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We are continuing the development of codes solving large-scale realistic models of aero-, hydrodynamic and astrophysical problems on fast vector and parallel versions of three-dimensional of aero- and hydrodynamics codes, tested by us on a variety of two-dimensional problems. These codes are used now for solutions of astronomical, astrophysical and cosmological problems. The main part of the code development is the reduction of its computational complexity, to make it feasible to run in a moderate time (days of super-computers) large simulations of galaxy evolution over a large fraction of Hubble time. For this purpose we use symbolic computational methods and computer algebra programs and tools, developed by us. Particularly successful was the development of specialized fast (scalar, vector and parallel) subroutines of evaluation of special functions and their integrals in the astrophysical code (needed for computation of chemical, thermodynamical and gravitational effects), that consume most of the runtime of the programs. Our algorithms for special function evaluations are based on our fast methods of power series and rational approximation computations. *Symbolic Programming. (jhb)*

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**MASSIVE SYMBOLIC MATHEMATICAL COMPUTATIONS
AND THEIR APPLICATIONS**

Quarterly Report
July 1988

D.V. Chudnovsky, G.V. Chudnovsky, M. Friedman
and K. Prendergast

Since our last Quarterly Report, we achieved certain progress in further development, implementation and optimization of algorithms, numerical methods, computer realizations and graphical display of computer simulation and modeling of realistic mathematical and physical problems.

1. Vector and Parallel Three-Dimensional Flow, Multi-Fluid and Astrophysical Codes.

We are continuing the development of codes solving large-scale realistic models of aero-, hydrodynamic and astrophysical problems on fast vector and parallel machines. We are preparing several groups of parallel versions of three-dimensional of aero- and hydrodynamics codes, tested by us on a variety of two-dimensional problems. These codes are used now for solutions of astronomical, astrophysical and cosmological problems. The main part of the code development is the reduction of its computational complexity, to make it feasible to run in a moderate time (days of supercomputers) large simulations of galaxy evolution over a large fractions of Hubble time. For this purpose we use symbolic computational methods and computer algebra programs and tools, developed by us. Particularly successful was the development of specialized fast (scalar, vector and parallel) subroutines of evaluation of special functions and their integrals in the astrophysical code (needed for computation of chemical, thermodynamical and gravitational effects), that consume most of the runtime of the programs. Our algorithms for special function evaluations are based on our fast methods of power series and rational approximation computations. The next milestone will be the run of large three-dimensional programs describing the galaxy formation and evolution, with development of needed high-resolution graphics representation of data needed for visualization of complex evolution in the parameter space (depending on cooling and heating rates, star formation and possible presence of dark matter).

2. Parallel Computations.

The development of parallel algorithms and computational schemes for large finite element problems is continuing with the utilization of a 30 processor Balance computer. Several schemes for accelerating the algorithms are being explored and applied to model problems with 10^4 degrees of freedom to test their efficiency. Because of speed and memory limitations of the Balance computer, we are exploring the use of alternative parallel computers for the investigation of much larger systems.

3. Vector and Parallel Arithmetic Applications.

We are developing basic arithmetic algorithms for vector and large parallel SIMD machines, that include optimized bignum operations and primality proving and factorization techniques. Some of these algorithms are currently being implemented in hardware.

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