005 and submitted to *Computer Physics Communications.* In April 2006, the editor requested clarifications before making a definitive decision.

3. Smolarski examined the sparsity patterns of inverses of certain types of "diagonally striped" banded matrices in order to develop some understanding of the types of SPAI preconditioners that might work better for MGFLD and MGBT matrices. A manuscript, entitled, *Diagonally striped matrices and approximate inverse preconditioners*, was completed and submitted to *SIAM J. on Matrix Analysis and Applications* in October 2003. The manuscript reflects the types of SPAI preconditioners used in V2D code experiments. A revised version of the manuscript was resubmitted to the *Journal of Computational and Applied Mathematics* in March 2004 and was accepted for publication. It appeared in February 2006 (see bibliographical listing below).

4. Work continued in integrating the parallel version of Chebycode (developed in Year 1 by Ryan Szypowski) into the Swesty-Myra V2D code as an alternative to using BiCGstab. Initial debugging has been completed with the appropriate modification of Chebycode's data structures to correspond to those used in theV2D code. Initial test results indicate that Chebycode may be quite promising as an alternative to BiCGstab. Further tests are needed to validate the code with datasets of different sizes. A report describing the initial results of

code run with Chebycode and with BiCGstab was scheduled to be presented at the Copper Mountain Conference on Iterative Methods, March 28 – April 2, 2004.

5. Smolarski presented a talk at the Copper Mountain Conference (April 1, 2004) entitled "Implementing Chebyshev Iteration on Parallel Architectures: Some Preliminary Results," reporting on work by Swesty, Paul E. Saylor (Univ. Ill.), and Ryan Szypowski (Univ. Calif. San Diego) in integrating Chebycode into Swesty's V2D code and the simple corner balance (crooked pipe) problem with the use of striped SPAI preconditioners.

6. In May 2004, Smolarski and Swesty had numerous phone conversations. A significant amount of time and energy was spent in locating and correcting a transient bug in the V2D code, slowing further progress. The used of these striped preconditioners proved to be very effective and they were also tried with a simple corner balance (crooked pipe) problem to provide additional verification of their overall effectiveness.

Publications:

A Comparison of Algorithms for the Efficient Solution of the Linear Systems Arising from Multi-Group Flux-Limited Diffusion Problems, by F. D. Swesty, D. Smolarski, P. Saylor, *The Astrophysical Journal, Supplement Series,* 143:1 (July 2004), pp. 369-387.

Diagonally striped matrices and approximate inverse preconditioners, by Dennis C. Smolarski, S.J., *Journal of Computational and Applied Mathematics,* 186:2 (15 February 2006), pp. 416-431. (cf. item 3 above)