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Informal Report

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LOS ALAMOS SCIENTIFIC LABORATORY
Post Office Box 1663 Los Alamos, New Mexico 87545

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L. D. Cloutman

SOLA-STAR: A ONE-DIMENSIONAL ICED-ALE HYDRODYNAMICS PROGRAM FOR SPHERICALLY SYMMETRIC FLOWS

by

L. D. Cloutman

ABSTRACT

This report describes a simple, general-purpose, and efficient algorithm for solving one-dimensional spherically symmetric, transient fluid-dynamics problems using a variation of the ICED-ALE technique. Included are the finite difference equations, three test problems that illustrate various capabilities of the program, and a complete code description, including a listing, sample data decks and output, a summary of important variable names, and hints for conversion to other operating systems.

I. INTRODUCTION

Several years ago we reported a technique for implementing the ICED-ALE methodology in a form suitable for numerically simulating a wide variety of spherically symmetric fluid flows.[1] An experimental computer program, VEGA, was written to test this methodology and was applied to the star formation problem. Although that technique was designed for astrophysical applications, it is by no means limited to them. In the interim, Group T-3 has developed the SOLA series of simplified numerical fluid dynamics programs[2,3] specificially for public distribution. In response to requests for copies of the VEGA program, we are presenting a simplified version, SOLA-STAR, in this report. This code follows the philosophy of the SOLA series inasmuch as the code is easy to understand and use, it can be used by persons with little numerical fluid dynamics experience, it is easily modified to include more complicated physics, and it is useful both as a teaching device and a serious research tool.

The numerical algorithm used in the present program is basically the same as reported in Ref. 1, so no derivation of the difference equations will be presented in this report. The derivation is based on a volume integration of the governing equations, and the interested reader can find the details in Refs. 1 and 4-6. The algorithm consists of two phases. Phase I is a partially implicit Lagrangian time step. In Phase II, the solution is rezoned (if desired) in a physically motivated manner that conserves mass, momentum, and internal energy. The only stability requirement is that

$$\frac{|u|\delta t}{\delta r} < 1 \tag{1}$$

everywhere on the mesh, where u is the velocity, δt is the time step, and δr is the width of a computational mesh cell. This limit requires that the fluid moves less than one cell width each computational cycle. Observance of this limit, proper choice of the donor cell parameter α (to be described later), and choosing the time step such that no variable changes its value by more than some small amount, say 20%, has been sufficient to achieve numerical stability for all of the problems that we have run. A more detailed discussion of stability of the method (and of many other aspects of the method) can be found in Ref. 1.

II. EQUATIONS FOR SPHERICALLY SYMMETRIC FLOWS

To simplify the program and minimize both computing time and core requirements, SOLA-STAR assumes a single-component ideal gas. The differential equations that we model are

$$\frac{\partial \rho}{\partial t} + \frac{1}{r^2}\frac{\partial}{\partial r}(r^2 \rho u) = 0 \quad , \tag{2}$$

$$\frac{\partial \rho u}{\partial t} + \frac{1}{r^2}\frac{\partial}{\partial r}(r^2 \rho u^2) = -\rho g - \frac{\partial p}{\partial r} + \frac{1}{r^2}\frac{\partial}{\partial r}\left(r^2 (2\mu+\lambda)\frac{\partial u}{\partial r}\right) - \frac{2u(2\mu+\lambda)}{r^2} + \frac{2u}{r}\frac{\partial \lambda}{\partial r} \quad , \tag{3}$$

and

$$\frac{\partial \rho I}{\partial t} + \frac{1}{r^2}\frac{\partial}{\partial r}(r^2 \rho u I) = -p\frac{1}{r^2}\frac{\partial}{\partial r}(r^2 u) + \frac{1}{r^2}\frac{\partial}{\partial r}\left(r^2 K \frac{\partial T}{\partial r}\right) + 2\mu\left[\left(\frac{\partial u}{\partial r}\right)^2 + \frac{2u^2}{r^2}\right] + \lambda\left[\frac{1}{r^2}\frac{\partial}{\partial r}(r^2 u)\right]^2 \quad , \tag{4}$$

where t is time, r is radius, ρ is the density, u is the radial velocity, p is the pressure, μ is the coefficient of viscosity, λ is the second coefficient of viscosity, g is the gravitational acceleration, I is the specific internal energy, K is the conductivity, and T is the temperature. Normally we use

$$\lambda = -\frac{2}{3}\mu \quad , \tag{5}$$

which is accurate for an ideal monatomic gas. If experimental values of λ are available for polyatomic gases, they can be used. However, the program will need modification. The graviational acceleration is computed from a difference approximation to

$$g = \frac{4\pi G}{r^2}\int_0^r \rho x^2 \, dx \quad , \tag{6}$$

where G is the gravitational constant. This procedure is more accurate than solution of the Poisson equation for the gravitational potential. The set of equations is closed by the equation of state, which we assume to be

$$p = (\gamma - 1)\rho I \quad , \tag{7}$$

where γ is the ratio of specific heats.

III. DIFFERENCE EQUATIONS

The SOLA-STAR difference equations are written in terms of the primitive variables p, ρ, I, r, and u. Furthermore, simple averages are used to find values of variables at points other than those where they are defined. Transformations of variables are frequently advocated as a means of achieving better accuracy on a given computational mesh. However, as discussed in the SOLA-ICE report,[3] this approach has a number of disadvantages and pitfalls for general-purpose programs. First, it is much easier to create conservative difference schemes in the primitive variables. Second, transformations commonly introduce transcendental functions such as square roots and exponentials into the equations, and these functions are expensive to compute. Third, the transformed equations are usually more complicated, resulting in more debugging effort and increased execution time. Fourth, the transformation that gives the best accuracy is problem dependent and, in general, unknown. Heuristic arguments that lead to particular transformations are at best unreliable. Finally, if good resolution is used, all well-behaved transformations will give the same results as the primitive variables.

Advancement of the variables in time is accomplished in two phases. Phase I consists of a partially implicit Lagrangian time step, and Phase II consists of the rezoning procedure. The velocity is defined at cell edges, (or vertices) as shown in Fig. 1, and all other quantities are defined at cell centers.

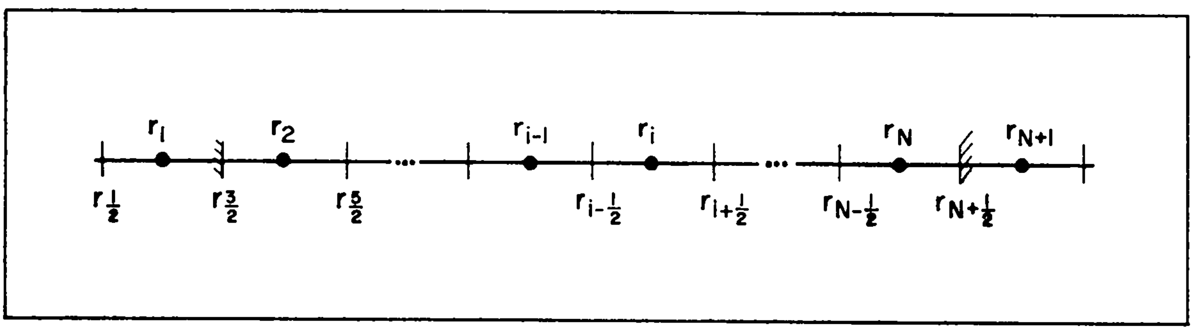

Fig. 1.

The SOLA-STAR computing mesh. Cell centers have integer subscripts, and cell edges have half-integer subscripts. We specify the cell edge positions and define the cell center positions by $r_i = 0.5 *(r_{i+\frac{1}{2}} + r_{i-\frac{1}{2}})$. Cells 1 and N+1 are fictitious cells.

The spatial difference approximations for Phase I are derived by integrating the dynamical equations over a control volume taken to be a spherical shell coincident with the computational mesh. This procedure has been adequately described elsewhere,[1,4,5,6] so it will not be repeated here. The equations are written as fully implicit, and then they are made linear in the advanced time quantities. The linearization is illustrated by the equation of state:

$$P_j^{n+1} = (\gamma-1)_j^{n+1} \rho_j^{n+1} I_j^{n+1} \doteq \left(\gamma-1\right)_j^n \left(\rho_j^{n+1} I_j^n + \rho_j^n I_j^{n+1} - \rho_j^n I_j^n\right) \tag{8}$$

where the superscript denotes the time level, and the subscript denotes the spatial computational cell. We have computed protostellar models through central hydrogen dissociation and ionization (where the γ of the gas changes radically) with no sign of instability from the use of the explicit value of γ. In such a case we define γ not as the ratio of specific heats, but as $\gamma-1 \equiv P/\rho I$. The function $\gamma-1$ is constant over much of the (ρ,T) plane, so a bilinear interpolation is accurate. In the regions of the (ρ,T) plane where $(\gamma-1)$ is not constant, this interpolation scheme may be preferred over many of the higher order schemes advocated in the literature, including both second and third order polynomials and splines. Indiscriminant use of some of these schemes can introduce spurious oscillations into $\gamma-1$, leading to inaccurate numerical solutions.

Let us write the continuity equation as

$$\frac{d\rho}{dt} + \rho D = 0 \quad , \tag{9}$$

where

$$D = \frac{1}{r^2}\frac{\partial}{\partial r}(r^2 u) \quad . \tag{10}$$

Define the quantity

$$d_j^n = - \frac{\delta t}{1+\delta t \; D_j^n} \quad , \tag{11}$$

where

$$D_j^n = \frac{u_{j+\frac{1}{2}}^n - u_{j-\frac{1}{2}}^n}{r_{j+\frac{1}{2}} - r_{j-\frac{1}{2}}} + 2 \, \frac{u_{j+\frac{1}{2}}^n + u_{j-\frac{1}{2}}^n}{r_{j+\frac{1}{2}} + r_{j-\frac{1}{2}}} \tag{12}$$

Then Eq. (9) is approximated by

$$\rho_j^{n+1} - d_j^n \, \rho_j^n \, D_j^{n+1} = \rho_j^n \quad , \tag{13}$$

which may be expanded to

$$\rho_j^{n+1} - u_{j+\frac{1}{2}}^{n+1} \rho_j^n \, d_j^n \left(\frac{2}{r_{j+\frac{1}{2}} + r_{j-\frac{1}{2}}} + \frac{1}{r_{j+\frac{1}{2}} - r_{j-\frac{1}{2}}} \right) - u_{j-\frac{1}{2}}^{n+1} \rho_j^n \, d_j^n \left(\frac{2}{r_{j+\frac{1}{2}} + r_{j-\frac{1}{2}}} - \frac{1}{r_{j+\frac{1}{2}} - r_{j-\frac{1}{2}}} \right) = \rho_j^n \quad . \tag{14}$$

As with all our difference equations, the geometric quantities (that is, r, A, and V) are the old-time values. The left-hand side of Eq. (9) is differenced directly because the control volume integration procedure would provide no immediate information on new densities. It would merely give us the trivial fact that the mass in a cell does not change. The advanced-time cell volume, necessary to compute the advanced time density from the cell mass, is not directly available.

The equation for the specific internal energy may be written as

$$\frac{\partial \rho I}{\partial t} + \frac{1}{r^2}\frac{\partial}{\partial r}(r^2 \rho u I) = - pD + \frac{1}{r^2}\frac{\partial}{\partial r}\left(r^2 K \frac{\partial T}{\partial r}\right) + \Phi \quad . \tag{15}$$

For numerical reasons we have found it expedient to define the flux

$$F = K\frac{\partial T}{\partial r} = K\frac{\partial}{\partial r}\left(\frac{I}{c_v}\right) \quad , \tag{16}$$

and carry along this extra equation. For normal gases, $K = \mu c_p/Pr$, where Pr is the Prandtl number and c_p is the specific heat at constant pressure. For stellar problems where we are modeling radiation diffusion, K is the radiative conductivity. The quantity c_v is defined as I/T, so it is not always the usual specific heat. It is tabulated and treated numerically the same as γ-1 for the general case. Incidentally, the turbulent conductivity defined by Eq. (28) of Ref. 1 did not work well and was replaced by an estimate based on the mixing length theory. The diffusion term in Eq. (15) is replaced by

$$\frac{1}{r^2}\frac{\partial}{\partial r}(r^2 F) \quad .$$

Carrying the additional flux equation is necessary wherever $\chi \equiv \log_{10}(K\delta t/\rho c_v \delta r^2)$ approaches or exceeds the number of digits carried in the calculation, because the coefficient matrix has a term like $1 + 2 \times 10^{\chi}$. The one gets lost in round off if χ is too large, and the matrix package cannot successfully recover the one in the course of solving the linear system.

The expression for the viscous dissipation term in Eq. (15) is

$$\Phi \equiv 2\mu \left[\left(\frac{\partial u}{\partial r} \right)^2 + \frac{2u^2}{r^2} \right] + \lambda \left[\frac{1}{r^2} \frac{\partial}{\partial r} (r^2 u) \right]^2 \quad . \tag{17}$$

The difference approximation to Eq. (15) is derived by integrating over the spherical shell between $r = r_{j-\frac{1}{2}}$ and $r = r_{j+\frac{1}{2}}$, using the procedure described in Ref. 1. Define normalized cells volumes

$$V_{c,j} \equiv r^3_{j+\frac{1}{2}} - r^3_{j-\frac{1}{2}} \quad , \tag{18}$$

and normalized vertex areas

$$A_{j-\frac{1}{2}} = 3r^2_{j-\frac{1}{2}} \quad . \tag{19}$$

Then

$$\begin{aligned} I_j^{n+1} = I_j^n + \delta t \Bigg\{ & \frac{V_{c,j}}{M_{c,j}} \Phi_j + \frac{1}{M_{c,j}} \left[A_{j+\frac{1}{2}} F^{n+1}_{j+\frac{1}{2}} - A_{j-\frac{1}{2}} F^{n+1}_{j-\frac{1}{2}} \right] \\ & - \frac{1}{2M_{c,j}} \Bigg[p_j^{n+1} \left(A_{j+\frac{1}{2}} u^n_{j+\frac{1}{2}} - A_{j-\frac{1}{2}} u^n_{j-\frac{1}{2}} \right) + p_j^n \Big(A_{j+\frac{1}{2}} u^{n+1}_{j+\frac{1}{2}} \\ & - A_{j-\frac{1}{2}} u^{n+1}_{j-\frac{1}{2}} \Big) \Bigg] \Bigg\} \quad , \end{aligned} \tag{20}$$

where

$$M^n_{c,j} = \rho^n_j \, V_{c,j} \quad , \tag{21}$$

and

$$\Phi_j = \mu^n_j \Bigg\{ 2\left[2\left(u^{n+1}_{j+\frac{1}{2}} - u^{n+1}_{j-\frac{1}{2}}\right)\left(u^n_{j+\frac{1}{2}} - u^n_{j-\frac{1}{2}}\right) - \left(u^n_{j+\frac{1}{2}} - u^n_{j-\frac{1}{2}}\right)^2\right]\left(r_{j+\frac{1}{2}} - r_{j-\frac{1}{2}}\right)^{-2}$$

$$+ 2\left[4\left(u^{n+1}_{j+\frac{1}{2}} + u^{n+1}_{j-\frac{1}{2}}\right)\left(u^n_{j+\frac{1}{2}} + u^n_{j-\frac{1}{2}}\right) - 2\left(u^n_{j+\frac{1}{2}} + u^n_{j-\frac{1}{2}}\right)^2\right]\left(r_{j+\frac{1}{2}} + r_{j-\frac{1}{2}}\right)^{-2}$$

$$- \frac{2}{3(V_{c,j})^2}\left[2\left(A_{j+\frac{1}{2}}\, u^{n+1}_{j+\frac{1}{2}} - A_{j-\frac{1}{2}}\, u^{n+1}_{j-\frac{1}{2}}\right)\left(A_{j+\frac{1}{2}}\, u^n_{j+\frac{1}{2}} - A_{j-\frac{1}{2}}\, u^n_{j-\frac{1}{2}}\right)\right.$$

$$\left. - \left(A_{j+\frac{1}{2}}\, u^n_{j+\frac{1}{2}} - A_{j-\frac{1}{2}}\, u^n_{j-\frac{1}{2}}\right)^2\right]\Bigg\} \quad . \tag{22}$$

The viscous dissipation term is positive-definite if all velocities are at the same time level, but we lose this physical characteristic by using velocities from a mixture of time levels. This is probably not serious, but it should be noted.

The flux equation is

$$F^{n+1}_{j+\frac{1}{2}} = \frac{2K^n_{j+\frac{1}{2}}}{r_{j+2/3} - r_{j-\frac{1}{2}}}\left(\frac{I^{n+1}_{j+1}}{c^n_{v,j+1}} - \frac{I^{n+1}_j}{c^n_{v,j}}\right) \quad . \tag{23}$$

The momentum equation is given by

$$\frac{\partial \rho u}{\partial t} + \frac{1}{r^2}\frac{\partial}{\partial r}\left(r^2 \rho u^2\right) = -\rho g - \frac{\partial p}{\partial r} + \frac{1}{r^2}\frac{\partial}{\partial r}\left[r^2 (2\mu+\lambda)\frac{\partial u}{\partial r}\right]$$

$$- \frac{2u(2\mu+\lambda)}{r^2} + \frac{2u}{r}\frac{\partial \lambda}{\partial r} \quad . \tag{24}$$

The Lagrangian form of Eq. (24) is differenced by integrating over a spherical shell (momentum control volume) between $r_{j-1} = 0.5(r_{j-3/2} + r_{j-\frac{1}{2}})$ and $r_j = 0.5(r_{j+\frac{1}{2}} + r_{j-\frac{1}{2}})$.

$$\frac{M^n_{v,j-\frac{1}{2}}}{\delta t}\left(u^{n+1}_{j-\frac{1}{2}} - u^n_{j-\frac{1}{2}}\right) = -M^n_{v,j-\frac{1}{2}}\, g_{j-\frac{1}{2}} - 2V_{v,j-\frac{1}{2}} \frac{\left(p^{n+1}_j - p^{n+1}_{j-1}\right)}{r_{j+\frac{1}{2}} - r_{j-3/2}}$$

$$+ \frac{4}{3}\left[A_j\, \mu^n_j \frac{u^{n+1}_{j+\frac{1}{2}} - u^{n+1}_{j-\frac{1}{2}}}{r_{j+\frac{1}{2}} - r_{j-\frac{1}{2}}}\right.$$

$$\left. - A_{j-1}\, \mu^n_{j-1} \frac{u^{n+1}_{j-\frac{1}{2}} - u^{n+1}_{j-3/2}}{r_{j-\frac{1}{2}} - r_{j-3/2}}\right]$$

$$- \frac{4}{3} V_{v,j-\frac{1}{2}} \left[\frac{u^{n+1}_{j-\frac{1}{2}}}{r_{j-\frac{1}{2}}}\; 2\left(\frac{\mu^n_j - \mu^n_{j-1}}{r_{j+\frac{1}{2}} - r_{j-3/2}}\right.\right.$$

$$\left.\left. + \frac{\mu^n_j + \mu^n_{j-1}}{r_{j-\frac{1}{2}}}\right)\right] , \qquad (25)$$

where the vertex masses and vertex volumes are given by

$$M_{v,j-\frac{1}{2}} = (M_{c,j} + M_{c,j-1})/2 \quad , \qquad (26)$$

$$V_{v,j-\frac{1}{2}} = r^3_j - r^3_{j-1} \quad . \qquad (27)$$

The shell areas, A_j, are defined at cell centers, as indicated by the integral subscripts. To obtain the gravitational acceleration, we perform the sum

$$g_{j-\frac{1}{2}} = \frac{4\pi G}{3r^2_{j-\frac{1}{2}}} \sum_{i=2}^{j-1} M_{c,i} \quad . \qquad (28)$$

The equations form a banded linear system in the advanced time quantities, so they may be solved by a banded matrix package, such as the one by Hindmarsh.[7] The left element of each row of the band is stored in the computer with an index of 1. A simple mnemonic display of the subscripting scheme is given in the program listing in Appendix A.

In Phase II we are modeling the convection term

$$\iint_S \rho Q \, (\underset{\sim}{u}_g - \underset{\sim}{\tilde{u}}) \cdot \hat{n} \, ds \quad , \tag{29}$$

where $\underset{\sim}{u}_g$ is the grid velocity and $\underset{\sim}{\tilde{u}}$ is the fluid velocity at the end of Phase I. We define the difference velocity for our one-dimensional problems, $w_{j-\frac{1}{2}} \equiv u_{g,j-\frac{1}{2}} - \tilde{u}_{j-\frac{1}{2}}$, which is the velocity of the mesh relative to the fluid. Then $w_{j-\frac{1}{2}} A_{j-\frac{1}{2}} \delta t$ is the volume relative to the fluid that is swept out by the moving grid point. One might be tempted to take for, say the density, simply an average of the densities on either side of the moving mesh point. This is called centered differencing, and it is unstable. For this reason we use a mixture of centered differencing and donor cell differencing. The donor cell component adds a strong stabilizing diffusional truncation error that compensates for the destabilizing diffusional error of centered differencing.

Define the donor cell parameter, $\alpha_{j+\frac{1}{2}}$, by

$$\alpha_{j+\frac{1}{2}} = - \bar{\alpha} \, \mathrm{sgn} \, (w_{j+\frac{1}{2}}) \quad , \tag{30}$$

where the function sgn is the sign of the argument, and $\bar{\alpha}$ is a constant, $0 \leqslant \bar{\alpha} \leqslant 1$. As an example of the difference form of the convection term for a cell centered quantity,

$$M^{n+1}_{c,j} = M^{n}_{c,j} - \frac{\delta t}{2} \left\{ w_{j-\frac{1}{2}} A_{j-\frac{1}{2}} \left[(1 + \alpha_{j-\frac{1}{2}}) \, \tilde{\rho}_{j-1} + (1 - \alpha_{j-\frac{1}{2}}) \tilde{\rho}_j \right] \right.$$
$$\left. - \, w_{j+\frac{1}{2}} A_{j+\frac{1}{2}} \left[(1 + \alpha_{j+\frac{1}{2}}) \, \tilde{\rho}_j + (1 - \alpha_{j+\frac{1}{2}}) \, \tilde{\rho}_{j+1} \right] \right\} \quad . \tag{31}$$

The tildes denote results from Phase I. This is a straightforward approximation to Eq. (29) for $Q = 1$. The density is obtained by calculating volumes from the new mesh position

$$r_{j-\frac{1}{2}}^{n+1} = r_{j-\frac{1}{2}}^{n} + u_{g,j-\frac{1}{2}}\,\delta t \quad . \tag{32}$$

Then

$$\rho_j^{n+1} = \frac{M_{c,j}^{n+1}}{V_{c,j}^{n+1}} \quad , \tag{33}$$

which ensures mass conservation. The convection of internal energy is handled in exactly the same manner.

For momentum the control volume runs from cell center to cell center, and a slight modification is necessary. The difference velocity must be obtained by averaging the difference velocities of the neighboring vertices. This leads to

$$u_{j-\frac{1}{2}}^{n+1} = \frac{1}{M_{v,j-\frac{1}{2}}^{n+1}} \Bigg\{ M_{v,j-\frac{1}{2}}^{n} u_{j-\frac{1}{2}}^{n} - \frac{\delta t}{4} \Bigg[\tilde{\rho}_{j-1} (w_{j-\frac{1}{2}} + w_{j-3/2}) A_{j-1} \Big((1+\alpha_{j-1}) \tilde{u}_{j-3/2} + (1-\alpha_{j-1}) \tilde{u}_{j-\frac{1}{2}} \Big) - \tilde{\rho}_j (w_{j-\frac{1}{2}} + w_{j+\frac{1}{2}}) A_j \Big((1 + \alpha_j)\, \tilde{u}_{j-\frac{1}{2}} + (1 - \alpha_j)\, \tilde{u}_{j+\frac{1}{2}} \Big) \Bigg] \Bigg\} \quad , \tag{34}$$

where

$$\alpha_j = - \bar{\alpha}\ \mathrm{sgn}\ (w_{j-\frac{1}{2}} + w_{j+\frac{1}{2}}) \quad . \tag{35}$$

It is not necessary to use the same $\bar{\alpha}$ in the momentum equation as in the equation for the mass or energy. We have found empirically that we need more donor cell in the mass and energy equations to keep cells from emptying out in the neighborhood of steep gradients.

For problems with strong shocks, an explicit artificial viscous pressure is helpful in attaining numerical stability and accurate jump conditions. The form we have chosen is

$$q_j^n = - \Lambda \rho_j^n (x_{j+\frac{1}{2}} - x_{j-\frac{1}{2}})^2 D_j^n \min (0, D_j^n) \quad , \tag{36}$$

where Λ is a constant of order unity. To the right side of Eq. (20), we add $- \delta t\, q_j^n D_j^n$. To the right side of Eq. (25), we add $2V_{v,j-\frac{1}{2}} (q_{j-1}^n - q_j^n)/(r_{j+\frac{1}{2}} - r_{j-3/2})$. In regions of expansion, q vanishes. In regions of compression, the q terms provide velocity diffusion in the momentum equation and "viscous" conversion of kinetic energy to thermal energy in the I equation. These terms have an effective kinematic viscosity that is roughly the fluid velocity times a mesh cell size in the neighborhood of a shock. The artificial viscous effects are concentrated in the regions of strongest compression, precisely where they are needed the most. For problems with no shocks, $\Lambda = 0$ is recommended.

IV. NUMERICAL EXAMPLES

This section contains three numerical examples that illustrate the kinds of problems that may be solved with SOLA-STAR. The first example provides a test problem to be used to check out new copies of the code. These examples are crude simulations of physical problems, and are not intended to be compared to observations without some refinement. The first problem is the early collapse phase of a protostellar cloud. This is basically the same problem solved by Larson.[8] The second test problem is a simple blast wave for which there is an analytical solution. The third problem is the solar wind solution by Hundhausen and Gentry.[9] They considered the effects of transients imposed on a steady state solar wind.

A. Collapse Of a Protostellar Cloud

The first numerical fluid dynamics calculation of the collapse of a dense interstellar cloud to form a protostar was published by Larson.[8] His initial condition was an isothermal cloud of uniform density that was just unstable toward gravitational collapse according to the Jeans criterion. The outer boundary condition was u=0 at just under the Jeans' radius. Larson's solution for a one solar mass cloud was confirmed by Ruppel and Cloutman,[1] and the results presented in this subsection and the code listing and output in Appendix A are for a similar one solar mass cloud.

Since some results of VEGA calculations were described fully and compared to Larson's results in reference 1, we will limit the present discussion to the use of this problem as a test case for new copies of the program. Appendix A provides the actual computer output at 0, 1, 500, and 3000 cycles. The following physical events can be seen in the solution as it develops. First, a rarefaction is created at the outer boundary at $t = 0$ by the collapse of the cloud. It travels inward at the speed of sound. The density is spatially constant but temporally increasing inside the rarefaction, and it falls off as $1/r^2$ outside. This behavior is illustrated in figure 2 with the curve from cycle 300 ($t = 2.981 \times 10^{12}$ s). The velocity profile consists of two linear segments with the minimum at the rarefaction, as illustrated in figure 3. The material is isothermal at 10 K. When the rarefaction reaches the center, the embryonic star is formed. The density becomes peaked at the center, forming a body nearly in hydrostatic equilibrium, surrounded by an accretion shock. The central body contains roughly 10^{-3} solar masses and has a radius of about 10^{14} cm. Upon its creation, the protostar may oscillate briefly. Cloud material falls supersonically to the accretion shock, is decelerated, and added to the protostar. The central density continues to rise. When it reaches about 10^{-13} g/cm^3, the central temperature also begins to rise. This phase is illustrated in figures 2 and 3 with the curves from cycle 900 ($t = 8.578 \times 10^{12}$ s). When the central temperature reaches 2000 K, the calculation is terminated. Figure 4 shows the structure at 3500 cycles ($t = 8.653 \times 10^{12}$ s), shortly before termination. Real gas physics is needed to go farther because of the importance of H_2 dissociation. This has been done in VEGA by making tables of $(\gamma-1) \equiv p/\rho I$ and $c_v \equiv I/T$ using the equation of state in Paczynski's stellar envelope program.[10] This pseudo-γ and pseudo-specific heat are easy to insert into the code, and they need to be evaluated only at time level n for use in the coefficient matrix. In addition, they are constant over large parts of the ρ-T plane, so bilinear interpolation is sufficiently accurate.

B. Spherical Blast Wave

The spherical blast wave is a classical test problem for numerical fluid dynamics codes, and it is a much more severe test than piston-driven shocks or shock tubes. In these latter cases, the solutions are piece-wise constant except for the expansion wave in a shock tube, which generally has only modest

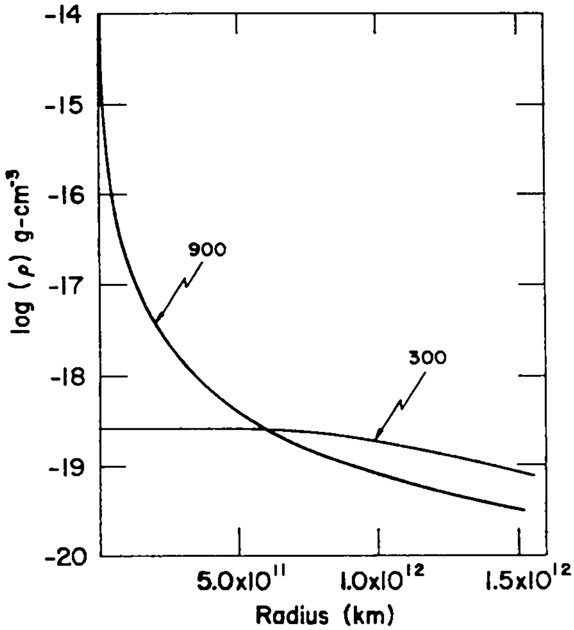

Fig. 2.
Runs of density at cycles 300 and 900 in the protostar calculation.

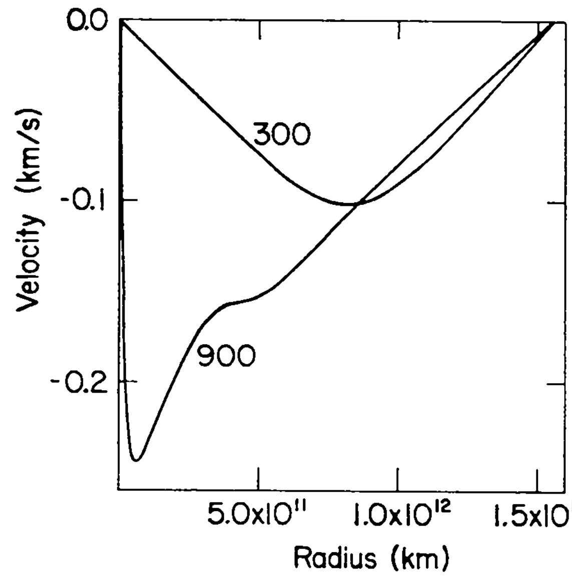

Fig. 3.
Runs of velocity at 300 and 900 cycles in the protostar calculation.

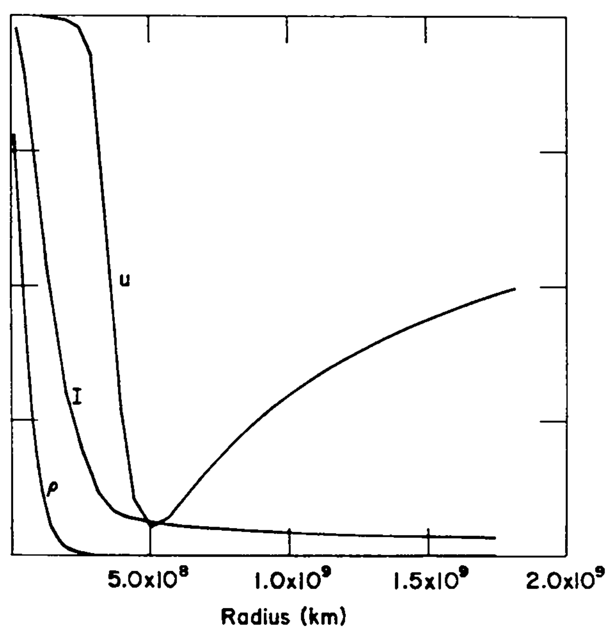

Fig. 4.
The protostar solution at 3500 cycles. The vertical axis runs from -3×10^5 to 0 $cm\text{-}s^{-1}$ for the radial velocity (u), 0 to 1.5×10^{-8} $g\text{-}cm^{-3}$ for the density (ρ), and 0 to 10^{11} for the specific internal energy (I).

curvature. On the other hand, the blast wave solution is sharply peaked, presenting a real challenge for finite difference methods.

The sample problem discussed in this section is based on a 10^{51} erg point explosion in a 10,000 K and $\rho = 2.4 \times 10^{-9}$ g/cm^3 ambient medium with $\gamma = 5/3$. Appendix B gives UPDATE modifications and the data deck.

Figure 5 shows the numerical solution for the density at two different times. The solid curves are for $\alpha = 1.0$ (pure donor cell transport) and the dashed curve is for $\alpha = 0.6$. Note that decreasing α reduces the numerical diffusion, thereby sharpening the peaks. Note also the improvement in the density jump condition as the wave progresses. This is due to two phenomena. First, the initial condition is not the Taylor-Sedov solution, toward which the solution evolves. Second, and more importantly, the resolution of the sharp self-similar peak improves as the radius of the shock grows to include more cells.

C. Solar Wind

A simple solar wind model is presented to illustrate use of the code with inflow and outflow boundaries. It also has the left-most vertex away from the

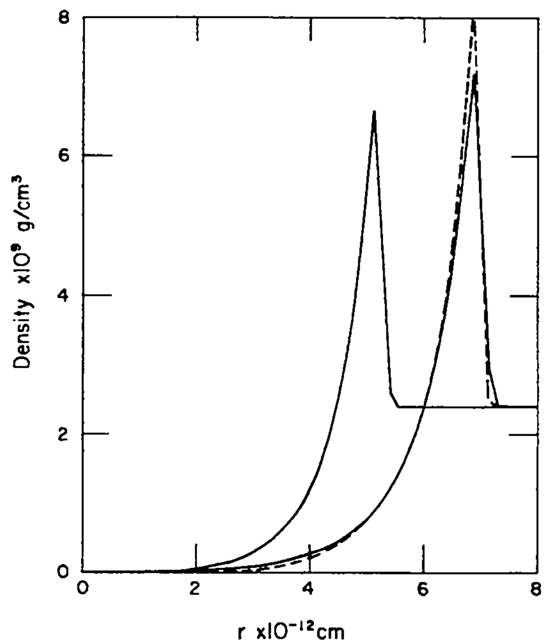

Fig. 5.
Runs of density for blast wave solutions. The solid curves are for $\alpha = 1.0$ at 150 cycles ($t = 96.5$ s) and 300 cycles ($t = 216.5$ s). The dashed curve is for $\alpha = 0.6$ at 300 cycles ($t = 212.3$ s). The peak of the analytical solution is 9.6×10^{-9} g cm^{-3} at $r = 7.2 \times 10^{12}$ cm at 300 cycles.

origin. This feature is also useful for running a Cartesian problem merely by making X(2) much larger than the total width of the mesh.

The sample solutions presented here are repetitions of solutions by Hundhausen and Gentry (HG).[9] The first step in this problem is to find a steady state solar wind solution. This could be accomplished by letting the program go through a transient phase. However, the computational effort was minimized by using an inviscid analytical solution as the initial condition. Then transient disturbances were introduced into the solution to represent perturbations by solar flares, and their propagation was followed.

The initial condition is an inviscid adiabatic radial expansion of an ideal gas:

$$p = (\gamma-1)\rho I = C_1\rho^{\gamma} \quad , \tag{37}$$

$$r^2\rho u = C_2 \quad , \tag{38}$$

and

$$u\frac{du}{dr} + \frac{1}{\rho}\frac{dp}{dr} + \frac{GM}{r^2} = 0 \quad , \tag{39}$$

where M is the mass of the sun. Substituting (37) into (39) and integrating, we find

$$I + \frac{1}{2}u^2 + \frac{p}{\rho} - \frac{GM}{r} = C_3 \quad , \tag{40}$$

which is the Bernoulli equation for this problem. The constants C_1, C_2, and C_3 are evaluated by specifying the values of all variables at $r = 1.25 \times 10^{12}$ cm, which is outside the critical point of the inviscid solar wind. Elimination of all dependent variables except ρ leads to a transcendental equation for ρ:

$$\rho^2\left(C_3 + \frac{GM}{r} - \frac{\gamma C_1}{\gamma-1}\rho^{\gamma-1}\right) = \frac{C_2^{\,2}}{2r^4} \tag{41}$$

This form is solved iteratively by the program, and then the other variables are found trivially by using equations (37) and (38).

The inflow boundary at the left is straightforward, as can be seen from the UPDATE modifications given in the appendix C. However, outflow boundaries are always more troublesome. One simple form that is frequently useful is the continuative boundary, where all gradients are set to zero on the boundary. This procedure is often adequate for supersonic flows, but can reflect unwanted signals into the mesh for subsonic flows. We use an alternate approach, the radiation condition

$$\frac{\partial c}{\partial t} + u \frac{\partial c}{\partial r} = 0 \quad , \tag{42}$$

where c is one of the flow variables, in place of the continuative boundary. A small bump in the velocity at the right end of the mesh is strictly a numerical artifact of the outflow boundary. It is slightly smaller using equation (42) than the continuative boundary, and the supersonic outflow prevents it from propagating into the mesh. The user may have to develop a better outflow boundary condition for some problems.

The first numerical solution we ran was the generation of a steady state solution. The analytic solution from equations (37), (38), and (41) was used as the initial condition. The parameters of HG were used. The problem was run beyond the time it takes an element of fluid to cross the mesh, and the numerical and analytic steady states were compared. During the transient, the interface between the fluid originally in the mesh and the fluid that subsequently flowed into the mesh propagated to the right, showing a small disturbance of increasing amplitude that exited the mesh without reflection. Comparison of the computer-generated plots shows the analytic and computational solutions are almost indistinguishable. Examination of the numerical output shows that the worst errors are near the left boundary where gradients of the variables are the largest. The mesh has been compressed in this region to reduce the error, which has a maximum of 4% in the pressure. The other variables are computed more accurately, and the accuracy of all variables improves at larger r.

The second numerical solution was the same as the transient shock problem solved by HG. A disturbance lasting 2.1 hours was introduced into the mesh at

$t_o = 2 \times 10^5$ s. This initial period was introduced to allow the inner boundary perturbation to propagate well into the mesh where it could be ignored. This procedure is probably not necessary. Figure (6) corresponds to figures (1)-(3) of HG, and the interested reader is invited to compare the results. The top row of figure 6 shows the solution at 2.0 hrs. after t_o. The analytical solution has a velocity of 1570 km/s just behind the shock, in good agreement with our calculation. The velocity jump in HG's figure 1 is a bit too high. Our velocity profile has a spike behind the shock. As we are running with $\alpha = 0.5$, this feature is probably a dispersive truncation error. HG show no spike, suggesting that perhaps their solution was obtained using full donor cell transport ($\alpha = 1$). However, Gentry (private communication) has pointed out that at least part of the HG work was done with a scheme that was more closely related to the truncation error cancellation technique of Rivard and collaborators,[11] which is similar in principle to locally computing and applying the minimum α needed in each cell to get numerical stability. This procedure often allows signficant dispersive errors to occur, especially near a strong shock, so it is not clear what differencing scheme HG used to obtain their published results.

An unexpected feature of the numerical solutions is the density jump across the shock. The analytic value is a factor of four. Our solution gives a factor of seven, and HG's jump is about the same in spite of the label on their graph showing good agreement with a factor of four jump. The explanation may be that the density gradient is quite large in this region, so shocked material compressed by the correct amount is more than four times as dense as the material ahead of the shock, several cells away.

The second row of figure 6 is taken at $t_o + 4.3$ hr. The agreement with HG is better than at $t_o + 2.1$ hr, especially in the velocity field. The density jump in the SOLA-STAR solution is still apparently a bit higher than expected.

The bottom row of figure 6 was taken at $t_o + 20.1$ hr, as was HG's figure 3. HG's velocity curve is slightly broader and smoother. Their density jump and ours now are close to the desired factor of four, but the velocity and density profiles differ somewhat in detail. Although our solution is in qualitative agreement with that of HG, it is clear that some unanswered questions about these solar wind solutions remain.

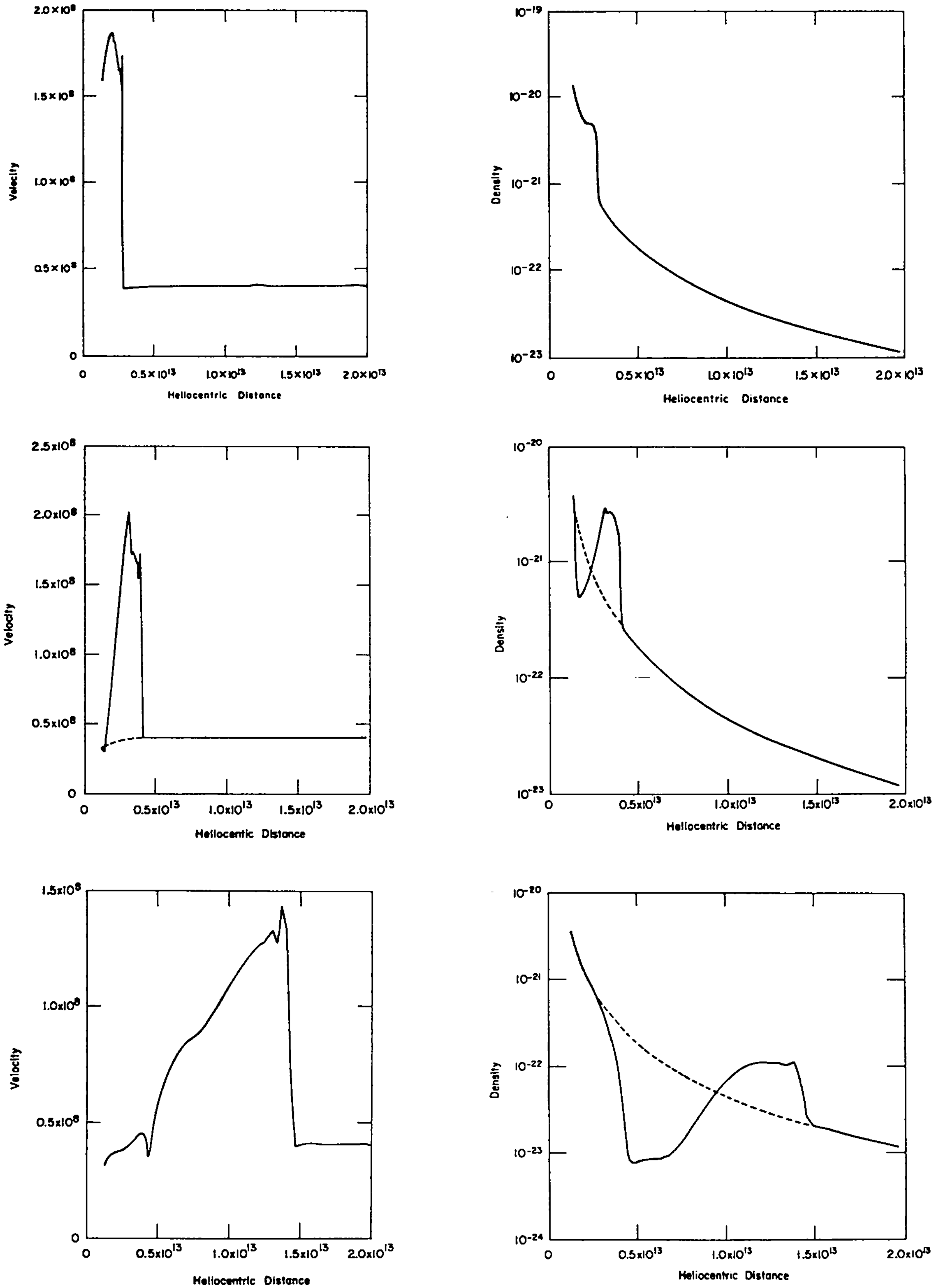
Velocity
Density
Heliocentric Distance
2.0×10^8
1.5×10^8
1.0×10^8
0.5×10^8
2.5x10^8
0
0.5×10^13
1.0×10^13
1.5×10^13
2.0×10^13
10^-19
10^-20
10^-21
10^-22
10^-23
10^-24

Fig. 6.

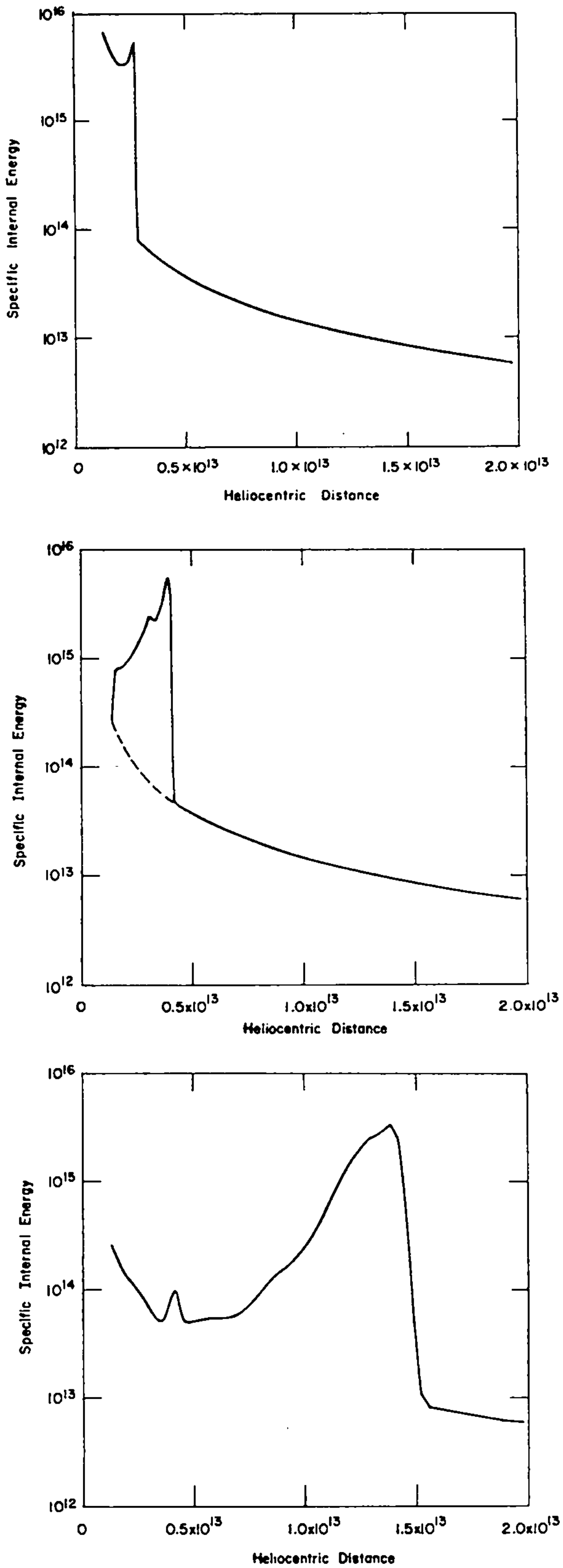

Fig. 6 (con't)
The solar wind solution at 2.0 hr., 4.3 hr., and 20.1 hr. after beginning the shock wave inflow for the top, middle, and bottom rows of figures respectively. Dashed lines indicate the steady state solar wind.

REFERENCES

1. Ruppel, H. M. and Cloutman, L. D., "A General Numerical Fluid Dynamics Algorithm for Astrophysical Applications," Los Alamos Scientific Laboratory report LA-6149-MS (1975).

2. Hirt, C. W., Nichols, B. D., and Romero, N. C., "SOLA - A Numerical Solution Algorithm for Transient Fluid Flows," Los Alamos Scientific Laboratory report LA-5852 (1975).

3. Cloutman, L. D., Hirt, C. W., and Romero, N. C., "SOLA-ICE: A Numerical Solution Algorithm for Transient Compressible Fluid Flows," Los Alamos Scientific Laboratory report LA-6236 (1976).

4. Hirt, C. W., Amsden, A. A., and Cook, J. L., "An Arbitrary Lagrangian-Eulerian Computing Method for All Flow Speeds," J. Comp. Phys., 14, 227 (1974).

5. Amsden, A. A. and Hirt, C. W., "YAQUI: An Arbitrary Lagrangian-Eulerian Computer Program for Fluid Flow at All Speeds," Los Alamos Scientific Laboratory report LA-5100 (1973).

6. Butler, T. D., Cloutman, L. D., Dukowicz, J. K., and Ramshaw, J. D., "CONCHAS: An Arbitary Lagrangian-Eulerian Computer Code for Multicomponent Chemically Reactive Fluid Flow at All Speeds," Los Alamos Scientific Laboratory report LA-8129-MS (1979).

7. Hindmarsh, A. C., "Banded Linear Systems with Pivoting," UCID-30060, Lawrence Livermore Laboratory, Livermore, CA (1970).

8. Larson, R. B., "Numerical Calculations of the Dynamics of a Collapsing Proto-Star," MNRAS, 145, 271 (1969).

9. Hundhausen, A. J. and Gentry, R. A., "Numerical Simulation of Flare-Generated Disturbances in the Solar Wind," J. Geophys. Research, 74, 2908 (1969).

10. Paczynski, B., "Envelopes of Red Supergiants," Acta Astronomica, 19, 1 (1969).

11. Rivard, W. C., Farmer, O. A., Butler, T. D., and O'Rourke, P. J., "A Method for Increased Accuracy in Eulerian Fluid Dynamics Calculations," Los Alamos Scientific Laboratory report LA-5426-MS (1973).

APPENDIX A

SAMPLE PROBLEM

This appendix provides a listing of SOLA-STAR, a list of main variables, and some information to help the new user convert the code to a non-LASL operating system. We begin by noting that, for the most part, the code is written in ANSI-standard FORTRAN. The CDC computers carry approximately 13 digits, which has proved adequate. However for machines with a short word length, such as IBM, it will be necessary to use double precision throughout the code. This is good practice for any hydrodynamics program, but especially so for SOLA-STAR with its large linear system solver.

SOLA-STAR can be used on quite modest computers. This version of SOLA-STAR requires 77 K_8 words of memory. However, this number can be reduced if necessary by adjusting the size of dimensioned arrays or by sacrificing the plotting capability. The arrays B and AA are dimensioned for a maximum of JBAR = 150 real cells. The grind time, that is the time required to complete one time step for one cell, is 5.3 ms on a CDC 6400. This is approximately a factor of 10 longer than for a CDC 7600 and a factor of 2 larger than for a CDC 6600.

The main system-dependent feature is the graphics package. Logical unit 7 is the film file, and it can be eliminated if graphics output is not desired. The following is a list of graphical output routines used by SOLA-STAR. These routines will have to be replaced by the non-LASL user's local equivalent or deleted from the program.

1. CALL ADV(NF): If $1 \leq NF \leq 21$, the film is advanced NF frames. Otherwise, the call is ignored.
2. CALL EMPTY: Empty the FILM file buffer onto disk. Unless the run is unexpectedly aborted, this routine is superfluous.
3. CALL LINCNT(N): N is modulo 64. The next line of output directed to the film file is directed to the Nth line.
4. CALL SPLØT(IOP,N,X,Y,ICHAR,ICØN): Standardized plot routine. Four types of grid: IØP = 1, 2, 3, or 4 gives linear-linear, linear-log, log-linear, or log-log plots respectively. N successive points are plotted from the tables X and Y (abscissas and ordinates respectively). ICHAR is a code number for a character to be plotted at each point

(ICHAR = 42 is a dot). If IC∅N ≠ 0, the points are connected by straight lines.

5. CALL WLCH(IX,IY,CN,NCH,NS): Writes large horizontal characters beginning with SC 4020 coordinates (IX,IY). SC 4020 coordinates define a location on the film frame, with (0,0) at the upper left hand corner and (1023,1023) at the lower right hand corner. NC is the number of characters to be written beginning with the variable NCH. NS is an integer character size parameter, $1 \leq NS \leq 5$.

The sample problems in the Appendixes require minor changes to the basic code, and it is convenient to specify the changes in CDC UPDATE format, even though many users will not have this software. A statement of the form *INSERT SV.n means insert the F∅RTRAN statements between the *INSERT card and the next statement beginning with an * behind statement number SV.n The card *DELETE SV.m,SV.n means delete statements SV.m through SV.n and replace them with any statements between the *DELETE and the next * card. The *IDENT statement merely specifies a name to be associated with the set of modifications and may be ignored by users not using the UPDATE utility.

Table I lists the major program variables and their definitions. The remainder of this appendix is a program listing and sample output suitable for testing new SOLA-STAR decks. It is recommended that the new user try these problems to become thoroughly familiar with this code before embarking on his or her own research program.

TABLE I

DEFINITION OF SOLA-STAR VARIABLES

	Definition
AA	Coefficient matrix (band only) of the linear system.
AJ	Areas of cell faces.
B	Right hand side of the linear system.
CND	Thermal conductivity.
DØNM	Donor cell parameter α for the ρ and I equations.
DØNMØM	Donor cell parameter for the u equation.
DT	Time step.
DTK	Maximum allowed value of $\|u\delta t/\delta x\|$, normally about 0.25.
DTMAX	Maximum value of DT allowed in the run.
DX	Width of the innermost two real cells and left hand fictitious cell.
EI	Specific internal energy I.
EM	Vertex masses.
EMC	Cell masses.
FMASS	Total mass of the system.
FMØM	Total momentum of the system.
FOURPI	Four times π.
G	Gravitational constant.
GAMMA	γ, the ratio of specific heats.
GRDVL	Velocity of grid points as fraction of fluid velocity; zero for Eulerian run, unity for Lagrangian calculation. Can also be fractional or SUBRØUTINE GRID can be rewritten to provide an arbirtrary, user-chosen grid motion.
JBAR	Number of real cells.
JP1	JBAR + 1.
JP2	JBAR + 2.
JP3	JBAR + 3.
KPR	Get one line summary print every KPR cycles.
LFILM	Get film output every LFILM cycles.
MUVISC	Coefficient of viscosity μ.

NDIM	Dimension of B and first dimension of AA. Must be at least NEQ * JP2.
NDIM2	Second dimension of AA.
NDT	Number of time steps.
NEQ	Number of dependent variables in the linear system.
NM	Get full printout every NM cycles.
P	Pressure p.
PDVCEN	Time centering parameter for $p\nabla\cdot\vec{u}$ in the I equation.
RCV	Reciprocal of the specific heat, T/I.
RHØ	Density ρ.
RHOL	Density at the end of Phase I.
RMAX	Coordinate r of the right hand boundary.
RMIN	Coordinate r of the left hand boundary.
RSAV	Central density (RHO(2)) as a function of t. Saved for plotting purposes only.
T	Time t.
TIM	Array containing t for use in plotting RSAV.
U	Fluid velocity $u_{j-\frac{1}{2}}$.
UD	Difference velocity $w_{j-\frac{1}{2}}$.
UG	Grid velocity.
UT1	Fluid velocity at the left boundary.
UTMAX	Fluid velocity at the right boundary.
VJC	Cell volumes.
VJV	Vertex volumes.
VLAM	Λ, the artificial viscosity parameter.
UT	Velocity after Phase I.
X	Vertex positions $r_{j-\frac{1}{2}}$.

```
      PROGRAM VEGA (OUTPUT=100,TAPE5=100,TTY,TAPE59=TTY,
     $ TAPE5=100)
      REAL MUVISC
      COMMON /A1/JBAR,JP1,JP2,JP3,DT,T,N,NDT,FMASS,FMOM,ET,EINT,NM,LFILM
      COMMON /A2/ EM(200),X(200),U(200),MUVISC(200)
      COMMON /3/ EI(200),E(200),DTMAX,VLAM,DTK
      COMMON /4/ RHO(200),EMC(200),P(200),RHOL(200)
      COMMON /A5/ UT(200),UD(200)
      COMMON /12/ GAMMA,UT1,UTMAX,DONM,DONMOM,GRDVEL
      COMMON /A14/ EMCT(200),UG(200),DPHI(200)
      COMMON /A15/ RCV(200),CND(200),R2DR(200),TNOT4
      COMMON /A40/FOURPI,AJ(200),XMR(160)
      COMMON /TIMEV/ RSAV(2000),TIM(2000),ITIME
      COMMON  LA,LB,AA(770,16),JBNEQ,NDIM,IP(770)
      DIMENSION ZNU(200),THE(200),ALF(200),BET(200),ZKAP(200),TAU(200)
      DIMENSION B(770),RM(200),RDX(200),AJC(200)
      DIMENSION RJC(200),VJC(200),RRJC(200),PHI(200),ZJ(200),
     1 ZN(200),RA(200),RB(200),RC(200),RD(200),VJV(200)
      DATA T,N/0.,0/
      DATA FOURPI,G/12.56637062,6.68E-8/
      DATA PDVCEN/1./
      DATA LFILM,KPR,NM/25,1,50/
C ***
C *** SET UP
C ***
      CALL INPUT
      GM1=GAMMA-1.
      TNOT4=(EI(JP1)*RCV(JP1))**4
      WRITE (5,230) TNOT4
      WRITE (7,230) TNOT4
C *** LA IS NUMBER OF ELEMENTS TO LEFT OF DIAGONAL, LB TO RIGHT
      LA=5
      LB=5
      NEQ=5
      NDIM=770
      NDIM2=16
      JBNEQ=JP1*NEQ
      DO 10 J=2,JP2
      RDX(J)=1./(X(J+1)-X(J))
      RJC(J)=.5*(X(J)+X(J+1))
```

```
      AJC(J)=3.*RJC(J)*RJC(J)
      RRJC(J)=0.5/RJC(J)
      RA(J)=RDX(J)+2.*RRJC(J)
      RB(J)=RDX(J)-2.*RRJC(J)
      RC(J)=(RDX(J)+RRJC(J))*RRJC(J)
      RD(J)=(RDX(J)-RRJC(J))*RRJC(J)
      VJC(J)=X(J+1)**3-X(J)**3
      EMC(J)=RHO(J)*VJC(J)
   10 CONTINUE
      RJC(1)=0.5*(X(1)+X(2))
C *** R2DR(2)=0 TO MAKE DI/DR=0 AT ORIGIN
      R2DR(2)=0.
      DO 20 J=3,JP2
      R2DR(J)=1./(X(J+1)-X(J-1))
      AJ(J)=3.*X(J)*X(J)
      VJV(J)=RJC(J)**3-RJC(J-1)**3
   20 EM(J)=0.5*(EMC(J-1)+EMC(J))
      AJ(2)=3.*X(2)*X(2)
      AJ(JP3)=3.*X(JP3)*X(JP3)
      VJV(2)=RJC(2)**3-X(2)**3
      EM(2)=0.5*EMC(2)
      CALL CONDUCT
      CALL OUTPUT
      DTT=DT
      ITIME=0
C ***
C *** HYDRODYNAMICS LOOP
C ***
      DO 200 N=1,NDT
      ITIME=ITIME+1
      IF (ITIME.GT.500) ITIME=1
      DT=AMIN1(DTT,1.1*DT)
      T=T+DT
      TEMPE=EI(2)*RCV(2)
      IF(MOD(N,KPR).EQ.0) WRITE (6,220) DT,T,N,RHO(2),U(15),TEMPE
      IF (MOD(N,KPR).EQ.0)WRITE (7,220) DT,T,N,RHO(2),U(15),TEMPE
      IF (TEMPE .GT. 3000.) CALL EXIT
      JBM=JBAR-1
      BET(2)=0.
      BET(JP2)=X(JP2)**2*RDX(JP1)
```

```
      DPHI(2)=0.
      SUM=0.
      DUG=FOURPI*G/3.
      DO 30 J=3,JP1
      BET(J)=X(J)*X(J)/(RJC(J)-RJC(J-1))
      SUM=SUM+EMC(J-1)*DUG
      DPHI(J)=SUM/(X(J)*X(J))
   30 CONTINUE
      DPHI(JP2)=(SUM+EMC(JP1)*DUG)/(X(JP2)*X(JP2))
      GMAX=ABS(DPHI(JP2))
      CALL CONDUCT
      R2DR(JP3)=0.
      DO 80 J=2,JP2
      T1=U(J+1)-U(J)
      T2=U(J+1)+U(J)
      T3=0.
      IF (J.NE.JP2) T3=DT/EMC(J)
      ZD=T1*RDX(J)+2.*T2*RRJC(J)
      T4=-DT/(1.+DT*ZD)
      T5=2.*T1*RDX(J)**2
      T6=4.*T2*RRJC(J)**2
      BET(J)=(T1*RDX(J))**2+2.*(T2*RRJC(J))**2
      ZNU(J)=0.5*T3
      ALF(J)=2.*T3*MUVISC(J)*VJC(J)
      THE(J)=U(J+1)*AJ(J+1)-U(J)*AJ(J)
      ZKAP(J)=T5+T6
      TAU(J)=T5-T6
      RM(J)=DT/EM(J)
      PHI(J)=T4*RHO(J)
   80 CONTINUE
C *** MATRIX STRUCTURE
C ***
C *** FORMAT BLOCK
C ***
C                     RHO          U           P           I          F
C
C   P                                       K,L+2
C
C   U                          K+1,L
C
```

```
C    RHO              K+2,L-2
C
C    FLUX                                                       K+3,L+1
C
C    EI                                                  K+4,L-1
C
      DO 90 I=1,NDIM
      DO 90 J=1,NDIM2
   90 AA(I,J)=0.
      AA(2,6)=1.
      AA(4,7)=1.
      K=1-NEQ
      L=LA+1
      DIVR=0.
      ARTPP=0.
      DO 120 J=2,JP2
      K=K+NEQ
      AA(K,L)=-GM1*EI(J)
      AA(K,L+2)=1.
      AA(K,L+3)=-GM1*RHO(J)
      DIVL=DIVR
      DIVR=0.
      IF (J .LT. JP2) DIVR=(AJ(J+1)*U(J+1)-AJ(J)*U(J))/VJC(J)
      IF (DIVR .GT. 0.) DIVR=0.
      ARTPM=ARTPP
      ARTPP=VLAM*RHO(J)*DIVR*DIVR/(RDX(J)*RDX(J))
      IF(J .EQ. 2) GO TO 100
      AA(K+1,L-5)=-4.*VJV(J)*RM(J)*MUVISC(J-1)*(R2DR(J)*RDX(J-1)-RC(J-1)
     1)
      AA(K+1,L-4)=-RM(J)*AJ(J)
      AA(K+1,L)=1.+4.*VJV(J)*RM(J)*(MUVISC(J)*(R2DR(J)*RDX(J)+RC(J))
     1 +MUVISC(J-1)*(R2DR(J)*RDX(J-1)-RD(J-1)))
      AA(K+1,L+1)=RM(J)*AJ(J)
      AA(K+1,L+5)=-4.*VJV(J)*RM(J)*MUVISC(J)*(R2DR(J)*RDX(J)+RD(J))
      AA(K+3,L-5)=2.*CND(J)*RCV(J)*R2DR(J)
      AA(K+3,L+1)=1.
      AA(K+3,L)=-2.*CND(J)*RCV(J+1)*R2DR(J)
  100 AA(K+4,L-3)=ALF(J)*TAU(J)-PDVCEN*ZNU(J)*P(J)*AJ(J)*2.
      AA(K+4,L-2)=2.*ZNU(J)*THE(J)
     $ *PDVCEN
```

```
      AA(K+4,L-1)=1.
      IF (J.EQ.JP2) GO TO 110
      AA(K+4,L)=2.*ZNU(J)*AJ(J)
      AA(K+4,L+5)=-2.*ZNU(J)*AJ(J+1)
  110 CONTINUE
      AA(K+4,L+2)=2.*PDVCEN*ZNJ(J)*P(J)*AJ(J+1)-ALF(J)*ZKAP(J)
      AA(K+2,L-2)=1.
      AA(K+2,L-1)=PHI(J)*RB(J)
      AA(K+2,L+4)=-PHI(J)*RA(J)
      B(K)=-GM1*RHO(J)*EI(J)
      B(K+1)=U(J)
      IF (J .GT. 2) B(K+1)=B(K+1)+RM(J)*AJ(J)*(ARTPM-ARTPP)
      B(K+1)=B(K+1)-DT*DPHI(J)
      B(K+2)=RHO(J)
      B(K+3)=0.
      B(K+4)=EI(J)-ALF(J)*BET(J)-DT*ARTPP*DIVR/RHO(J)
     $ +2.*(2.*PDVCEN-1.)*ZNU(J)*THE(J)*P(J)
  120 CONTINUE
      AA(K+1,L-5)=0.
      AA(K+1,L-4)=0.
      AA(K+1,L+1)=0.
      AA(K+1,L+5)=0.
      AA(K+1,L)=1.
      B(K+1)=0.
      AA(K,L)=0.
      AA(K,L+3)=0.
      AA(K,L-3)=-1.
      B(K)=0.
      AA(K+2,L-1)=0.
      AA(K+2,L+4)=0.
      CALL DECB (IER)
      CALL SOLB (B)
      K=1-NEQ
      DO 130 J=2,JP2
      K=K+NEQ
      RHOL(J)=B(K)
      UT(J)=B(K+1)
      P(J)=B(K+2)
      EI(J)=B(K+3)
      DPHI(J)=B(K+4)
```

```
  130 CONTINUE
      UT(2)=UT1
      RHOL(1)=RHOL(2)
      RHOL(JP2)=RHOL(JP1)
C ***
C *** REZONE SECTION
C ***
      CALL GRID
      DO 150 J=2,JP1
      DUB1=-ABS(DONM)*SIGN(1.,UD(J))
      DUB2=-ABS(DONM)*SIGN(1.,UD(J+1))
      EMCT(J)=EMC(J)-0.5*DT*(UD(J)*AJ(J)*((1.+DUB1)*RHOL(J-1)+(1.-DUB1)*
     1RHOL(J))-UD(J+1)*AJ(J+1)*((1.+DUB2)*RHOL(J)+(1.-DUB2)*RHOL(J+1)))
      E(J)=(EI(J)*EMC(J)-.5*DT*(UD(J)*AJ(J)*((1.+DUB1)*RHOL(J-1)*EI(J-1)
     1+(1.-DUB1)*RHOL(J)*EI(J))-UD(J+1)*AJ(J+1)*((1.+DUB2)*RHOL(J)*EI(J)
     2+(1.-DUB2)*RHOL(J+1)*EI(J+1))))/EMCT(J)
  150 CONTINUE
      EMCT(JP2)=EMC(JP2)
      E(JP2)=EI(JP2)
      DO 160 J=3,JP2
      DUB1=-ABS(DONMOM)*SIGN(1.,UD(J)+UD(J-1))
      DUB2=-ABS(DONMOM)*SIGN(1.,UD(J)+UD(J+1))
      U(J)=EM(J)*UT(J)-.25*DT*(RHOL(J-1)*(UD(J)+UD(J-1))*AJC(J-1)*((1.+
     1DUB1)*UT(J-1)+(1.-DUB1)*UT(J))-RHOL(J)*(UD(J)+UD(J+1))*AJC(J)*(
     2(1.+DUB2)*UT(J)+(1.-DUB2)*UT(J+1)))
  160 CONTINUE
      U(JP2)=0.
      DPHI(2)=0.
      DO 170 J=2,JP2
      RDX(J)=1./(X(J+1)-X(J))
      RJC(J)=.5*(X(J)+X(J+1))
      AJC(J)=3.*RJC(J)*RJC(J)
      RRJC(J)=0.5/RJC(J)
      RA(J)=RDX(J)+2.*RRJC(J)
      RB(J)=RDX(J)-2.*RRJC(J)
      RC(J)=(RDX(J)+RRJC(J))*RRJC(J)
      RD(J)=(RDX(J)-RRJC(J))*RRJC(J)
      VJC(J)=X(J+1)**3-X(J)**3
      EMC(J)=EMCT(J)
      RHO(J)=EMC(J)/VJC(J)
```

```
      EI(J)=E(J)
  170 CONTINUE
      RJC(1)=0.5*(X(1)+X(2))
      DTT=DTMAX
      DO 180 J=3,JP2
      R2DR(J)=1./(X(J+1)-X(J-1))
      AJ(J)=3.*X(J)*X(J)
      VJV(J)=RJC(J)**3-RJC(J-1)**3
      EM(J)=0.5*(EMC(J-1)+EMC(J))
      U(J)=U(J)/EM(J)
      IF (U(J).NE.0.) DTT=AMIN1(DTT,DTK*(X(J+1)-X(J))/ABS(U(J)))
  180 CONTINUE
      VJV(2)=RJC(2)**3-X(2)**3
      AJ(2)=3.*X(2)*X(2)
      AJ(JP3)=3.*X(JP3)*X(JP3)
      EM(2)=0.5*EMCT(2)
      U(2)=UT1
      RHO(1)=RHO(2)
      RHO(JP2)=RHO(JP1)
      EI(1)=EI(2)
C ***
C *** TIME ACCOUNTING
C ***
      IF (MOD(N,NM).NE.0 .AND. MOD(N,LFILM).NE.0 .AND. N.GT.1)
     $ GO TO 192
      ET=0.
      EINT=0.
      FMASS=0.
      FMOM=0.
      DO 190 J=2,JP2
      FMOM=FMOM+EM(J)*UT(J)
      ET=ET+0.5*EM(J)*UT(J)*UT(J)
      IF (J .EQ. JP2) GO TO 190
      ET=ET+EMC(J)*EI(J)
      EINT=EINT+EMC(J)*EI(J)
      FMASS=FMASS+EMC(J)
      FMOM=FMOM+EM(J)*UT(J)
  190 CONTINUE
      ET=ET*FOURPI/3.
      EINT=EINT*FOURPI/3.
```

```
      FMASS=FMASS*FOURPI/3.
      FMOM=FMOM*FOURPI/3.
  192 CONTINUE
      RSAV(ITIME)=ALOG10(RHO(2))
      TIM(ITIME)=T
      IF (N.EQ.1) CALL OUTPUT
      IF (MOD(N,NM).EQ.0.OR.MOD(N,LFILM).EQ.0) CALL OUTPUT
  200 CONTINUE
      CALL EXIT
C ***
C *** FORMAT BLOCK
C ***
  220 FORMAT (2X,4HDT =,1PE17.8,2X,3HT =,E17.8,I5,3E13.5)
  230 FORMAT (1X,1PE20.8)
      END
      SUBROUTINE INPUT
      COMMON /A1/JBAR,JP1,JP2,JP3,DT,T,N,NDT,FMASS,FMOM,ET,EINT,NM,LFILM
      COMMON /A2/ EM(200),X(200),U(200),MUVISC(200)
      COMMON /3/ EI(200),E(200),DTMAX,VLAM,DTK
      COMMON /4/ RHO(200),EMC(200),P(200),RHOL(200)
      COMMON /A5/ UT(200),UD(200)
      COMMON /10/ ITITLE(8)
      COMMON /12/ GAMMA,UT1,UTMAX,DONM,DONMOM,GRDVEL
      COMMON /A14/ EMCT(200),UG(200),DPHI(200)
      COMMON /A15/ RCV(200),CND(200),R2DR(200),TNDT4
      REAL MUVISC
      DATA (EM(J),J=1,200)/200*0./
      DATA (MUVISC(J),J=1,200)/200*0./
      DATA (UT(J),J=1,200)/200*0./
      DATA (UD(J),J=1,200)/200*0./
      DATA (UG(J),J=1,200)/200*0./
      DATA (RCV(J),J=1,200)/200*1.911098562E-08/
C ***
C *** READ DATA DECK
C ***
      READ (5,50) (ITITLE(J),J=1,8)
      WRITE (6,50) (ITITLE(J),J=1,8)
      WRITE (7,50) (ITITLE(J),J=1,8)
      READ (5,60) JBAR,NDT
      WRITE (6,60)  JBAR,NDT
```

```
      WRITE (7,60) JBAR,NOT
      JP1=JBAR+1
      JP2=JP1+1
      JP3=JP2+1
      READ (5,70) DT,DX,GRDVEL
      WRITE (6,70)  DT,DX,GRDVEL
      WRITE (7,70) DT,DX,GRDVEL
      READ (5,70) RMIN,RMAX
      WRITE (6,70) RMIN,RMAX
      WRITE (7,70) RMIN,RMAX
      READ (5,70) DONM,DONMOM
      WRITE (6,70) DONM,DONMOM
      WRITE (7,70) DONM,DONMOM
      READ (5,70) GAMMA,UT1,UTMAX
      WRITE (6,70) GAMMA,UT1,UTMAX
      WRITE (7,70) GAMMA,UT1,UTMAX
      READ (5,70) VLAM,DTMAX,DTK
      WRITE (6,70) VLAM,DTMAX,DTK
      WRITE (7,70) VLAM,DTMAX,DTK
      U(2)=UT1
      U(JP2)=UTMAX
C ***
C *** SET UP MESH
C ***
      X(2)=RMIN
      RMLO=0.5
      RMHI=2.
      RATIO=1.
      DRB=DX
   10 CONTINUE
      DX=DRB
      DO 20 J=3,JP3
      IF (J.GT.4.AND.J.LT.JBAR) DX=DX*RATIO
      X(J)=X(J-1)+DX
   20 CONTINUE
      WRITE (6,80) RATIO,X(JP2),DX
      IF (RATIO.GT.2.95.AND.X(JP2).LT.RMAX) CALL EXIT
      IF (ABS((X(JP2)-RMAX)/RMAX).LT.1.E-4) GO TO 30
      IF (X(JP2).GT.RMAX) RMHI=RATIO
      IF (X(JP2).LE.RMAX) RMLO=RATIO
```

```
      RATIO=0.5*(RMLO+RMHI)
      GO TO 10
   30 CONTINUE
      X(1)=2.*X(2)-X(3)
C ***
C *** INITIALIZE DEPENDENT VARIABLES
C ***
      DO 40 J=1,JP2
      RHO(J)=1.10E-19
      RHO(J)=1.26E-19
      P(J)=3.696E-11
      P(J)=4.39758E-11
      U(J)=0.
      EI(J)=P(J)/((GAMMA-1.)*RHO(J))
   40 CONTINUE
      U(2)=UT1
      U(JP3)=U(JP2)
      UD(JP3)=0.
      UT(JP3)=0.
      CALL SETKAP
      RETURN
C
   50 FORMAT (8A10)
   60 FORMAT (10H          ,I10,10H          ,I10)
   70 FORMAT (10H          ,E10.3,10H          ,E10.3,10H          ,
     1 E10.3)
   80 FORMAT (1X,*RATIO, RMAX FROM MESH GEN*,1P3E16.8)
      END
      SUBROUTINE SETKAP
      COMMON/KAPA/KAP(51,31),XMF,YMF,ZMF
      REAL KAP
C ***
C *** READS GOB OPACITY DECK
C ***
      READ (5,100) XMF,YMF
  100 FORMAT (10F8.5)
      ZMF=1.-XMF-YMF
      I=0
      K2=0
  300 CONTINUE
```

```
      I=I+1                                                             SV
      IF (I .GT. 51) GO TO 304                                          SV
  301 FORMAT (1X,I5,14F5.2)                                             SV
      K2=K2+1                                                           SV
      READ (5,301) K1,(KAP(I,J),J=1,14)                                 SV
      IF (K1 .NE. K2) GO TO 302                                         SV
      K2=K2+1                                                           SV
      READ (5,301) K1,(KAP(I,J),J=15,28)                                SV
      IF (K1 .NE. K2) GO TO 302                                         SV
      K2=K2+1                                                           SV
      READ (5,301) K1,(KAP(I,J),J=29,31)                                SV
      IF (K1 .NE. K2) GO TO 302                                         SV
      GO TO 300                                                         SV
  302 CONTINUE                                                          SV
  303 FORMAT (1X,21HWRONG OPACITY CARD,K=I3)                            SV
      WRITE (6,303) K2                                                  SV
      CALL EXIT                                                         SV
  304 CONTINUE                                                          SV
      RETURN                                                            SV
      END                                                               SV
      SUBROUTINE OUTPUT                                                 SV
      REAL MUVISC                                                       SV
      COMMON /A1/JBAR,JP1,JP2,JP3,DT,T,N,NDT,FMASS,FMOM,ET,EINT,NM,LFILMSV
      COMMON /A2/ EM(200),X(200),U(200),MUVISC(200)                     SV
      COMMON /3/ EI(200),E(200),DTMAX,VLAM,DTK                          SV
      COMMON /4/ RHO(200),EMC(200),P(200),RHOL(200)                     SV
      COMMON /A5/ UT(200),UD(200)                                       SV
      COMMON /10/ ITITLE(8)                                             SV
      COMMON /12/ GAMMA,JT1,UTMAX,DONM,DONMOM,GRDVEL                    SV
      COMMON /A14/ EMCT(200),JG(200),DPHI(200)                          SV
      COMMON /A15/ RCV(200),CND(200),R2DR(200),TNOT4                    SV
      COMMON /A40/FOURPI,AJ(200),XMR(160)                               SV
      COMMON /TIMEV/ RSAV(2000),TIM(2000),ITIME                         SV
      DIMENSION AL(200), BL(200), CL(200)                               SV
      DIMENSION XC(200),TEM(200)                                        SV
      DATA UTITLE/10HX-VELOCITY/                                        SV
      DATA (DPHI(J),J=1,200)/200*0./                                    SV
      DATA PTITLE/8HPRESSURE/                                           SV
      DATA (XMR(J),J=1,160)/160*0./                                     SV
      DATA RHOTITL/7HDENSITY/                                           SV
      DATA XITLE/3HSIE/                                                 SV
```

```
C ***
C *** BCD OUTPUT
C ***
      DO 25 J=2,JP2
      IF (J .GT. 2) XMR(J)=XMR(J-1)+FOURPI*EMC(J-1)/3.
      DPHI(J)=-FOURPI*AJ(J)*DPHI(J)/3.
      TEM(J)=EI(J)*RCV(J)
   25 CONTINUE
      IUMIN=6
      IUMAX=7
      IF (N.LE.1) GO TO 10
      IF (MOD(N,NM).NE.0) IUMIN=7
      IF (MOD(N,LFILM).NE.0) IUMAX=6
      IF (IUMIN.GT.IUMAX) IUMAX=7
   10 DO 20 IU=IUMIN,IUMAX
      WRITE (IU,40) EINT,ET,FMASS,FMOM,N
      IF (IU.EQ.7) CALL ADV (1)
      WRITE (IU,50)
      WRITE (IU,60)(I,X(I),U(I),RHO(I),EI(I),P(I),CND(I),DPHI(I),
     1 XMR(I),TEM(I),I=2,JP2)
   20 CONTINUE
C ***
C *** GRAPHICAL OUTPUT
C ***
      IF (IUMAX .EQ. 6) RETURN
      CALL SPLOT (1,JP1,X(2),U(2),42,1)
      CALL WLCH (0,0,56,ITITLE,2)
      CALL WLCH (0,25,10,UTITLE,1)
      CALL LINCNT (60)
      WRITE (7,70)T,N
      DO 30 J=2,JP1
      XC(J)=.5*(X(J)+X(J+1))
      AL(J)=ALOG10(RHO(J))
      BL(J)=ALOG10(EI(J))
      CL(J)=ALOG10(P(J))
   30 CONTINUE
      CALL SPLOT (1,JP1-1,XC(2),P(2),42,1)
      CALL WLCH (0,0,56,ITITLE,2)
      CALL WLCH (0,25,8,PTITLE,1)
      CALL LINCNT (60)
```

```
      WRITE (7,70)T,N
      CALL SPLOT (1,JP1-1,XC(2),EI(2),42,1)
      CALL WLCH (0,0,56,ITITLE,2)
      CALL WLCH (0,25,3,XITLE,1)
      CALL LINCNT (60)
      WRITE (7,70)T,N
      CALL SPLOT (1,JP1-1,XC(2),RHO(2),42,1)
      CALL WLCH (0,0,56,ITITLE,2)
      CALL WLCH (0,25,7,RHOTITL,1)
      CALL LINCNT (60)
      WRITE (7,70)T,N
      CALL SPLOT (1,JP1-1,XC(2),CND(2),42,1)
      CALL WLCH (0,0,56,ITITLE,2)
      CALL WLCH (0,25,3,3HCND,1)
      CALL LINCNT (60)
      WRITE (7,70)T,N
      IF (N.GT.10) CALL SPLOT (2,ITIME,TIM,RSAV,42,1)
      IF (N.GT.10) CALL WLCH (0,25,8,8HRHO VS T,1)
      CALL LINCNT (60)
      WRITE (7,70)T,N
      JBAR=JP1-1
      CALL SPLOT (2,JBAR,XC(2),AL(2),42,1)
      CALL WLCH(0,25,7,RHOTITL,1)
      CALL SPLOT (2,JBAR,XC(2),BL(2),42,1)
      CALL WLCH(0,25,3, XITLE,1)
      CALL SPLOT (2,JBAR,XC(2),CL(2),42,1)
      CALL WLCH(0,25,8,PTITLE,1)
      XJCL=1.E-3*X(JP2)
      DO 7000 J=2,JP1
      JCL=J
      IF (X(J) .GT. XJCL) GO TO 7001
 7000 CONTINUE
 7001 CONTINUE
      IF (JCL .EQ. JP1 .OR. JCL .LT. 3) GO TO 7002
      CALL SPLOT(1,JCL,X(2),U(2),42,1)
      CALL WLCH(0,25,10,UTITLE,1)
      CALL SPLOT(1,JCL-1,XC(2),  P(2),42,1)
      CALL WLCH(0,25,8,PTITLE,1)
      CALL SPLOT(1,JCL-1,XC(2), EI(2),42,1)
      CALL WLCH(0,25,3, XITLE,1)
```

```
      CALL SPLOT(1,JCL-1,XC(2),RHO(2),42,1)
      CALL WLCH(0,25,7,RHOTITL,1)
 7002 CONTINUE
      WRITE (59,70) T,N
      IF (TEM(2) .GT. 2000.) CALL EXIT
      RETURN
C ***
C *** FORMAT BLOCK
C ***
   40 FORMAT (1X,17HINTERNAL ENERGY =,1PE13.6,
     1 15H TOTAL ENERGY =,E13.6,7H MASS =,E13.6,11H MOMENTUM =,E13.6,
     1 8H CYCLE =,I7)
   50 FORMAT (4X,1HJ,7X,1HX,12X,1HU,11X,3HRHO,10X,2HEI,11X,1HP,
     $ 10X,3HCND,11X,1HL,10X,2HMR,11X,1HT)
   60 FORMAT (1X,I3,1P9E13.5)
   70 FORMAT (6H TIME=,1PE10.3,7H CYCLE=,I5)
      END
      SUBROUTINE GRID
      REAL MUVISC
      COMMON /A1/JBAR,JP1,JP2,JP3,DT,T,N,NDT,FMASS,FMOM,ET,EINT,NM,LFILM
      COMMON /A2/ EM(200),X(200),U(200),MUVISC(200)
      COMMON /A5/ UT(200),UD(200)
      COMMON /12/ GAMMA,UT1,UTMAX,DONM,DONMOM,GRDVEL
      COMMON /A14/ EMCT(200),UG(200),DPHI(200)
C ***
C *** DEFINE GRID VELOCITY UG, REZONE (DIFFERENCE) VELOCITY UD,
C *** AND NEW VERTEX POSITIONS X.
C *** GRDVEL = 0., EULERIAN.  GRDVEL =1., LAGRANGIAN.
C ***
      DO 10 J=2,JP2
      UG(J)=GRDVEL*UT(J)
      UD(J)=UG(J)-UT(J)
      X(J)=X(J)+DT*UG(J)
   10 CONTINUE
      X(JP3)=2.*X(JP2)-X(JP1)
      X(1)=2.*X(2)-X(3)
      RETURN
      END
      REAL FUNCTION KAPPA(RO1,TE)
C *** T LIMITS OF TABLE ARE LOG(T)=3.3 AND 8.2
```

```
C *** RHO TABLE LIMITS ARE 1.E-12 AND 1000.
      COMMON/KAPA/KAP(51,31),XMF,YMF,ZMF
      REAL KAP,KAPP
      INTEGER DI,TI
      DATA DUSTK/0.15/
C *** DUST OPACITY ONLY
      KAPPA=DUSTK
      IF (TE .LE. 1500.) RETURN
C *** GAS OPACITY
      RO=RO1
      D=2.0*ALOG10(RO)+25.0
      DI=INT(D)
      D=D-DI
      T=20.*ALOG10(TE)-65.
      IF (T .GT. 35.) T=35.+(T-35.)*0.25
      TI=INT(T)
      T=T-TI
      IF (DI .GE. 1) GO TO 30
      DI=1
      D=0.
   30 CONTINUE
      IF (DI .LE. 30) GO TO 31
      DI=30
      D=1.
   31 CONTINUE
      IF (TI .GE. 1) GO TO 32
      TI=1
      T=0.
   32 CONTINUE
      IF (TI .LE. 50) GO TO 33
      TI=50
      T=1.
   33 KAPP=(1.-T)*((1.-D)*KAP(TI,DI)+D*KAP(TI,DI+1))+
     1 T*((1.-D)*KAP (TI+1,DI)+D*KAP(TI+1,DI+1))
      KAPPA=EXP(2.3026*KAPP)
      IF (TE .GE. 2000.) RETURN
C *** DUST PLUS GAS OPACITIES
      T=(2000.-TE)*0.002
      KAPPA=T*DUSTK+(1.-T)*KAPPA
      RETURN
```

```
      END
      SUBROUTINE CONDUCT
      REAL KAPPA,MUVISC
      COMMON /A1/JBAR,JP1,JP2,JP3,DT,T,N,NDT,FMASS,FMOM,ET,EINT,NM,LFILM
      COMMON /A2/ EM(200),X(200),U(200),MUVISC(200)
      COMMON /3/ EI(200),E(200),DTMAX,VLAM,DTK
      COMMON /4/ RHO(200)
      COMMON /A15/ RCV(200),CND(200),R2DR(200),TNOT4
      DATA PR/1.0/
C ***
C *** COMPUTE CONDUCTIVITY CND AND VISCOSITY MUVISC.
C ***
      DO 10 J=2,JP1
      TEM=EI(J)*RCV(J)
      MUVISC(J)=7.15E-05*SQRT(TEM)
      TEM=0.5*(TEM+EI(J-1)*RCV(J-1))
      ROE=0.5*(RHO(J)+RHO(J-1))
      AA=ROE*TEM*KAPPA(ROE,TEM)
      TGRAD=2.*(RCV(J)*EI(J)-EI(J-1)*RCV(J-1))*R2DR(J)
      CND(J)=3.02383E-04*(TEM**4-TNOT4)/((1.-4.*TGRAD/(3.*AA))*AA)
C     CND(J)=3.02383E-04*TEM*TEM*TEM/(ROE*KAPPA(ROE,TEM))
C     CND(J)=0.5*(MUVISC(J)+MUVISC(J-1))/PR
   10 CONTINUE
      MUVISC(1)=MUVISC(2)
      MUVISC(JP2)=MUVISC(JP1)
      CND(JP1)=CND(JP1-1)
      CND(JP1+1)=CND(JP1)
      RETURN
      END
      SUBROUTINE DECB(IER)
      COMMON  ML,MU,B(770,15),N,NDIM,IP(770)
C
C     LU DECOMPOSITION OF BAND MATRIX A.. L*U=P*A,WHERE P IS A
C     PERMUTATION MATRIX, L IS A UNIT LOWER TRIANGULAR MATRIX,
C     AND U IS AN UPPER TRIANGULAR MATRIX.
C     N = ORDER OF MATRIX.
C     B = N BY (2*ML+MU+1) ARRAY CONTAINING  THE MATRIX A ON INPUT
C     AND ITS FACTORED FORM ON OUTPUT.
C     ON INPUT, B(I,K) (1.LE.I.LE.N) CONTAINS THE K-TH
C     DIAGONAL OF A, OR A(I,J) IS STORED IN B(I,J-I+ML+1).
```

```
C     ON OUTPUT, B CONTAINS THE L AND U FACTORS, WITH
C     U IN COLUMNS 1 TO ML+MU+1, AND L IN COLUMNS
C     ML+MU+2 TO 2*ML+MU+1.
C     ML,MU= WIDTHS OF THE LOWER AND UPPER PARTS OF THE BAND, NOT
C     COUNTING THE MAIN DIAGONAL. TOTAL BANDWIDTH IS ML+MU+1.
C     NDIM = THE FIRST DIMENSION (COLUMN LENGHT) OF THE ARRAY B.
C     NDIM MUST BE . GE. N.
C     IP = ARRAY OF LENGTH N CONTAINING PIVOT INFORMATION.
C     IER = ERROR INDICATOR..
C     = 0 IF NO ERROR,
C     = K IF THE K-TH PIVOT CHOSEN WAS ZERO ( A IS SINGULAR).
C     CAUTION.. IF ML=0, THIS ROUTINE CONTAINS EMPTY DO-LOOPS
C     WHICH MUST BE COMPILED CORRECTLY (I.E.NO ACTION TAKEN).
C     THE INPUT ARGUMENTS ARE NDIM,N,ML,MU,B.
C     THE OUTPUT ARGUMENTS ARE B,IP,IER.
C
      IER=0
      LL=ML+MU+1
      N1=N-1
      DO 3 I=1,ML
      II=MU+I
      K=ML+1-I
      DO 1 J=1,II
    1 B(I,J)=B(I,J+K)
      K=II+1
      DO 2 J=K,LL
    2 B(I,J)=0.
    3 CONTINUE
      LR=ML
      DO 9 NR=1,N1
      NP=NR+1
      IF( LR.NE.N) LR=LR+1
      MX=NR
      XM=ABS(B(NR))
      DO 4 I=NP,LR
      IF(ABS(B(I)).LE.XM)GO TO 4
      MX=I
      XM=ABS(B(I))
    4 CONTINUE
      IP(NR)=MX
```

```
      IF(MX.EQ.NR)GO TO 6
      DO 5 I=1,LL
      XX=B(NR,I)
      B(NR,I)=B(MX,I)
    5 B(MX,I)=XX
    6 XM=B(NR)
      IF(XM.EQ.0.)GO TO 10
      B(NR)=1./XM
      XM=-B(NR)
      KK=MINO(N-NR,LL-1)
      DO 8 I=NP,LR
      J=LL+I-NR
      XX=B(I)*XM
      B(NR,J)=XX
      DO 7 II=1,KK
    7 B(I,II)=B(I,II+1)+XX*B(NR,II+1)
    8 B(I,LL)=0.
    9 CONTINUE
      NR=N
      IF(B(N).EQ.0.)GO TO 10
      B(N)=1./B(N)
      RETURN
   10 IER=NR
      RETURN
      END
      SUBROUTINE SOLB(Y)
      COMMON  ML,MU,B(770,16),N,NDIM,IP(770)
      DIMENSION Y(1)
C
C     SOLUTION OF A*X=C GIVEN LU DECOMPOSITION OF A FROM DECB.
C     Y = RIGHT-HAND VECTOR C, OF LENGTH N, ON INPUT,
C     = SOLUTION VECTOR X ON OUTPUT.
C     CAUTION.. IF ML=0, THIS ROUTINE CONTAINS EMPTY DO-LOOPS
C     WHICH MUST BE COMPILED CORRECTLY (I.E. NO ACTION TAKEN).
C     ALL THE ARGUMENTS ARE INPUT ARGUMENTS.
C     THE OUTPUT ARGUMENT IS Y.
C
      N1=N-1
      LL=ML+MU+1
      DO 3 NR=1,N1
```

```
      IF(IP(NR).EQ.NR)GO TO 1
      J=IP(NR)
      XX=Y(NR)
      Y(NR)=Y(J)
      Y(J)=XX
    1 KK=MIN0(N-NR,ML)
      DO 2 I=1,KK
    2 Y(NR+I)=Y(NR+I)+Y(NR)*B(NR,LL+I)
    3 CONTINUE
      LL=LL-1
      Y(N)=Y(N)*B(N)
      KK=0
      DO 5 NB=1,N1
      NR=N-NB
      IF(KK.NE.LL)KK=KK+1
      DP=0.
      DO 4 I=1,KK
    4 DP=DP+B(NR,I+1)*Y(NR+I)
    5 Y(NR)=(Y(NR)-DP)*B(NR)
      RETURN
      END
      SUBROUTINE UNDROP
      CALL GFR80(1HU,4HVEGA,4,3H105,5HT3LDC,4HKEEP)
      CALL GRPHLUN(7)
      CALL LIB4020
      CALL GRPHFTN
      CALL SETFLSH
      RETURN
      END
```

```
*****     *IDENT FIX
*****     *DELETE SV.23
                DATA LFILM,KPR,NM/100,5,500/
*****     *INSERT SV.371
                IF (J .LE. 5) RHO(J)=RHO(J)*FLOAT(10-MAX0(2,J))*0.25
*****     *INSERT SV.26
                CALL UNDROP
```

```
10/26/77 EXPORT VEGA BASE CASE
JBAR              120    NDT             4000
DT          1.000E+010DX          3.000E+012 GRDVEL       0.0
RMIN        0.000E+000 RMAX       1.560E+017
DONR MASS  1.0      DONR MOM     1.0
GAMMA            1.667UT1                       UTMAX
VLAM        0.            DTMAX     +1.000E+10 DTK       0.20
 .70000  .27000
     1-4.45-3.30-3.20-2.85-2.72-2.67-2.64-2.63-2.53-2.62-2.62-2.62-2.61-2.60
     2-2.60-2.59-2.58-2.55-2.54-2.52-2.49-2.46-2.42-5.54-4.59-4.59-4.59-4.59
     3-4.59-4.59-4.59
     4-4.73-4.71-4.59-4.14-3.52-3.04-2.80-2.69-2.65-2.63-2.61-2.60-2.59-2.57
     5-2.55-2.52-2.49-2.44-2.39-2.33-2.26-2.18-2.09-5.32-4.41-4.41-4.41-4.41
     6-4.41-4.41-4.41
     7-4.53-4.51-4.43-4.41-4.29-4.05-3.60-3.12-2.83-2.69-2.62-2.57-2.53-2.48
     8-2.43-2.36-2.29-2.20-2.09-1.98-1.85-1.72-1.58-5.09-4.23-4.23-4.23-4.23
     9-4.23-4.23-4.23
    10-4.44-4.41-4.38-4.31-4.21-4.08-3.90-3.64-3.28-2.90-2.60-2.41-2.25-2.13
    11-2.01-1.88-1.73-1.59-1.43-1.28-1.12 -.95 -.80-4.87-4.05-4.05-4.05-4.05
    12-4.05-4.05-4.05
    13-4.31-4.29-4.32-4.24-4.10-3.92-3.68-3.39-3.06-2.72-2.38-2.07-1.82-1.62
    14-1.45-1.27-1.08 -.90 -.71 -.52 -.33 -.14  .00-4.65-3.87-3.87-3.87-3.87
    15-3.87-3.87-3.87
    16-4.13-4.14-4.23-4.12-3.94-3.68-3.37-3.04-2.69-2.35-2.03-1.72-1.44-1.20
    17 -.93 -.75 -.53 -.30 -.08  .15  .38  .51  .66-4.43-3.70-3.70-3.70-3.70
    18-3.70-3.70-3.70
    19-3.95-3.99-4.03-3.92-3.71-3.39-3.03-2.69-2.35-2.04-1.73-1.43-1.13 -.86
    20 -.60 -.35 -.06  .21  .47  .74 1.01 1.25 1.06-4.21-3.52-3.52-3.52-3.52
    21-3.52-3.52-3.52
    22-3.31-3.40-3.56-3.52-3.37-3.12-2.82-2.51-2.17-1.82-1.47-1.13 -.80 -.51
    23 -.24  .05  .33  .61  .89 1.17 1.46 1.72 1.25-3.99-3.34-3.34-3.34-3.34
    24-3.34-3.34-3.34
    25-2.63-2.79-2.95-2.98-2.93-2.78-2.55-2.28-1.96-1.59-1.21 -.84 -.50 -.20
    26  .03  .37  .66  .95 1.25 1.54 1.83 2.08 1.39-3.77-3.16-3.16-3.15-3.16
    27-3.16-3.16-3.15
    28-1.90-2.05-2.24-2.37-2.39-2.27-2.06-1.81-1.53-1.23 -.91 -.58 -.26  .05
    29  .36  .57  .98 1.29 1.60 1.91 2.22 2.45 1.51-3.55-2.98-2.98-2.98-2.98
    30-2.98-2.95-2.98
    31-1.27-1.39-1.49-1.61-1.66-1.56-1.39-1.18 -.96 -.72 -.47 -.20  .09  .38
    32  .58  .97 1.28 1.58 1.88 2.18 2.47 2.66 1.61-3.33-2.80-2.80-2.80-2.80
```

```
33-2.80-2.80-2.80
34 -.79 -.79 -.77 -.79 -.80 -.73 -.62 -.47 -.30 -.10  .11  .33  .56  .81
35 1.05 1.32 1.59 1.85 2.12 2.38 2.64 2.78 1.71-3.11-2.62-2.62-2.62-2.62
36-2.62-2.62-2.62
37 -.40 -.32 -.23 -.15 -.08 -.01  .07  .19  .33  .49  .67  .86 1.05 1.29
38 1.52 1.76 2.01 2.25 2.49 2.73 2.95 3.01 1.82-2.89-2.44-2.44-2.44-2.44
39-2.44-2.44-2.44
40 -.44 -.26 -.07  .18  .42  .59  .74  .86  .97 1.10 1.24 1.39 1.55 1.76
41 1.97 2.15 2.40 2.52 2.83 3.05 3.25 3.19 1.92-2.66-2.26-2.26-2.26-2.26
42-2.26-2.26-2.26
43 -.47 -.28 -.03  .22  .55  .89 1.19 1.39 1.54 1.66 1.77 1.90 2.05 2.21
44 2.38 2.58 2.78 2.97 3.17 3.36 3.52 3.35 2.02-2.44-2.08-2.08-2.08-2.08
45-2.08-2.08-2.08
46 -.47 -.40 -.31  .01  .43  .85 1.28 1.62 1.90 2.09 2.24 2.37 2.50 2.63
47 2.78 2.95 3.12 3.31 3.49 3.67 3.80 3.49 2.12-2.22-1.90-1.90-1.90-1.90
48-1.90-1.90-1.90
49 -.47 -.47 -.48 -.18  .24  .68 1.14 1.59 2.00 2.31 2.56 2.74 2.88 3.01
50 3.14 3.25 3.44 3.60 3.78 3.97 4.07 3.62 2.23-2.00-1.72-1.72-1.72-1.72
51-1.72-1.72-1.72
52 -.47 -.47 -.49 -.26  .09  .49  .93 1.42 1.90 2.33 2.69 2.96 3.16 3.32
53 3.45 3.58 3.72 3.87 4.04 4.23 4.30 3.73 2.33-1.78-1.54-1.54-1.54-1.54
54-1.54-1.54-1.54
55 -.47 -.47 -.47 -.30 -.04  .29  .70 1.19 1.71 2.22 2.68 3.04 3.32 3.54
56 3.71 3.85 3.98 4.12 4.28 4.43 4.43 3.80 2.43-1.56-1.36-1.36-1.36-1.36
57-1.36-1.36-1.36
58 -.47 -.47 -.47 -.35 -.15  .15  .53 1.01 1.53 2.07 2.58 3.01 3.37 3.66
59 3.89 4.07 4.21 4.36 4.50 4.57 4.49 3.86 2.52-1.34-1.19-1.19-1.19-1.19
60-1.19-1.19-1.19
61 -.47 -.47 -.47 -.39 -.23  .03  .38  .83 1.34 1.89 2.43 2.91 3.33 3.71
62 4.02 4.24 4.41 4.58 4.70 4.70 4.53 3.92 2.62-1.12-1.01-1.01-1.01-1.01
63-1.01-1.01-1.01
64 -.47 -.47 -.47 -.40 -.26 -.04  .27  .69 1.18 1.73 2.28 2.79 3.26 3.69
65 4.05 4.34 4.57 4.78 4.92 4.94 4.72 4.02 2.72 -.90 -.83 -.83 -.83 -.83
66 -.83 -.83 -.83
67 -.47 -.47 -.47 -.40 -.28 -.10  .17  .56 1.04 1.57 2.13 2.66 3.17 3.64
68 4.06 4.41 4.69 4.94 5.11 5.14 4.87 4.11 2.82 -.68 -.65 -.65 -.65 -.65
69 -.65 -.65 -.65
70 -.47 -.47 -.47 -.41 -.29 -.14  .09  .46  .91 1.43 1.99 2.53 3.05 3.56
71 4.02 4.43 4.77 5.06 5.27 5.32 5.00 4.19 2.93 -.46 -.47 -.47 -.47 -.47
72 -.47 -.47 -.47
```

73	-.47	-.47	-.47	-.42	-.32	-.18	.03	.38	.82	1.33	1.88	2.42	2.95	3.46
74	3.95	4.40	4.79	5.11	5.35	5.41	5.08	4.27	3.03	-.24	-.29	-.29	-.29	-.29
75	-.29	-.29	-.29											
76	-.47	-.47	-.47	-.44	-.36	-.23	-.02	.32	.75	1.26	1.80	2.33	2.85	3.38
77	3.88	4.34	4.76	5.10	5.34	5.39	5.09	4.33	3.12	-.01	-.11	-.11	-.11	-.11
78	-.11	-.11	-.11											
79	-.47	-.47	-.47	-.45	-.40	-.28	-.07	.26	.68	1.18	1.72	2.24	2.76	3.28
80	3.78	4.25	4.68	5.05	5.30	5.32	5.07	4.38	3.22	.21	.07	.07	.07	.07
81	.07	.07	.07											
82	-.47	-.47	-.47	-.47	-.44	-.32	-.12	.20	.60	1.10	1.63	2.14	2.65	3.16
83	3.67	4.15	4.58	4.95	5.20	5.22	5.00	4.42	3.32	.43	.25	.25	.25	.25
84	.25	.25	.25											
85	-.47	-.47	-.47	-.49	-.47	-.36	-.16	.14	.52	1.00	1.52	2.02	2.52	3.04
86	3.54	4.01	4.44	4.32	5.07	5.06	4.88	4.43	3.41	.65	.43	.43	.43	.43
87	.43	.43	.43											
88	-.47	-.47	-.47	-.49	-.48	-.39	-.23	.01	.35	.80	1.31	1.82	2.34	2.87
89	3.39	3.87	4.30	4.67	4.92	4.93	4.81	4.45	3.51	.87	.61	.61	.61	.61
90	.61	.61	.61											
91	-.47	-.47	-.47	-.49	-.48	-.42	-.30	-.11	.17	.60	1.10	1.61	2.15	2.70
92	3.22	3.71	4.14	4.50	4.76	4.80	4.73	4.46	3.60	1.09	.79	.79	.79	.79
93	.79	.79	.79											
94	-.47	-.47	-.47	-.48	-.47	-.44	-.36	-.22	.01	.39	.87	1.39	1.94	2.50
95	3.04	3.54	3.97	4.34	4.59	4.68	4.65	4.47	3.69	1.31	.97	.97	.97	.97
96	.97	.97	.97											
97	-.47	-.47	-.47	-.48	-.47	-.45	-.41	-.30	-.09	.25	.68	1.18	1.72	2.29
98	2.85	3.36	3.81	4.19	4.47	4.58	4.59	4.44	3.77	1.53	1.15	1.15	1.15	1.15
99	1.15	1.15	1.15											
100	-.47	-.47	-.47	-.47	-.47	-.47	-.44	-.35	-.17	.12	.51	.98	1.50	2.07
101	2.64	3.17	3.65	4.05	4.35	4.49	4.52	4.39	3.82	1.75	1.32	1.32	1.32	1.32
102	1.32	1.32	1.32											
103	-.47	-.47	-.47	-.47	-.47	-.49	-.47	-.39	-.23	.01	.34	.78	1.29	1.85
104	2.43	2.98	3.48	3.91	4.23	-.39	4.43	4.30	3.84	1.97	1.50	1.20	.71	-.27
105	-1.20	-2.29	-3.39											
106	-.47	-.47	-.47	-.47	-.47	-.48	-.49	-.46	-.40	-.30	-.13	.15	.55	1.07
107	1.63	2.22	2.76	3.21	3.54	3.74	3.82	3.79	3.65	2.79	2.20	1.75	1.19	.24
108	-.70	-1.77	-2.86											
109	-.47	-.47	-.47	-.47	-.47	-.47	-.47	-.47	-.47	-.44	-.37	-.22	.02	.38
110	.83	1.35	1.91	2.39	2.77	3.01	3.15	3.18	3.18	3.11	2.78	2.27	1.67	.74
111	-.19	-1.25	-2.33											
112	-.47	-.47	-.47	-.47	-.47	-.47	-.47	-.48	-.48	-.48	-.46	-.42	-.31	-.14

121	113	.13	.54	1.02	1.53	1.99	2.31	2.54	2.64	2.71	2.83	2.91	2.69	2.15	1.25
122	114	.32	-.74	-1.81											
123	115	-.47	-.47	-.47	-.47	-.47	-.47	-.47	-.47	-.47	-.47	-.47	-.47	-.45	-.41
124	116	-.29	-.05	.27	.70	1.17	1.60	1.96	2.19	2.36	2.52	2.70	2.81	2.55	1.74
125	117	.81	-.24	-1.29											
126	118	-.47	-.47	-.47	-.47	-.47	-.47	-.47	-.47	-.47	-.47	-.47	-.47	-.46	-.46
127	119	-.42	-.36	-.22	.06	.43	.92	1.40	1.77	2.06	2.23	2.36	2.52	2.57	2.12
128	120	1.29	.26	-.79											
129	121	-.47	-.47	-.47	-.47	-.47	-.47	-.47	-.47	-.47	-.47	-.47	-.47	-.47	-.47
130	122	-.47	-.45	-.39	-.26	-.03	.34	.77	1.23	1.64	1.89	2.05	2.16	2.24	2.22
131	123	1.70	.75	-.30											
132	124	-.47	-.47	-.47	-.47	-.47	-.47	-.47	-.47	-.47	-.47	-.47	-.47	-.47	-.47
133	125	-.47	-.47	-.44	-.40	-.30	-.10	.19	.59	1.01	1.31	1.53	1.65	1.74	1.89
134	126	1.64	1.15	.19											
135	127	-.47	-.47	-.47	-.47	-.47	-.47	-.47	-.47	-.47	-.47	-.47	-.47	-.47	-.47
136	128	-.48	-.48	-.47	-.47	-.43	-.37	-.23	.01	.30	.59	.85	1.01	1.15	1.33
137	129	1.50	1.41	.65											
138	130	-.48	-.48	-.48	-.48	-.48	-.48	-.48	-.48	-.48	-.48	-.48	-.48	-.48	-.48
139	131	-.48	-.48	-.48	-.48	-.48	-.47	-.44	-.35	-.21	-.02	.20	.39	.57	.74
140	132	.93	1.15	.97											
141	133	-.48	-.48	-.48	-.48	-.48	-.48	-.48	-.48	-.48	-.48	-.48	-.48	-.48	-.48
142	134	-.48	-.48	-.48	-.48	-.48	-.48	-.47	-.46	-.43	-.35	-.24	-.09	.07	.22
143	135	.41	.66	.86											
144	136	-.49	-.49	-.49	-.49	-.49	-.49	-.49	-.49	-.49	-.49	-.49	-.49	-.49	-.49
145	137	-.49	-.49	-.49	-.49	-.49	-.49	-.49	-.49	-.49	-.47	-.43	-.35	-.26	-.15
146	138	-.01	.20	.43											
147	139	-.50	-.50	-.50	-.50	-.50	-.50	-.50	-.50	-.50	-.50	-.50	-.50	-.50	-.50
148	140	-.50	-.50	-.50	-.50	-.50	-.50	-.50	-.50	-.50	-.50	-.49	-.47	-.43	-.37
149	141	-.28	-.14	.03											
150	142	-.51	-.51	-.51	-.51	-.51	-.51	-.51	-.51	-.51	-.51	-.51	-.51	-.51	-.51
151	143	-.51	-.51	-.51	-.51	-.51	-.51	-.51	-.51	-.51	-.52	-.52	-.52	-.50	-.48
152	144	-.44	-.36	-.26											
153	145	-.53	-.53	-.53	-.53	-.53	-.53	-.53	-.53	-.53	-.53	-.53	-.53	-.53	-.53
154	146	-.53	-.53	-.53	-.53	-.53	-.53	-.53	-.53	-.53	-.53	-.53	-.53	-.53	-.53
155	147	-.51	-.49	-.43											
156	148	-.55	-.55	-.56	-.56	-.54	-.55	-.56	-.56	-.56	-.55	-.56	-.56	-.56	-.56
157	149	-.55	-.56	-.56	-.56	-.56	-.55	-.56	-.56	-.56	-.56	-.56	-.56	-.56	-.56
158	150	-.55	-.55	-.53											
159	151	-.61	-.61	-.61	-.61	-.61	-.61	-.61	-.61	-.61	-.61	-.61	-.61	-.61	-.61
160	152	-.61	-.61	-.61	-.61	-.61	-.61	-.61	-.61	-.61	-.61	-.61	-.61	-.61	-.61
161	153	-.61	-.60	-.60											

```
10/26/77 EXPORT VEGA BASE CASE
JBAR             120   NDT             4000
DT          .100E+110X            .300E+13 GROVEL     0.
RMIN        0.          RMAX      .156E+18
DONR MASS   .100E+01DONR MOM      .100E+01
GAMMA       .167E+01UTI           0.         UTMAX       0.
VLAM        0.          DTMAX     .100E+11 DTK        .200E+00
RATIO, RMAX FROM MESH GEN  1.00000000E+00  3.60000000E+14  3.00000000E+12
RATIO, RMAX FROM MESH GEN  1.50000000E+00  3.20455180E+33  5.34091967E+32
RATIO, RMAX FROM MESH GEN  1.25000000E+00  3.34859587E+24  4.18574484E+23
RATIO, RMAX FROM MESH GEN  1.12500000E+00  2.74689621E+19  2.28908193E+18
RATIO, RMAX FROM MESH GEN  1.06250000E+00  6.39254202E+16  3.19852101E+15
RATIO, RMAX FROM MESH GEN  1.09375000E+00  1.31528751E+18  8.96806708E+16
RATIO, RMAX FROM MESH GEN  1.07812500E+00  2.87955631E+17  1.71423233E+16
RATIO, RMAX FROM MESH GEN  1.07031250E+00  1.35305050E+17  7.42745396E+15
RATIO, RMAX FROM MESH GEN  1.07421375E+00  1.97281657E+17  1.12923683E+16
RATIO, RMAX FROM MESH GEN  1.07226563E+00  1.63356036E+17  9.15999748E+15
RATIO, RMAX FROM MESH GEN  1.07128906E+00  1.48664504E+17  8.24875514E+15
RATIO, RMAX FROM MESH GEN  1.07177734E+00  1.55835727E+17  8.69254737E+15
RATIO, RMAX FROM MESH GEN  1.07202148E+00  1.59551199E+17  8.92323859E+15
RATIO, RMAX FROM MESH GEN  1.07189941E+00  1.57682425E+17  8.80714425E+15
RATIO, RMAX FROM MESH GEN  1.07183838E+00  1.56756333E+17  8.74965983E+15
RATIO, RMAX FROM MESH GEN  1.07180786E+00  1.56295346E+17  8.72105726E+15
RATIO, RMAX FROM MESH GEN  1.07179260E+00  1.56065366E+17  8.70679075E+15
RATIO, RMAX FROM MESH GEN  1.07178497E+00  1.55950504E+17  8.69956617E+15
RATIO, RMAX FROM MESH GEN  1.07178379E+00  1.56007924E+17  8.70322774E+15
      1.00000420E+04
INTERNAL ENERGY =           -I TOTAL ENERGY =          -I MASS =          -I MOMENTUM =          -I CYCLE =      0
```

J	X	U	RHO	EI	P	CND	L	MR	T
2	0.	0.	2.52000E-19	2.61630E+08	4.39758E-11	-1.49992E+19	0.	0.	5.00001E+00
3	3.00000E+12	0.	2.20500E-19	2.99036E+08	4.39758E-11	8.74058E+12	0.	2.85005E+19	5.71429E+00
4	6.00000E+12	0.	1.89000E-19	3.48840E+08	4.39758E-11	6.31347E+12	0.	2.03066E+20	6.66667E+00
5	9.21537E+12	0.	1.57500E-19	4.18608E+08	4.39758E-11	4.02691E+12	0.	6.51630E+20	8.00001E+00
6	1.26616E+13	0.	1.26000E-19	5.23260E+08	4.39758E-11	1.39212E+12	0.	1.47448E+21	1.00000E+01
7	1.63552E+13	0.	1.26000E-19	5.23260E+08	4.39758E-11	0.	0.	2.71215E+21	1.00000E+01
8	2.03139E+13	0.	1.26000E-19	5.23260E+08	4.39758E-11	0.	0.	4.82740E+21	1.00000E+01
9	2.45568E+13	0.	1.26000E-19	5.23260E+08	4.39758E-11	0.	0.	8.21902E+21	1.00000E+01
10	2.91044E+13	0.	1.26000E-19	5.23260E+08	4.39758E-11	0.	0.	1.34149E+22	1.00000E+01
11	3.39734E+13	0.	1.26000E-19	5.23260E+08	4.39758E-11	0.	0.	2.11078E+22	1.00000E+01
12	3.92023E+13	0.	1.26000E-19	5.23260E+08	4.39758E-11	0.	0.	3.22007E+22	1.00000E+01
13	4.48012E+13	0.	1.26000E-19	5.23260E+08	4.39758E-11	0.	0.	4.78632E+22	1.00000E+01
14	5.08021E+13	0.	1.26000E-19	5.23260E+08	4.39758E-11	0.	0.	6.96027E+22	1.00000E+01
15	5.72337E+13	0.	1.26000E-19	5.23260E+08	4.39758E-11	0.	0.	9.93530E+22	1.00000E+01
16	6.41271E+13	0.	1.26000E-19	5.23260E+08	4.39758E-11	0.	0.	1.39585E+23	1.00000E+01
17	7.15153E+13	0.	1.26000E-19	5.23260E+08	4.39758E-11	0.	0.	1.93447E+23	1.00000E+01
18	7.94340E+13	0.	1.25000E-19	5.23260E+08	4.39758E-11	0.	0.	2.64935E+23	1.00000E+01
19	8.79211E+13	0.	1.25000E-19	5.23260E+08	4.39758E-11	0.	0.	3.59109E+23	1.00000E+01
20	9.70174E+13	0.	1.26000E-19	5.23260E+08	4.39758E-11	0.	0.	4.82361E+23	1.00000E+01
21	1.06767E+14	0.	1.26000E-19	5.23260E+08	4.39758E-11	0.	0.	6.42748E+23	1.00000E+01
22	1.17216E+14	0.	1.26000E-19	5.23260E+08	4.39758E-11	0.	0.	8.50408E+23	1.00000E+01
23	1.28416E+14	0.	1.26000E-19	5.23260E+08	4.39758E-11	0.	0.	1.11807E+24	1.00000E+01
24	1.40419E+14	0.	1.26000E-19	5.23260E+08	4.39758E-11	0.	0.	1.46169E+24	1.00000E+01
25	1.53284E+14	0.	1.25000E-19	5.23260E+08	4.39758E-11	0.	0.	1.90127E+24	1.00000E+01
26	1.67073E+14	0.	1.26000E-19	5.23260E+08	4.39758E-11	0.	0.	2.46177E+24	1.00000E+01
27	1.81851E+14	0.	1.26000E-19	5.23260E+08	4.39758E-11	0.	0.	3.17442E+24	1.00000E+01
28	1.97691E+14	0.	1.26000E-19	5.23260E+08	4.39758E-11	0.	0.	4.07815E+24	1.00000E+01
29	2.14658E+14	0.	1.26000E-19	5.23260E+08	4.39758E-11	0.	0.	5.22146E+24	1.00000E+01
30	2.32863E+14	0.	1.26000E-19	5.23260E+08	4.39758E-11	0.	0.	6.66480E+24	1.00000E+01
31	2.52365E+14	0.	1.26000E-19	5.23260E+08	4.39758E-11	0.	0.	8.48330E+24	1.00000E+01
32	2.73256E+14	0.	1.26000E-19	5.23260E+08	4.39758E-11	0.	0.	1.07704E+25	1.00000E+01
33	2.95668E+14	0.	1.26000E-19	5.23260E+08	4.39758E-11	0.	0.	1.30422E+25	1.00000E+01
34	3.19079E+14	0.	1.26000E-19	5.23260E+08	4.39758E-11	0.	0.	1.72429E+25	1.00000E+01
35	3.45412E+14	0.	1.26000E-19	5.23260E+08	4.39758E-11	0.	0.	2.17511E+25	1.00000E+01

36	3.72994E+14	0.	1.26000E-19	5.23260E+08	4.39758E-11	0.	0.	2.73687E+25	1.00000E+01
37	4.02555E+14	0.	1.26000E-19	5.23260E+08	4.39758E-11	0.	0.	3.44303E+25	1.00000E+01
38	4.34239E+14	0.	1.26000E-19	5.23260E+08	4.39758E-11	0.	0.	4.32165E+25	1.00000E+01
39	4.68197E+14	0.	1.26000E-19	5.23260E+08	4.39758E-11	0.	0.	5.41687E+25	1.00000E+01
40	5.04593E+14	0.	1.26000E-19	5.23260E+08	4.39758E-11	0.	0.	6.78087E+25	1.00000E+01
41	5.43602E+14	0.	1.26000E-19	5.23260E+08	4.39758E-11	0.	0.	8.47820E+25	1.00000E+01
42	5.85411E+14	0.	1.26000E-19	5.23260E+08	4.39758E-11	0.	0.	1.05887E+26	1.00000E+01
43	6.30221E+14	0.	1.26000E-19	5.23260E+08	4.39758E-11	0.	0.	1.32111E+26	1.00000E+01
44	6.78249E+14	0.	1.26000E-19	5.23260E+08	4.39758E-11	0.	0.	1.64675E+26	1.00000E+01
45	7.29724E+14	0.	1.26000E-19	5.23260E+08	4.39758E-11	0.	0.	2.05086E+26	1.00000E+01
46	7.84895E+14	0.	1.26000E-19	5.23260E+08	4.39758E-11	0.	0.	2.55208E+26	1.00000E+01
47	8.44026E+14	0.	1.26000E-19	5.23260E+08	4.39758E-11	0.	0.	3.17342E+26	1.00000E+01
48	9.07402E+14	0.	1.26000E-19	5.23260E+08	4.39758E-11	0.	0.	3.94329E+26	1.00000E+01
49	9.75328E+14	0.	1.26000E-19	5.23260E+08	4.39758E-11	0.	0.	4.89679E+26	1.00000E+01
50	1.04813E+15	0.	1.26000E-19	5.23260E+08	4.39758E-11	0.	0.	6.07723E+26	1.00000E+01
51	1.12616E+15	0.	1.26000E-19	5.23260E+08	4.39758E-11	0.	0.	7.53804E+26	1.00000E+01
52	1.20979E+15	0.	1.26000E-19	5.23260E+08	4.39758E-11	0.	0.	9.34520E+26	1.00000E+01
53	1.29942E+15	0.	1.26000E-19	5.23260E+08	4.39758E-11	0.	0.	1.15801E+27	1.00000E+01
54	1.39549E+15	0.	1.26000E-19	5.23260E+08	4.39758E-11	0.	0.	1.43430E+27	1.00000E+01
55	1.49846E+15	0.	1.26000E-19	5.23260E+08	4.39758E-11	0.	0.	1.77579E+27	1.00000E+01
56	1.60881E+15	0.	1.26000E-19	5.23260E+08	4.39758E-11	0.	0.	2.19774E+27	1.00000E+01
57	1.72709E+15	0.	1.26000E-19	5.23260E+08	4.39758E-11	0.	0.	2.71899E+27	1.00000E+01
58	1.85386E+15	0.	1.26000E-19	5.23260E+08	4.39758E-11	0.	0.	3.36274E+27	1.00000E+01
59	1.98974E+15	0.	1.26000E-19	5.23260E+08	4.39758E-11	0.	0.	4.15763E+27	1.00000E+01
60	2.13538E+15	0.	1.26000E-19	5.23260E+08	4.39758E-11	0.	0.	5.13894E+27	1.00000E+01
61	2.29144E+15	0.	1.26000E-19	5.23260E+08	4.39758E-11	0.	0.	6.35017E+27	1.00000E+01
62	2.45873E+15	0.	1.26000E-19	5.23260E+08	4.39758E-11	0.	0.	7.84493E+27	1.00000E+01
63	2.63802E+15	0.	1.26000E-19	5.23260E+08	4.39758E-11	0.	0.	9.68931E+27	1.00000E+01
64	2.83018E+15	0.	1.26000E-19	5.23260E+08	4.39758E-11	0.	0.	1.19647E+28	1.00000E+01
65	3.03614E+15	0.	1.26000E-19	5.23260E+08	4.39758E-11	0.	0.	1.47715E+28	1.00000E+01
66	3.25689E+15	0.	1.26000E-19	5.23260E+08	4.39758E-11	0.	0.	1.82334E+28	1.00000E+01
67	3.49348E+15	0.	1.26000E-19	5.23260E+08	4.39758E-11	0.	0.	2.25027E+28	1.00000E+01
68	3.74706E+15	0.	1.26000E-19	5.23260E+08	4.39758E-11	0.	0.	2.77671E+28	1.00000E+01
69	4.01884E+15	0.	1.26000E-19	5.23260E+08	4.39758E-11	0.	0.	3.42580E+28	1.00000E+01
70	4.31013E+15	0.	1.26000E-19	5.23260E+08	4.39758E-11	0.	0.	4.22602E+28	1.00000E+01
71	4.62234E+15	0.	1.26000E-19	5.23260E+08	4.39758E-11	0.	0.	5.21248E+28	1.00000E+01
72	4.95695E+15	0.	1.26000E-19	5.23260E+08	4.39758E-11	0.	0.	6.42841E+28	1.00000E+01
73	5.31559E+15	0.	1.26000E-19	5.23260E+08	4.39758E-11	0.	0.	7.92710E+28	1.00000E+01
74	5.69998E+15	0.	1.26000E-19	5.23260E+08	4.39758E-11	0.	0.	9.77414E+28	1.00000E+01
75	6.11196E+15	0.	1.26000E-19	5.23260E+08	4.39758E-11	0.	0.	1.20504E+29	1.00000E+01
76	6.55351E+15	0.	1.26000E-19	5.23260E+08	4.39758E-11	0.	0.	1.48553E+29	1.00000E+01
77	7.02676E+15	0.	1.26000E-19	5.23260E+08	4.39758E-11	0.	0.	1.83116E+29	1.00000E+01
78	7.53399E+15	0.	1.26000E-19	5.23260E+08	4.39758E-11	0.	0.	2.25701E+29	1.00000E+01
79	8.07763E+15	0.	1.26000E-19	5.23260E+08	4.39758E-11	0.	0.	2.78171E+29	1.00000E+01
80	8.66030E+15	0.	1.26000E-19	5.23260E+08	4.39758E-11	0.	0.	3.42813E+29	1.00000E+01
81	9.28480E+15	0.	1.26000E-19	5.23260E+08	4.39758E-11	0.	0.	4.22451E+29	1.00000E+01
82	9.95413E+15	0.	1.26000E-19	5.23260E+08	4.39758E-11	0.	0.	5.20557E+29	1.00000E+01
83	1.06715E+16	0.	1.26000E-19	5.23260E+08	4.39758E-11	0.	0.	6.41411E+29	1.00000E+01
84	1.14404E+16	0.	1.26000E-19	5.23260E+08	4.39758E-11	0.	0.	7.90280E+29	1.00000E+01
85	1.22645E+16	0.	1.26000E-19	5.23260E+08	4.39758E-11	0.	0.	9.73653E+29	1.00000E+01
86	1.31477E+16	0.	1.26000E-19	5.23260E+08	4.39758E-11	0.	0.	1.19952E+30	1.00000E+01
87	1.40943E+16	0.	1.26000E-19	5.23260E+08	4.39758E-11	0.	0.	1.47772E+30	1.00000E+01
88	1.51089E+16	0.	1.26000E-19	5.23260E+08	4.39758E-11	0.	0.	1.82038E+30	1.00000E+01
89	1.61964E+16	0.	1.26000E-19	5.23260E+08	4.39758E-11	0.	0.	2.24240E+30	1.00000E+01
90	1.73619E+16	0.	1.26000E-19	5.23260E+08	4.39758E-11	0.	0.	2.76216E+30	1.00000E+01
91	1.86110E+16	0.	1.26000E-19	5.23260E+08	4.39758E-11	0.	0.	3.40229E+30	1.00000E+01
92	1.99499E+16	0.	1.26000E-19	5.23260E+08	4.39758E-11	0.	0.	4.19065E+30	1.00000E+01
93	2.13849E+16	0.	1.26000E-19	5.23260E+08	4.39758E-11	0.	0.	5.16153E+30	1.00000E+01
94	2.29228E+16	0.	1.26000E-19	5.23260E+08	4.39758E-11	0.	0.	6.35718E+30	1.00000E+01
95	2.45712E+16	0.	1.26000E-19	5.23260E+08	4.39758E-11	0.	0.	7.82960E+30	1.00000E+01
96	2.63380E+16	0.	1.26000E-19	5.23260E+08	4.39758E-11	0.	0.	9.64284E+30	1.00000E+01
97	2.82315E+16	0.	1.26000E-19	5.23260E+08	4.39758E-11	0.	0.	1.18758E+31	1.00000E+01
98	3.02610E+16	0.	1.26000E-19	5.23260E+08	4.39758E-11	0.	0.	1.46254E+31	1.00000E+01

99	3.24352E+16	0.	1.26000E-19	5.23260E+08	4.39758E-11	0.	0.	1.80114E+31	1.00000E+01
100	3.47575E+16	0.	1.26000E-19	5.23260E+08	4.39758E-11	0.	0.	2.21810E+31	1.00000E+01
101	3.72602E+16	0.	1.26000E-19	5.23260E+08	4.39758E-11	0.	0.	2.73153E+31	1.00000E+01
102	3.99443E+16	0.	1.26000E-19	5.23260E+08	4.39758E-11	0.	0.	3.36375E+31	1.00000E+01
103	4.28146E+16	0.	1.26000E-19	5.23260E+08	4.39758E-11	0.	0.	4.14225E+31	1.00000E+01
104	4.58910E+16	0.	1.26000E-19	5.23260E+08	4.39758E-11	0.	0.	5.10085E+31	1.00000E+01
105	4.91883E+16	0.	1.26000E-19	5.23260E+08	4.39758E-11	0.	0.	6.28122E+31	1.00000E+01
106	5.27222E+16	0.	1.26000E-19	5.23260E+08	4.39758E-11	0.	0.	7.73465E+31	1.00000E+01
107	5.65099E+16	0.	1.26000E-19	5.23260E+08	4.39758E-11	0.	0.	9.52429E+31	1.00000E+01
108	6.05694E+16	0.	1.26000E-19	5.23260E+08	4.39758E-11	0.	0.	1.17279E+32	1.00000E+01
109	6.49204E+16	0.	1.26000E-19	5.23260E+08	4.39758E-11	0.	0.	1.44412E+32	1.00000E+01
110	6.95838E+16	0.	1.26000E-19	5.23260E+08	4.39758E-11	0.	0.	1.77821E+32	1.00000E+01
111	7.45819E+16	0.	1.26000E-19	5.23260E+08	4.39758E-11	0.	0.	2.18957E+32	1.00000E+01
112	7.99388E+16	0.	1.26000E-19	5.23260E+08	4.39758E-11	0.	0.	2.69608E+32	1.00000E+01
113	8.56803E+16	0.	1.26000E-19	5.23260E+08	4.39758E-11	0.	0.	3.31973E+32	1.00000E+01
114	9.18340E+16	0.	1.26000E-19	5.23260E+08	4.39758E-11	0.	0.	4.08761E+32	1.00000E+01
115	9.84294E+16	0.	1.26000E-19	5.23260E+08	4.39758E-11	0.	0.	5.03308E+32	1.00000E+01
116	1.05493E+17	0.	1.26000E-19	5.23260E+08	4.39758E-11	0.	0.	6.19721E+32	1.00000E+01
117	1.13075E+17	0.	1.26000E-19	5.23260E+08	4.39758E-11	0.	0.	7.63055E+32	1.00000E+01
118	1.21195E+17	0.	1.26000E-19	5.23260E+08	4.39758E-11	0.	0.	9.39536E+32	1.00000E+01
119	1.29898E+17	0.	1.26000E-19	5.23260E+08	4.39758E-11	0.	0.	1.15683E+33	1.00000E+01
120	1.38601E+17	0.	1.26000E-19	5.23260E+08	4.39758E-11	0.	0.	1.40528E+33	1.00000E+01
121	1.47305E+17	0.	1.26000E-19	5.23260E+08	4.39758E-11	0.	0.	1.68698E+33	1.00000E+01
122	1.56008E+17	0.	1.26000E-19	5.23260E+08	4.39758E-11	0.	0.	2.00401E+33	1.00000E+01

INTERNAL ENERGY = 1.048618E+42 TOTAL ENERGY = 1.048618E+42 MASS = 2.004007E+33 MOMENTUM =-1.477581E+35 CYCLE = 1

J	X	U	RHO	EI	P	CND	L	MR	T
2	0.	0.	1.99393E-19	4.46002E+08	4.40257E-11	-1.49992E+19	0.	0.	8.52353E+00
3	3.00000E+12	7.16541E+01	1.62301E-19	4.46002E+08	4.40131E-11	8.74058E+12	-8.75726E+17	2.25508E+19	8.52353E+00
4	6.00000E+12	9.70026E+01	1.46870E-19	4.46002E+08	4.39984E-11	6.31347E+12	-5.12902E+18	1.51042E+20	8.52353E+00
5	9.21537E+12	1.01764E+02	1.46018E-19	4.46002E+08	4.39836E-11	4.02691E+12	-1.23488E+19	4.99616E+20	8.52353E+00
6	1.26616E+13	7.60828E+01	1.47996E-19	4.46218E+08	4.39700E-11	1.39212E+12	-1.60365E+19	1.26248E+21	8.52766E+00
7	1.63552E+13	4.49913E+00	1.26000E-19	5.23261E+08	4.39764E-11	0.	0.	2.71622E+21	1.00000E+01
8	2.03139E+13	-6.22790E-01	1.26001E-19	5.23262E+08	4.39764E-11	0.	0.	4.83147E+21	1.00001E+01
9	2.45508E+13	-4.28498E-01	1.26001E-19	5.23263E+08	4.39765E-11	0.	0.	8.22311E+21	1.00001E+01
10	2.91044E+13	-3.08167E-01	1.26001E-19	5.23263E+08	4.39765E-11	0.	0.	1.34190E+22	1.00001E+01
11	3.39734E+13	-2.29901E-01	1.26001E-19	5.23263E+08	4.39765E-11	0.	0.	2.11120E+22	1.00001E+01
12	3.92023E+13	-1.76849E-01	1.26001E-19	5.23263E+08	4.39765E-11	0.	0.	3.22050E+22	1.00001E+01
13	4.48012E+13	-1.40101E-01	1.26001E-19	5.23263E+08	4.39765E-11	0.	0.	4.78677E+22	1.00001E+01
14	5.08021E+13	-1.14127E-01	1.26001E-19	5.23263E+08	4.39765E-11	0.	0.	6.96074E+22	1.00001E+01
15	5.72337E+13	-9.55745E-02	1.26001E-19	5.23263E+08	4.39765E-11	0.	0.	9.93579E+22	1.00001E+01
16	6.41271E+13	-8.22936E-02	1.26001E-19	5.23263E+08	4.39765E-11	0.	0.	1.39591E+23	1.00001E+01
17	7.15153E+13	-7.26607E-02	1.26001E-19	5.23263E+08	4.39765E-11	0.	0.	1.93453E+23	1.00001E+01
18	7.94340E+13	-6.63097E-02	1.26001E-19	5.23263E+08	4.39765E-11	0.	0.	2.64942E+23	1.00001E+01
19	8.79211E+13	-6.19698E-02	1.26001E-19	5.23263E+08	4.39766E-11	0.	0.	3.59116E+23	1.00001E+01
20	9.70174E+13	-5.93077E-02	1.26001E-19	5.23263E+08	4.39766E-11	0.	0.	4.82369E+23	1.00001E+01
21	1.06767E+14	-5.81542E-02	1.26001E-19	5.23263E+08	4.39766E-11	0.	0.	6.42759E+23	1.00001E+01
22	1.17216E+14	-5.81145E-02	1.26001E-19	5.23263E+08	4.39766E-11	0.	0.	8.50421E+23	1.00001E+01
23	1.28416E+14	-5.90434E-02	1.26001E-19	5.23263E+08	4.39766E-11	0.	0.	1.11809E+24	1.00001E+01
24	1.40419E+14	-6.08125E-02	1.26001E-19	5.23263E+08	4.39766E-11	0.	0.	1.46171E+24	1.00001E+01
25	1.53284E+14	-6.33373E-02	1.26001E-19	5.23263E+08	4.39766E-11	0.	0.	1.90129E+24	1.00001E+01
26	1.67073E+14	-6.65490E-02	1.26001E-19	5.23263E+08	4.39766E-11	0.	0.	2.46180E+24	1.00001E+01
27	1.81351E+14	-7.04013E-02	1.26001E-19	5.23263E+08	4.39766E-11	0.	0.	3.17446E+24	1.00001E+01
28	1.97691E+14	-7.48653E-02	1.26001E-19	5.23263E+08	4.39766E-11	0.	0.	4.07819E+24	1.00001E+01
29	2.14068E+14	-7.79244E-02	1.26001E-19	5.23263E+08	4.39766E-11	0.	0.	5.22152E+24	1.00001E+01
30	2.32863E+14	-8.55729E-02	1.26001E-19	5.23263E+08	4.39766E-11	0.	0.	6.66487E+24	1.00001E+01
31	2.52365E+14	-9.18133E-02	1.26001E-19	5.23263E+08	4.39766E-11	0.	0.	8.48339E+24	1.00001E+01
32	2.73266E+14	-9.86574E-02	1.26001E-19	5.23263E+08	4.39766E-11	0.	0.	1.07705E+25	1.00001E+01
33	2.95068E+14	-1.06121E-01	1.26001E-19	5.23263E+08	4.39766E-11	0.	0.	1.36424E+25	1.00001E+01
34	3.19579E+14	-1.14226E-01	1.26001E-19	5.23263E+08	4.39765E-11	0.	0.	1.72431E+25	1.00001E+01
35	3.45412E+14	-1.23003E-01	1.26001E-19	5.23263E+08	4.39766E-11	0.	0.	2.17513E+25	1.00001E+01
36	3.72994E+14	-1.32483E-01	1.26001E-19	5.23263E+08	4.39766E-11	0.	0.	2.73889E+25	1.00001E+01
37	4.02555E+14	-1.42705E-01	1.26001E-19	5.23263E+08	4.39766E-11	0.	0.	3.44307E+25	1.00001E+01
38	4.34239E+14	-1.53712E-01	1.26001E-19	5.23263E+08	4.39766E-11	0.	0.	4.32169E+25	1.00001E+01

39	4.65197E+14	-1.65552E-01	1.26001E-19	5.23263E+08	4.39766E-11	0.	0.	5.41693E+25	1.00001E+01
40	5.04594E+14	-1.78277E-01	1.26001E-19	5.23263E+08	4.39766E-11	0.	0.	6.78094E+25	1.00001E+01
41	5.43002E+14	-1.91944E-01	1.26001E-19	5.23263E+08	4.39766E-11	0.	0.	8.47829E+25	1.00001E+01
42	5.85411E+14	-2.06615E-01	1.26001E-19	5.23263E+08	4.39766E-11	0.	0.	1.05888E+26	1.00001E+01
43	6.30221E+14	-2.22360E-01	1.26001E-19	5.23263E+08	4.39766E-11	0.	0.	1.32113E+26	1.00001E+01
44	6.78249E+14	-2.39250E-01	1.26001E-19	5.23263E+08	4.39766E-11	0.	0.	1.64677E+26	1.00001E+01
45	7.29724E+14	-2.57365E-01	1.26001E-19	5.23263E+08	4.39766E-11	0.	0.	2.05088E+26	1.00001E+01
46	7.84695E+14	-2.76772E-01	1.26001E-19	5.23263E+08	4.39766E-11	0.	0.	2.55211E+26	1.00001E+01
47	8.44026E+14	-2.97521E-01	1.26001E-19	5.23263E+08	4.39766E-11	0.	0.	3.17345E+26	1.00001E+01
48	9.07402E+14	-3.19951E-01	1.26001E-19	5.23263E+08	4.39766E-11	0.	0.	3.94334E+26	1.00001E+01
49	9.75328E+14	-3.43883E-01	1.26001E-19	5.23263E+08	4.39766E-11	0.	0.	4.89685E+26	1.00001E+01
50	1.04813E+15	-3.69543E-01	1.26001E-19	5.23263E+08	4.39766E-11	0.	0.	6.07729E+26	1.00001E+01
51	1.12616E+15	-3.97053E-01	1.26001E-19	5.23263E+08	4.39766E-11	0.	0.	7.53812E+26	1.00001E+01
52	1.20979E+15	-4.26535E-01	1.26001E-19	5.23263E+08	4.39766E-11	0.	0.	9.34530E+26	1.00001E+01
53	1.29942E+15	-4.58134E-01	1.26001E-19	5.23263E+08	4.39766E-11	0.	0.	1.15802E+27	1.00001E+01
54	1.39549E+15	-4.92002E-01	1.26001E-19	5.23263E+08	4.39766E-11	0.	0.	1.43432E+27	1.00001E+01
55	1.49846E+15	-5.28303E-01	1.26001E-19	5.23263E+08	4.39766E-11	0.	0.	1.77581E+27	1.00001E+01
56	1.60881E+15	-5.67210E-01	1.26001E-19	5.23263E+08	4.39766E-11	0.	0.	2.19777E+27	1.00001E+01
57	1.72709E+15	-6.08911E-01	1.26001E-19	5.23263E+08	4.39766E-11	0.	0.	2.71902E+27	1.00001E+01
58	1.85386E+15	-6.53605E-01	1.26001E-19	5.23263E+08	4.39766E-11	0.	0.	3.36277E+27	1.00001E+01
59	1.98974E+15	-7.01503E-01	1.26001E-19	5.23263E+08	4.39766E-11	0.	0.	4.15767E+27	1.00001E+01
60	2.13536E+15	-7.52851E-01	1.26001E-19	5.23263E+08	4.39766E-11	0.	0.	5.13899E+27	1.00001E+01
61	2.29144E+15	-8.07878E-01	1.26001E-19	5.23263E+08	4.39766E-11	0.	0.	6.35023E+27	1.00001E+01
62	2.45873E+15	-8.66857E-01	1.26001E-19	5.23263E+08	4.39766E-11	0.	0.	7.84501E+27	1.00001E+01
63	2.63802E+15	-9.30069E-01	1.26001E-19	5.23263E+08	4.39766E-11	0.	0.	9.68941E+27	1.00001E+01
64	2.83018E+15	-9.97819E-01	1.26001E-19	5.23263E+08	4.39766E-11	0.	0.	1.19649E+28	1.00001E+01
65	3.03514E+15	-1.07043E+00	1.26001E-19	5.23263E+08	4.39766E-11	0.	0.	1.47717E+28	1.00001E+01
66	3.25589E+15	-1.14826E+00	1.26001E-19	5.23263E+08	4.39766E-11	0.	0.	1.82336E+28	1.00001E+01
67	3.49348E+15	-1.23167E+00	1.26001E-19	5.23263E+08	4.39766E-11	0.	0.	2.25029E+28	1.00001E+01
68	3.74706E+15	-1.32106E+00	1.26001E-19	5.23263E+08	4.39766E-11	0.	0.	2.77674E+28	1.00001E+01
69	4.01884E+15	-1.41690E+00	1.26001E-19	5.23263E+08	4.39766E-11	0.	0.	3.42583E+28	1.00001E+01
70	4.31013E+15	-1.51960E+00	1.26001E-19	5.23263E+08	4.39766E-11	0.	0.	4.22606E+28	1.00001E+01
71	4.62234E+15	-1.62957E+00	1.26001E-19	5.23263E+08	4.39766E-11	0.	0.	5.21253E+28	1.00001E+01
72	4.95695E+15	-1.74704E+00	1.26001E-19	5.23263E+08	4.39766E-11	0.	0.	6.42848E+28	1.00001E+01
73	5.31559E+15	-1.87408E+00	1.26001E-19	5.23263E+08	4.39766E-11	0.	0.	7.92718E+28	1.00001E+01
74	5.69998E+15	-2.00963E+00	1.26001E-19	5.23263E+08	4.39766E-11	0.	0.	9.77424E+28	1.00001E+01
75	6.11196E+15	-2.15485E+00	1.26001E-19	5.23263E+08	4.39766E-11	0.	0.	1.20505E+29	1.00001E+01
76	6.55351E+15	-2.31053E+00	1.26001E-19	5.23263E+08	4.39766E-11	0.	0.	1.48554E+29	1.00001E+01
77	7.02676E+15	-2.47738E+00	1.26001E-19	5.23263E+08	4.39766E-11	0.	0.	1.83117E+29	1.00001E+01
78	7.53399E+15	-2.65621E+00	1.26001E-19	5.23263E+08	4.39766E-11	0.	0.	2.25704E+29	1.00001E+01
79	8.07763E+15	-2.84785E+00	1.26001E-19	5.23263E+08	4.39766E-11	0.	0.	2.78174E+29	1.00001E+01
80	8.66030E+15	-3.05331E+00	1.26001E-19	5.23263E+08	4.39766E-11	0.	0.	3.42817E+29	1.00001E+01
81	9.28480E+15	-3.27348E+00	1.26001E-19	5.23263E+08	4.39766E-11	0.	0.	4.22455E+29	1.00001E+01
82	9.95413E+15	-3.50946E+00	1.26001E-19	5.23263E+08	4.39766E-11	0.	0.	5.20563E+29	1.00001E+01
83	1.06715E+16	-3.76233E+00	1.26001E-19	5.23263E+08	4.39766E-11	0.	0.	6.41417E+29	1.00001E+01
84	1.14404E+16	-4.03346E+00	1.26001E-19	5.23263E+08	4.39766E-11	0.	0.	7.90288E+29	1.00001E+01
85	1.22645E+16	-4.32400E+00	1.26001E-19	5.23263E+08	4.39766E-11	0.	0.	9.73664E+29	1.00001E+01
86	1.31477E+16	-4.63540E+00	1.26001E-19	5.23263E+08	4.39766E-11	0.	0.	1.19953E+30	1.00001E+01
87	1.40943E+16	-4.96915E+00	1.26001E-19	5.23263E+08	4.39766E-11	0.	0.	1.47774E+30	1.00001E+01
88	1.51089E+16	-5.32686E+00	1.26001E-19	5.23263E+08	4.39766E-11	0.	0.	1.82039E+30	1.00001E+01
89	1.61964E+16	-5.71025E+00	1.26001E-19	5.23263E+08	4.39766E-11	0.	0.	2.24242E+30	1.00001E+01
90	1.73619E+16	-6.12115E+00	1.26001E-19	5.23263E+08	4.39766E-11	0.	0.	2.76219E+30	1.00001E+01
91	1.86110E+16	-6.56158E+00	1.26001E-19	5.23263E+08	4.39766E-11	0.	0.	3.40233E+30	1.00001E+01
92	1.99499E+16	-7.03361E+00	1.26001E-19	5.23263E+08	4.39766E-11	0.	0.	4.19069E+30	1.00001E+01
93	2.13849E+16	-7.53952E+00	1.26001E-19	5.23263E+08	4.39766E-11	0.	0.	5.16159E+30	1.00001E+01
94	2.29228E+16	-8.08176E+00	1.26001E-19	5.23263E+08	4.39766E-11	0.	0.	6.35725E+30	1.00001E+01
95	2.45712E+16	-8.66292E+00	1.26001E-19	5.23263E+08	4.39766E-11	0.	0.	7.82969E+30	1.00001E+01
96	2.63380E+16	-9.28580E+00	1.26001E-19	5.23263E+08	4.39766E-11	0.	0.	9.64295E+30	1.00001E+01
97	2.82315E+16	-9.95346E+00	1.26001E-19	5.23263E+08	4.39766E-11	0.	0.	1.18759E+31	1.00001E+01
98	3.02610E+16	-1.06689E+01	1.26001E-19	5.23263E+08	4.39766E-11	0.	0.	1.46256E+31	1.00001E+01
99	3.24362E+16	-1.14358E+01	1.26001E-19	5.23263E+08	4.39766E-11	0.	0.	1.80116E+31	1.00001E+01
100	3.47675E+16	-1.22573E+01	1.26001E-19	5.23263E+08	4.39766E-11	0.	0.	2.21812E+31	1.00001E+01
101	3.72662E+16	-1.31387E+01	1.26001E-19	5.23263E+08	4.39766E-11	0.	0.	2.73155E+31	1.00001E+01

102	3.99443E+16	-1.40329E+01	1.26001E-19	5.23263E+08	4.39766E-11	0.	0.	3.36379E+31	1.00001E+01
103	4.28146E+16	-1.50949E+01	1.26001E-19	5.23263E+08	4.39766E-11	0.	0.	4.14229E+31	1.00001E+01
104	4.58910E+16	-1.61795E+01	1.26001E-19	5.23263E+08	4.39766E-11	0.	0.	5.10091E+31	1.00001E+01
105	4.91883E+16	-1.73420E+01	1.26001E-19	5.23263E+08	4.39766E-11	0.	0.	6.28129E+31	1.00001E+01
106	5.27222E+16	-1.85879E+01	1.26001E-19	5.23263E+08	4.39766E-11	0.	0.	7.73473E+31	1.00001E+01
107	5.65039E+16	-1.99233E+01	1.26001E-19	5.23263E+08	4.39766E-11	0.	0.	9.52439E+31	1.00001E+01
108	6.05694E+16	-2.13545E+01	1.26001E-19	5.23263E+08	4.39766E-11	0.	0.	1.17280E+32	1.00001E+01
109	6.49204E+16	-2.28885E+01	1.26001E-19	5.23263E+08	4.39766E-11	0.	0.	1.44414E+32	1.00001E+01
110	6.95838E+16	-2.45327E+01	1.26001E-19	5.23263E+08	4.39766E-11	0.	0.	1.77823E+32	1.00001E+01
111	7.45819E+16	-2.62949E+01	1.26001E-19	5.23263E+08	4.39766E-11	0.	0.	2.18960E+32	1.00001E+01
112	7.99388E+16	-2.81835E+01	1.26001E-19	5.23263E+08	4.39766E-11	0.	0.	2.69611E+32	1.00001E+01
113	8.56803E+16	-3.02075E+01	1.26001E-19	5.23263E+08	4.39766E-11	0.	0.	3.31976E+32	1.00001E+01
114	9.18340E+16	-3.23773E+01	1.26001E-19	5.23263E+08	4.39766E-11	0.	0.	4.08765E+32	1.00001E+01
115	9.84294E+16	-3.47026E+01	1.26001E-19	5.23263E+08	4.39766E-11	0.	0.	5.03314E+32	1.00001E+01
116	1.05493E+17	-3.71949E+01	1.26001E-19	5.23263E+08	4.39766E-11	0.	0.	6.19727E+32	1.00001E+01
117	1.13075E+17	-3.98660E+01	1.26001E-19	5.23263E+08	4.39766E-11	0.	0.	7.63063E+32	1.00001E+01
118	1.21195E+17	-4.27239E+01	1.26001E-19	5.23263E+08	4.39766E-11	0.	0.	9.39546E+32	1.00001E+01
119	1.29898E+17	-4.57974E+01	1.26001E-19	5.23263E+08	4.39766E-11	0.	0.	1.15684E+33	1.00001E+01
120	1.38601E+17	-4.88658E+01	1.26001E-19	5.23263E+08	4.39766E-11	0.	0.	1.40529E+33	1.00001E+01
121	1.47305E+17	-5.18879E+01	1.25993E-19	5.23240E+08	4.39717E-11	0.	0.	1.68699E+33	9.99964E+00
122	1.56008E+17	0.	1.25993E-19	5.23260E+08	4.39717E-11	0.	0.	2.00401E+33	1.00000E+01

DT =	6.93595150E+09	T =	3.56029979E+10	5	1.26021E-19	-4.96740E-01	1.00000E+01
DT =	1.00000000E+10	T =	8.08567973E+10	10	1.26037E-19	-1.43313E-01	1.00000E+01
DT =	1.00000000E+10	T =	1.30856797E+11	15	1.26105E-19	-2.44042E-01	1.00000E+01
DT =	1.00000000E+10	T =	1.80856797E+11	20	1.26205E-19	-3.45041E-01	1.00001E+01
DT =	1.00000000E+10	T =	2.30856797E+11	25	1.26339E-19	-4.46353E-01	1.00000E+01
DT =	1.00000000E+10	T =	2.80856797E+11	30	1.26508E-19	-5.47830E-01	1.00001E+01
DT =	1.00000000E+10	T =	3.30856797E+11	35	1.26710E-19	-6.49583E-01	1.00000E+01
DT =	1.00000000E+10	T =	3.80856797E+11	40	1.26946E-19	-7.51577E-01	1.00001E+01
DT =	1.00000000E+10	T =	4.30856797E+11	45	1.27217E-19	-8.54008E-01	1.00001E+01
DT =	1.00000000E+10	T =	4.80856797E+11	50	1.27522E-19	-9.56817E-01	1.00001E+01
DT =	1.00000000E+10	T =	5.30856797E+11	55	1.27863E-19	-1.06002E+00	1.00001E+01
DT =	1.00000000E+10	T =	5.80856797E+11	60	1.28240E-19	-1.16378E+00	1.00001E+01
DT =	1.00000000E+10	T =	6.30856797E+11	65	1.28653E-19	-1.26804E+00	1.00001E+01
DT =	1.00000000E+10	T =	6.80856797E+11	70	1.29103E-19	-1.37300E+00	1.00001E+01
DT =	1.00000000E+10	T =	7.30856797E+11	75	1.29589E-19	-1.47856E+00	1.00001E+01
DT =	1.00000000E+10	T =	7.80856797E+11	80	1.30114E-19	-1.58486E+00	1.00001E+01
DT =	1.00000000E+10	T =	8.30856797E+11	85	1.30678E-19	-1.69192E+00	1.00001E+01
DT =	1.00000000E+10	T =	8.80856797E+11	90	1.31281E-19	-1.79980E+00	1.00001E+01
DT =	1.00000000E+10	T =	9.30856797E+11	95	1.31924E-19	-1.90857E+00	1.00001E+01
DT =	1.00000000E+10	T =	9.80856797E+11	100	1.32609E-19	-2.01827E+00	1.00001E+01
DT =	1.00000000E+10	T =	1.03085680E+12	105	1.33335E-19	-2.12898E+00	1.00001E+01
DT =	1.00000000E+10	T =	1.08085680E+12	110	1.34105E-19	-2.24076E+00	1.00001E+01
DT =	1.00000000E+10	T =	1.13085680E+12	115	1.34919E-19	-2.35368E+00	1.00001E+01
DT =	1.00000000E+10	T =	1.18085680E+12	120	1.35778E-19	-2.46777E+00	1.00001E+01
DT =	1.00000000E+10	T =	1.23085680E+12	125	1.36684E-19	-2.58317E+00	1.00001E+01
DT =	1.00000000E+10	T =	1.28085680E+12	130	1.37538E-19	-2.69986E+00	1.00001E+01
DT =	1.00000000E+10	T =	1.33085680E+12	135	1.38641E-19	-2.81799E+00	1.00001E+01
DT =	1.00000000E+10	T =	1.38085680E+12	140	1.39695E-19	-2.93760E+00	1.00001E+01
DT =	1.00000000E+10	T =	1.43085680E+12	145	1.40802E-19	-3.05876E+00	1.00001E+01
DT =	1.00000000E+10	T =	1.48085680E+12	150	1.41963E-19	-3.18159E+00	1.00001E+01
DT =	1.00000000E+10	T =	1.53085680E+12	155	1.43179E-19	-3.30612E+00	1.00001E+01
DT =	1.00000000E+10	T =	1.58085680E+12	160	1.44454E-19	-3.43248E+00	1.00001E+01
DT =	1.00000000E+10	T =	1.63085680E+12	165	1.45789E-19	-3.56074E+00	1.00001E+01
DT =	1.00000000E+10	T =	1.68085680E+12	170	1.47187E-19	-3.69103E+00	1.00001E+01
DT =	1.00000000E+10	T =	1.73085680E+12	175	1.48648E-19	-3.82339E+00	1.00001E+01
DT =	1.00000000E+10	T =	1.78085680E+12	180	1.50177E-19	-3.95796E+00	1.00001E+01
DT =	1.00000000E+10	T =	1.83085680E+12	185	1.51776E-19	-4.09485E+00	1.00001E+01
DT =	1.00000000E+10	T =	1.88085680E+12	190	1.53448E-19	-4.23415E+00	1.00001E+01
DT =	1.00000000E+10	T =	1.93085680E+12	195	1.55195E-19	-4.37602E+00	1.00001E+01
DT =	1.00000000E+10	T =	1.98085680E+12	200	1.57021E-19	-4.52054E+00	1.00001E+01
DT =	1.00000000E+10	T =	2.03085680E+12	205	1.58930E-19	-4.66786E+00	1.00001E+01
DT =	1.00000000E+10	T =	2.08085680E+12	210	1.60925E-19	-4.81811E+00	1.00001E+01

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DT =   1.00000000E+10   T =   2.13085680E+12   215   1.63009E-19 -4.97146E+00   1.00001E+01
DT =   1.00000000E+10   T =   2.18085680E+12   220   1.65188E-19 -5.12801E+00   1.00001E+01
DT =   1.00000000E+10   T =   2.23085680E+12   225   1.67466E-19 -5.28795E+00   1.00001E+01
DT =   1.00000000E+10   T =   2.28085680E+12   230   1.69847E-19 -5.45145E+00   1.00001E+01
DT =   1.00000000E+10   T =   2.33085680E+12   235   1.72337E-19 -5.61867E+00   1.00001E+01
DT =   1.00000000E+10   T =   2.38085680E+12   240   1.74941E-19 -5.78931E+00   1.00001E+01
DT =   1.00000000E+10   T =   2.43085680E+12   245   1.77666E-19 -5.96506E+00   1.00002E+01
DT =   1.00000000E+10   T =   2.48085680E+12   250   1.80517E-19 -6.14463E+00   1.00002E+01
DT =   1.00000000E+10   T =   2.53085680E+12   255   1.83501E-19 -6.32875E+00   1.00002E+01
DT =   1.00000000E+10   T =   2.58085680E+12   260   1.86627E-19 -6.51763E+00   1.00002E+01
DT =   1.00000000E+10   T =   2.63085680E+12   265   1.89901E-19 -6.71154E+00   1.00002E+01
DT =   1.00000000E+10   T =   2.68085680E+12   270   1.93333E-19 -6.91074E+00   1.00002E+01
DT =   1.00000000E+10   T =   2.73085680E+12   275   1.96931E-19 -7.11550E+00   1.00002E+01
DT =   1.00000000E+10   T =   2.78085680E+12   280   2.00705E-19 -7.32612E+00   1.00002E+01
DT =   1.00000000E+10   T =   2.83085680E+12   285   2.04667E-19 -7.54293E+00   1.00002E+01
DT =   1.00000000E+10   T =   2.88085680E+12   290   2.08828E-19 -7.76628E+00   1.00002E+01
DT =   1.00000000E+10   T =   2.93085680E+12   295   2.13201E-19 -7.99651E+00   1.00002E+01
DT =   1.00000000E+10   T =   2.98085680E+12   300   2.17799E-19 -8.23400E+00   1.00002E+01
DT =   1.00000000E+10   T =   3.03085680E+12   305   2.22638E-19 -8.47921E+00   1.00002E+01
DT =   1.00000000E+10   T =   3.08085680E+12   310   2.27734E-19 -8.73256E+00   1.00002E+01
DT =   1.00000000E+10   T =   3.13085680E+12   315   2.33104E-19 -8.99453E+00   1.00002E+01
DT =   1.00000000E+10   T =   3.18085680E+12   320   2.38769E-19 -9.26564E+00   1.00002E+01
DT =   1.00000000E+10   T =   3.23085680E+12   325   2.44748E-19 -9.54645E+00   1.00002E+01
DT =   1.00000000E+10   T =   3.28085680E+12   330   2.51067E-19 -9.83756E+00   1.00002E+01
DT =   1.00000000E+10   T =   3.33085680E+12   335   2.57750E-19 -1.01396E+01   1.00002E+01
DT =   1.00000000E+10   T =   3.38085680E+12   340   2.64825E-19 -1.04534E+01   1.00002E+01
DT =   1.00000000E+10   T =   3.43085680E+12   345   2.72324E-19 -1.07795E+01   1.00002E+01
DT =   1.00000000E+10   T =   3.48085680E+12   350   2.80280E-19 -1.11189E+01   1.00002E+01
DT =   1.00000000E+10   T =   3.53085680E+12   355   2.88733E-19 -1.14725E+01   1.00002E+01
DT =   1.00000000E+10   T =   3.58085680E+12   360   2.97724E-19 -1.18412E+01   1.00002E+01
DT =   1.00000000E+10   T =   3.63085680E+12   365   3.07299E-19 -1.22261E+01   1.00003E+01
DT =   1.00000000E+10   T =   3.68085680E+12   370   3.17512E-19 -1.26284E+01   1.00003E+01
DT =   1.00000000E+10   T =   3.73085680E+12   375   3.28420E-19 -1.30494E+01   1.00003E+01
DT =   1.00000000E+10   T =   3.78085680E+12   380   3.40089E-19 -1.34905E+01   1.00003E+01
DT =   1.00000000E+10   T =   3.83085680E+12   385   3.52593E-19 -1.39532E+01   1.00003E+01
DT =   1.00000000E+10   T =   3.88085680E+12   390   3.66014E-19 -1.44394E+01   1.00003E+01
DT =   1.00000000E+10   T =   3.93085680E+12   395   3.80446E-19 -1.49508E+01   1.00003E+01
DT =   1.00000000E+10   T =   3.98085680E+12   400   3.95995E-19 -1.54896E+01   1.00003E+01
DT =   1.00000000E+10   T =   4.03085680E+12   405   4.12782E-19 -1.60580E+01   1.00003E+01
DT =   1.00000000E+10   T =   4.08085680E+12   410   4.30946E-19 -1.66587E+01   1.00003E+01
DT =   1.00000000E+10   T =   4.13085680E+12   415   4.50643E-19 -1.72943E+01   1.00003E+01
DT =   1.00000000E+10   T =   4.18085680E+12   420   4.72055E-19 -1.79678E+01   1.00003E+01
DT =   1.00000000E+10   T =   4.23085680E+12   425   4.95392E-19 -1.86824E+01   1.00004E+01
DT =   1.00000000E+10   T =   4.28085680E+12   430   5.20895E-19 -1.94414E+01   1.00004E+01
DT =   1.00000000E+10   T =   4.33085680E+12   435   5.48845E-19 -2.02478E+01   1.00004E+01
DT =   1.00000000E+10   T =   4.38085680E+12   440   5.79567E-19 -2.11046E+01   1.00004E+01
DT =   1.00000000E+10   T =   4.43085680E+12   445   6.13437E-19 -2.20140E+01   1.00004E+01
DT =   1.00000000E+10   T =   4.48085680E+12   450   6.50896E-19 -2.29768E+01   1.00004E+01
DT =   1.00000000E+10   T =   4.53085680E+12   455   6.92448E-19 -2.39916E+01   1.00004E+01
DT =   1.00000000E+10   T =   4.58085680E+12   460   7.38675E-19 -2.50537E+01   1.00005E+01
DT =   1.00000000E+10   T =   4.63085680E+12   465   7.90241E-19 -2.61534E+01   1.00005E+01
DT =   1.00000000E+10   T =   4.68085680E+12   470   8.47886E-19 -2.72745E+01   1.00005E+01
DT =   1.00000000E+10   T =   4.73085680E+12   475   9.12421E-19 -2.83919E+01   1.00005E+01
DT =   1.00000000E+10   T =   4.78085680E+12   480   9.84705E-19 -2.94730E+01   1.00005E+01
DT =   1.00000000E+10   T =   4.83085680E+12   485   1.06560E-18 -3.04622E+01   1.00005E+01
DT =   1.00000000E+10   T =   4.88085680E+12   490   1.15591E-18 -3.13107E+01   1.00006E+01
DT =   1.00000000E+10   T =   4.93085680E+12   495   1.25627E-18 -3.19505E+01   1.00006E+01
DT =   1.00000000E+10   T =   4.98085680E+12   500   1.36707E-18 -3.23148E+01   1.00006E+01
INTERNAL ENERGY = 1.048831E+42 TOTAL ENERGY = 1.113411E+42 MASS = 2.004007E+33 MOMENTUM =-2.915586E+37 CYCLE =     500
  J      X             U              RHO          EI           P            CND          L             MR           T
  2  0.            0.             1.39050E-18  5.23292E+08  4.85334E-10  3.56039E+14  0.            0.           1.00006E+01
  3  3.00000E+12  -1.70295E+03   1.39050E-18  5.23292E+08  4.85334E-10  3.56038E+14  9.24645E+16   1.57261E+20  1.00006E+01
  4  6.00000E+12  -3.39965E+03   1.39050E-18  5.23292E+08  4.85334E-10  3.56037E+14  7.39694E+17   1.25809E+21  1.00006E+01
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5	9.21537E+12	-5.21724E+00	1.39053E-18	5.23292E+03	4.85334E-10	3.56037E+14	2.57997E+18	4.55323E+21	1.00006E+01
6	1.25015E+13	-7.15475E+00	1.39052E-18	5.23292E+03	4.85333E-10	3.56036E+14	6.75104E+18	1.15228E+22	1.00006E+01
7	1.63552E+13	-7.28137E+00	1.39050E-18	5.23292E+03	4.85333E-10	3.56036E+14	1.49813E+19	2.54813E+22	1.00006E+01
8	2.03139E+13	-2.14387E+01	1.39050E-18	5.23292E+03	4.85333E-10	3.56035E+14	2.37054E+19	4.88245E+22	1.00006E+01
9	2.45535E+13	-1.38501E+01	1.39050E-18	5.23292E+03	4.85333E-10	3.56034E+14	5.07103E+19	8.62534E+22	1.00006E+01
10	2.91044E+13	-1.54355E+01	1.39050E-18	5.23292E+03	4.85333E-10	3.56033E+14	8.44223E+19	1.43593E+23	1.00006E+01
11	3.39784E+13	-1.92097E+01	1.39049E-18	5.23292E+03	4.85333E-10	3.56033E+14	1.34335E+20	2.28490E+23	1.00006E+01
12	3.92023E+13	-2.21811E+01	1.39049E-18	5.23292E+03	4.85333E-10	3.56032E+14	2.06307E+20	3.50907E+23	1.00006E+01
13	4.48012E+13	-2.53245E+01	1.39049E-18	5.23292E+03	4.85332E-10	3.56031E+14	3.07927E+20	5.23754E+23	1.00006E+01
14	5.06021E+13	-2.87122E+01	1.39049E-18	5.23292E+03	4.85332E-10	3.56030E+14	4.48975E+20	7.63664E+23	1.00006E+01
15	5.72337E+13	-3.23491E+01	1.39049E-18	5.23292E+03	4.85332E-10	3.56029E+14	6.41998E+20	1.09198E+24	1.00006E+01
16	6.41271E+13	-3.62439E+01	1.39049E-18	5.23292E+03	4.85331E-10	3.56028E+14	9.03028E+20	1.53597E+24	1.00006E+01
17	7.15153E+13	-4.04183E+01	1.39049E-18	5.23292E+03	4.85331E-10	3.56026E+14	1.25249E+21	2.13037E+24	1.00006E+01
18	7.94430E+13	-4.48972E+01	1.39049E-18	5.23292E+03	4.85330E-10	3.56025E+14	1.71630E+21	2.91928E+24	1.00006E+01
19	8.79211E+13	-4.96937E+01	1.39048E-18	5.23292E+03	4.85329E-10	3.56024E+14	2.32730E+21	3.95854E+24	1.00006E+01
20	9.70174E+13	-5.48270E+01	1.39048E-18	5.23292E+03	4.85329E-10	3.56023E+14	3.12695E+21	5.31870E+24	1.00006E+01
21	1.06707E+14	-6.03354E+01	1.39048E-18	5.23292E+03	4.85328E-10	3.56021E+14	4.16754E+21	7.08867E+24	1.00006E+01
22	1.17215E+14	-6.62391E+01	1.39048E-18	5.23292E+03	4.85325E-10	3.56019E+14	5.51482E+21	9.38031E+24	1.00006E+01
23	1.28416E+14	-7.25553E+01	1.39047E-18	5.23292E+03	4.85325E-10	3.56013E+14	7.25137E+21	1.23341E+25	1.00006E+01
24	1.40419E+14	-7.93433E+01	1.39047E-18	5.23292E+03	4.85323E-10	3.56016E+14	9.43073E+21	1.61262E+25	1.00006E+01
25	1.53284E+14	-8.66153E+01	1.39045E-18	5.23292E+03	4.85321E-10	3.56014E+14	1.23326E+22	2.09770E+25	1.00006E+01
26	1.67073E+14	-9.44257E+01	1.39045E-18	5.23292E+03	4.85319E-10	3.56012E+14	1.59689E+22	2.71625E+25	1.00006E+01
27	1.81851E+14	-1.02755E+02	1.39045E-18	5.23292E+03	4.85316E-10	3.56010E+14	2.05923E+22	3.50266E+25	1.00006E+01
28	1.97691E+14	-1.11705E+02	1.39044E-18	5.23292E+03	4.85313E-10	3.56008E+14	2.64552E+22	4.49997E+25	1.00006E+01
29	2.14658E+14	-1.21295E+02	1.39043E-18	5.23292E+03	4.85310E-10	3.56006E+14	3.38723E+22	5.76164E+25	1.00006E+01
30	2.32853E+14	-1.31574E+02	1.39042E-18	5.23292E+03	4.85306E-10	3.56004E+14	4.32355E+22	7.35438E+25	1.00006E+01
31	2.52365E+14	-1.42591E+02	1.39040E-18	5.23292E+03	4.85301E-10	3.56002E+14	5.50322E+22	9.36111E+25	1.00006E+01
32	2.73206E+14	-1.54398E+02	1.39039E-18	5.23292E+03	4.85295E-10	3.55999E+14	6.98685E+22	1.18849E+26	1.00006E+01
33	2.95606E+14	-1.57052E+02	1.39037E-18	5.23292E+03	4.85289E-10	3.55997E+14	8.64970E+22	1.50539E+26	1.00006E+01
34	3.19679E+14	-1.80514E+02	1.39035E-18	5.23292E+03	4.85281E-10	3.55994E+14	1.11852E+23	1.90271E+26	1.00006E+01
35	3.45412E+14	-1.95148E+02	1.39032E-18	5.23292E+03	4.85273E-10	3.55991E+14	1.41093E+23	2.40017E+26	1.00006E+01
36	3.72994E+14	-2.10725E+02	1.39029E-18	5.23292E+03	4.85263E-10	3.55989E+14	1.77657E+23	3.02223E+26	1.00006E+01
37	4.02555E+14	-2.27420E+02	1.39025E-18	5.23292E+03	4.85251E-10	3.55986E+14	2.23325E+23	3.79921E+26	1.00006E+01
38	4.34234E+14	-2.45311E+02	1.39022E-18	5.23292E+03	4.85238E-10	3.55984E+14	2.80303E+23	4.76866E+26	1.00006E+01
39	4.68197E+14	-2.64485E+02	1.39017E-18	5.23292E+03	4.85222E-10	3.55981E+14	3.51322E+23	5.97707E+26	1.00006E+01
40	5.04593E+14	-2.85033E+02	1.39012E-18	5.23292E+03	4.85204E-10	3.55979E+14	4.39761E+23	7.48199E+26	1.00006E+01
41	5.43602E+14	-3.07053E+02	1.39004E-18	5.23292E+03	4.85184E-10	3.55976E+14	5.49802E+23	9.35451E+26	1.00006E+01
42	5.85411E+14	-3.30561E+02	1.38999E-18	5.23292E+03	4.85160E-10	3.55974E+14	6.86613E+23	1.16830E+27	1.00006E+01
43	6.30221E+14	-3.55933E+02	1.38991E-18	5.23292E+03	4.85135E-10	3.55972E+14	8.56584E+23	1.45759E+27	1.00006E+01
44	6.78249E+14	-3.83035E+02	1.38982E-18	5.23292E+03	4.85101E-10	3.55971E+14	1.06761E+24	1.81681E+27	1.00006E+01
45	7.29724E+14	-4.12072E+02	1.38972E-18	5.23292E+03	4.85055E-10	3.55970E+14	1.32944E+24	2.26255E+27	1.00006E+01
46	7.84895E+14	-4.43135E+02	1.38959E-18	5.23292E+03	4.85023E-10	3.55970E+14	1.65412E+24	2.81537E+27	1.00006E+01
47	8.44026E+14	-4.76621E+02	1.38945E-18	5.23292E+03	4.84974E-10	3.55970E+14	2.05651E+24	3.50062E+27	1.00006E+01
48	9.07402E+14	-5.12237E+02	1.38929E-18	5.23292E+03	4.84919E-10	3.55971E+14	2.55495E+24	4.34959E+27	1.00006E+01
49	9.75328E+14	-5.50505E+02	1.38911E-18	5.23292E+03	4.84855E-10	3.55973E+14	3.17207E+24	5.40094E+27	1.00006E+01
50	1.04813E+15	-5.91505E+02	1.38889E-18	5.23292E+03	4.84781E-10	3.55977E+14	3.93578E+24	6.70232E+27	1.00006E+01
51	1.12615E+15	-6.35541E+02	1.38865E-18	5.23292E+03	4.84696E-10	3.55982E+14	4.88047E+24	8.31257E+27	1.00006E+01
52	1.20979E+15	-6.82454E+02	1.38835E-18	5.23292E+03	4.84598E-10	3.55989E+14	6.04854E+24	1.03042E+28	1.00006E+01
53	1.29942E+15	-7.32834E+02	1.38804E-18	5.23292E+03	4.84486E-10	3.55998E+14	7.49224E+24	1.27668E+28	1.00006E+01
54	1.39549E+15	-7.86774E+02	1.38765E-18	5.23292E+03	4.84356E-10	3.56009E+14	9.27589E+24	1.58105E+28	1.00006E+01
55	1.49845E+15	-8.44555E+02	1.38723E-18	5.23292E+03	4.84208E-10	3.56024E+14	1.14787E+25	1.95714E+28	1.00006E+01
56	1.60881E+15	-9.06421E+02	1.38675E-18	5.23292E+03	4.84037E-10	3.56042E+14	1.41981E+25	2.42170E+28	1.00006E+01
57	1.72709E+15	-9.72552E+02	1.38615E-18	5.23292E+03	4.83841E-10	3.56065E+14	1.75541E+25	2.99537E+28	1.00006E+01
58	1.85385E+15	-1.04391E+03	1.38551E-18	5.23292E+03	4.83615E-10	3.56092E+14	2.16940E+25	3.70358E+28	1.00006E+01
59	1.98974E+15	-1.11935E+03	1.38476E-18	5.23292E+03	4.83356E-10	3.56125E+14	2.67989E+25	4.57764E+28	1.00006E+01
60	2.13530E+15	-1.20049E+03	1.38398E-18	5.23292E+03	4.83053E-10	3.56165E+14	3.30915E+25	5.65011E+28	1.00006E+01
61	2.29144E+15	-1.28725E+03	1.38290E-18	5.23292E+03	4.82717E-10	3.56213E+14	4.08447E+25	6.98546E+28	1.00006E+01
62	2.45873E+15	-1.38034E+03	1.38175E-18	5.23291E+03	4.82321E-10	3.56270E+14	5.03933E+25	8.62701E+28	1.00006E+01
63	2.63932E+15	-1.47771E+03	1.38047E-18	5.23291E+03	4.81575E-10	3.56338E+14	6.21484E+25	1.06496E+29	1.00006E+01
64	2.83013E+15	-1.5[illegible]E+03	1.37935E-18	5.23291E+03	4.81359E-10	3.56418E+14	7.66120E+25	1.31420E+29	1.00006E+01
65	3.03614E+15	-1.69352E+03	1.37725E-18	5.23291E+03	4.80759E-10	3.56513E+14	9.43991E+25	1.62144E+29	1.00006E+01
66	3.25534E+15	-1.81742E+03	1.37[illegible]E-18	5.23291E+03	4.80092E-10	3.56624E+14	1.16261E+25	1.99984E+29	1.00006E+01
67	3.49345E+15	-1.94979E+03	1.37304E-18	5.23291E+03	4.79317E-10	3.55754E+14	1.43114E+25	2.46553E+29	1.00006E+01

68	3.74706E+15	-2.04525E+03	1.37047E-18	5.23291E+08	4.78431E-10	3.56930E+14	1.70076E+26	3.03950E+29	1.00006E+01
69	4.01884E+15	-2.23154E+03	1.36753E-18	5.23291E+08	4.77418E-10	3.57084E+14	2.16500E+26	3.74550E+29	1.00006E+01
70	4.31013E+15	-2.33724E+03	1.36417E-18	5.23291E+08	4.76261E-10	3.57291E+14	2.66055E+26	4.61401E+29	1.00006E+01
71	4.62234E+15	-2.55279E+03	1.36033E-18	5.23291E+08	4.74940E-10	3.57532E+14	3.26722E+26	5.68202E+29	1.00006E+01
72	4.95695E+15	-2.72862E+03	1.35598E-18	5.23291E+08	4.73434E-10	3.57812E+14	4.00927E+26	6.99480E+29	1.00006E+01
73	5.31559E+15	-2.91515E+03	1.35101E-18	5.23291E+08	4.71716E-10	3.58135E+14	4.91589E+26	8.60764E+29	1.00006E+01
74	5.69998E+15	-3.11275E+03	1.34535E-18	5.23291E+08	4.69767E-10	3.58510E+14	6.02215E+26	1.05881E+30	1.00006E+01
75	6.11196E+15	-3.32179E+03	1.33893E-18	5.23291E+08	4.67550E-10	3.58942E+14	7.37014E+26	1.30185E+30	1.00006E+01
76	6.55351E+15	-3.54252E+03	1.33165E-18	5.23291E+08	4.65035E-10	3.59441E+14	9.01011E+26	1.59992E+30	1.00006E+01
77	7.02676E+15	-3.77519E+03	1.32340E-18	5.23291E+08	4.62186E-10	3.60015E+14	1.10019E+27	1.96520E+30	1.00006E+01
78	7.53399E+15	-4.01994E+03	1.31408E-18	5.23290E+08	4.58966E-10	3.60674E+14	1.34163E+27	2.41248E+30	1.00006E+01
79	8.07763E+15	-4.27682E+03	1.30357E-18	5.23290E+08	4.55333E-10	3.61432E+14	1.63368E+27	2.95970E+30	1.00006E+01
80	8.66030E+15	-4.54577E+03	1.29175E-18	5.23290E+08	4.51243E-10	3.62301E+14	1.98614E+27	3.62848E+30	1.00006E+01
81	9.28480E+15	-4.82660E+03	1.27847E-18	5.23290E+08	4.46650E-10	3.63295E+14	2.41042E+27	4.44492E+30	1.00006E+01
82	9.95413E+15	-5.11900E+03	1.26361E-18	5.23290E+08	4.41505E-10	3.64432E+14	2.91974E+27	5.44037E+30	1.00006E+01
83	1.06715E+16	-5.42250E+03	1.24701E-18	5.23289E+08	4.35759E-10	3.65730E+14	3.52928E+27	6.55236E+30	1.00006E+01
84	1.14404E+16	-5.73645E+03	1.22855E-18	5.23289E+08	4.29364E-10	3.67210E+14	4.25634E+27	8.12571E+30	1.00006E+01
85	1.22645E+16	-6.06002E+03	1.20809E-18	5.23289E+08	4.22270E-10	3.68894E+14	5.12047E+27	9.91368E+30	1.00006E+01
86	1.31477E+16	-6.39221E+03	1.18550E-18	5.23288E+08	4.14432E-10	3.70807E+14	6.14350E+27	1.20793E+31	1.00006E+01
87	1.40943E+16	-6.73179E+03	1.16066E-18	5.23288E+08	4.05811E-10	3.72976E+14	7.34954E+27	1.46968E+31	1.00005E+01
88	1.51089E+16	-7.07733E+03	1.13348E-18	5.23288E+08	3.96372E-10	3.75429E+14	8.76488E+27	1.78532E+31	1.00005E+01
89	1.61964E+16	-7.42717E+03	1.10390E-18	5.23287E+08	3.86090E-10	3.78196E+14	1.04177E+28	2.16497E+31	1.00005E+01
90	1.73619E+16	-7.77941E+03	1.07188E-18	5.23287E+08	3.74954E-10	3.81310E+14	1.23377E+28	2.62034E+31	1.00005E+01
91	1.86110E+16	-8.13192E+03	1.03743E-18	5.23286E+08	3.62964E-10	3.84801E+14	1.45555E+28	3.16490E+31	1.00005E+01
92	1.99499E+16	-8.48231E+03	1.00061E-18	5.23285E+08	3.50138E-10	3.88704E+14	1.71018E+28	3.81399E+31	1.00005E+01
93	2.13849E+16	-8.82794E+03	9.61513E-19	5.23285E+08	3.36513E-10	3.93051E+14	2.00063E+28	4.58500E+31	1.00005E+01
94	2.29228E+16	-9.16591E+03	9.20312E-19	5.23284E+08	3.22142E-10	3.97871E+14	2.32969E+28	5.49741E+31	1.00005E+01
95	2.45712E+16	-9.49304E+03	8.77220E-19	5.23283E+08	3.07102E-10	4.03195E+14	2.69975E+28	6.57288E+31	1.00005E+01
96	2.63380E+16	-9.83591E+03	8.32507E-19	5.23282E+08	2.91486E-10	4.09047E+14	3.11270E+28	7.83527E+31	1.00004E+01
97	2.82315E+16	-1.01008E+04	7.86494E-19	5.23281E+08	2.75406E-10	4.15450E+14	3.56972E+28	9.31060E+31	1.00004E+01
98	3.02610E+16	-1.03739E+04	7.39541E-19	5.23280E+08	2.58988E-10	4.22419E+14	4.07112E+28	1.10270E+32	1.00004E+01
99	3.24362E+16	-1.06204E+04	6.92042E-19	5.23279E+08	2.42370E-10	4.29965E+14	4.61615E+28	1.30143E+32	1.00004E+01
100	3.47675E+16	-1.08375E+04	6.44409E-19	5.23278E+08	2.25698E-10	4.38088E+14	5.20288E+28	1.53044E+32	1.00004E+01
101	3.72662E+16	-1.10192E+04	5.97063E-19	5.23277E+08	2.09119E-10	4.46780E+14	5.82803E+28	1.79302E+32	1.00003E+01
102	3.99443E+16	-1.11614E+04	5.50416E-19	5.23276E+08	1.92779E-10	4.56020E+14	6.48693E+28	2.09261E+32	1.00003E+01
103	4.28146E+16	-1.12596E+04	5.04862E-19	5.23275E+08	1.76818E-10	4.65773E+14	7.17348E+28	2.43269E+32	1.00003E+01
104	4.58910E+16	-1.13091E+04	4.60764E-19	5.23274E+08	1.61362E-10	4.75987E+14	7.88020E+28	2.81679E+32	1.00003E+01
105	4.91883E+16	-1.13056E+04	4.18442E-19	5.23273E+08	1.46527E-10	4.86583E+14	8.59835E+28	3.24843E+32	1.00003E+01
106	5.27222E+16	-1.12451E+04	3.78170E-19	5.23272E+08	1.32409E-10	4.97455E+14	9.31814E+28	3.73111E+32	1.00002E+01
107	5.65099E+16	-1.11239E+04	3.40169E-19	5.23271E+08	1.19087E-10	5.08456E+14	1.00290E+29	4.26824E+32	1.00002E+01
108	6.05694E+16	-1.09389E+04	3.04603E-19	5.23270E+08	1.06018E-10	5.19385E+14	1.07198E+29	4.86316E+32	1.00002E+01
109	6.49204E+16	-1.06879E+04	2.71580E-19	5.23269E+08	9.50413E-11	5.29972E+14	1.13794E+29	5.51910E+32	1.00002E+01
110	6.95838E+16	-1.03692E+04	2.41151E-19	5.23268E+08	8.43752E-11	5.39856E+14	1.19968E+29	6.23920E+32	1.00002E+01
111	7.45819E+16	-9.99161E+03	2.13308E-19	5.23268E+08	7.46178E-11	5.48560E+14	1.25614E+29	7.02650E+32	1.00002E+01
112	7.99388E+16	-9.52375E+03	1.87992E-19	5.23267E+08	6.57474E-11	5.55473E+14	1.30627E+29	7.88398E+32	1.00001E+01
113	8.56803E+16	-8.99292E+03	1.65046E-19	5.23266E+08	5.77237E-11	5.59825E+14	1.34897E+29	8.81446E+32	1.00001E+01
114	9.18340E+16	-8.38336E+03	1.44429E-19	5.23265E+08	5.04897E-11	5.60665E+14	1.38301E+29	9.82055E+32	1.00001E+01
115	9.84294E+16	-7.68461E+03	1.25833E-19	5.23264E+08	4.39790E-11	5.56796E+14	1.40686E+29	1.09043E+33	1.00001E+01
116	1.05498E+17	-6.88192E+03	1.09114E-19	5.23264E+08	3.81269E-11	5.46560E+14	1.41876E+29	1.20669E+33	1.00001E+01
117	1.13075E+17	-5.96074E+03	9.41377E-20	5.23263E+08	3.28858E-11	5.27299E+14	1.41694E+29	1.33081E+33	1.00001E+01
118	1.21195E+17	-4.91453E+03	8.08500E-20	5.23262E+08	2.82362E-11	4.94115E+14	1.40029E+29	1.46267E+33	1.00001E+01
119	1.29893E+17	-3.73250E+03	6.94669E-20	5.23262E+08	2.42623E-11	4.39064E+14	1.36757E+29	1.60210E+33	1.00000E+01
120	1.38601E+17	-2.52663E+03	5.99123E-20	5.23261E+08	2.09391E-11	3.46242E+14	1.32346E+29	1.73911E+33	1.00000E+01
121	1.47305E+17	-1.27672E+03	5.19816E-20	5.23260E+08	1.81424E-11	3.46242E+14	1.26855E+29	1.87321E+33	1.00000E+01
122	1.56008E+17	0.	5.19816E-20	5.23260E+08	1.81424E-11	3.46242E+14	1.20534E+29	2.00401E+33	1.00000E+01

DT = 1.00000000E+10 T = 5.03085680E+12 505 1.48831E-18 -3.23444E+01 1.00006E+01
DT = 1.00000000E+10 T = 5.08085680E+12 510 1.61947E-18 -3.19981E+01 1.00007E+01
DT = 1.00000000E+10 T = 5.13085680E+12 515 1.75950E-18 -3.12620E+01 1.00007E+01
DT = 1.00000000E+10 T = 5.18085680E+12 520 1.90680E-18 -3.01547E+01 1.00007E+01
DT = 1.00000000E+10 T = 5.23085680E+12 525 2.05937E-18 -2.87269E+01 1.00007E+01
DT = 1.00000000E+10 T = 5.28085680E+12 530 2.21491E-18 -2.70540E+01 1.00008E+01
DT = 1.00000000E+10 T = 5.33085680E+12 535 2.37111E-18 -2.52254E+01 1.00008E+01
DT = 1.00000000E+10 T = 5.33085680E+12 540 2.52586E-18 -2.33319E+01 1.00008E+01

DT = 5.00138402E+06 T = 8.65047907E+12 3000 7.47005E-09 -2.61471E+05 1.56723E+03

INTERNAL ENERGY = 3.185007E+42 TOTAL ENERGY = 3.577505E+42 MASS = 2.004007E+33 MOMENTUM =-6.096601E+37 CYCLE = 3000

J	X	U	RHO	EI	P	CND	L	MR	T
2	0.	0.	7.47700E-09	8.20419E+10	4.09339E+02	1.19731E+15	0.	0.	1.56790E+03
3	3.00000E+12	-2.60557E+02	6.33634E-09	7.54902E+10	2.68889E+02	1.08281E+15	5.10860E+30	8.45629E+29	1.44269E+03
4	6.00000E+12	-5.46796E+02	3.28325E-09	6.57309E+10	1.44111E+02	1.14886E+15	3.11820E+31	5.07031E+30	1.25618E+03
5	9.21537E+12	-9.18405E+02	1.75555E-09	5.43794E+10	6.37837E+01	1.20899E+15	8.40181E+31	1.28626E+31	1.03924E+03
6	1.26616E+13	-1.41812E+03	8.36906E-10	4.32133E+10	2.41812E+01	1.26022E+15	1.51744E+32	2.20344E+31	8.25849E+02
7	1.63552E+13	-2.14356E+03	3.63142E-10	3.33074E+10	8.09659E+00	1.31159E+15	2.18112E+32	3.02551E+31	6.36537E+02
8	2.03139E+13	-3.32826E+03	1.44506E-10	2.50300E+10	2.42813E+00	1.37161E+15	2.74293E+32	3.63515E+31	4.78348E+02
9	2.45558E+13	-5.60479E+03	5.22688E-11	1.83196E+10	6.45971E-01	1.44574E+15	3.19431E+32	4.02439E+31	3.50106E+02
10	2.91044E+13	-1.17346E+04	1.56100E-11	1.29566E+10	1.40994E-01	1.55507E+15	3.59324E+32	4.23993E+31	2.47614E+02
11	3.39784E+13	-4.42311E+04	2.49671E-12	8.83735E+09	1.67165E-02	1.87181E+15	4.20534E+32	4.33524E+31	1.68890E+02
12	3.92023E+13	-1.33430E+05	5.39480E-13	7.02691E+09	2.91739E-03	3.70366E+15	4.50838E+32	4.35722E+31	1.34291E+02
13	4.48012E+13	-2.20184E+05	2.55524E-13	6.25850E+09	1.17779E-03	7.16749E+15	4.58545E+32	4.36392E+31	1.19606E+02
14	5.08021E+13	-2.57255E+05	1.75102E-13	5.77214E+09	7.19865E-04	9.24793E+15	4.61096E+32	4.36833E+31	1.10311E+02
15	5.72337E+13	-2.61513E+05	1.37924E-13	5.38951E+09	5.20257E-04	9.85661E+15	4.62226E+32	4.37247E+31	1.02999E+02
16	6.41271E+13	-2.53217E+05	1.14493E-13	5.06018E+09	4.01528E-04	9.80012E+15	4.62898E+32	4.37687E+31	9.67049E+01
17	7.15153E+13	-2.41378E+05	9.71446E-14	4.76644E+09	3.18797E-04	9.51752E+15	4.63395E+32	4.38177E+31	9.10914E+01
18	7.94340E+13	-2.29070E+05	8.33149E-14	4.50034E+09	2.56877E-04	9.17452E+15	4.63808E+32	4.38728E+31	8.60059E+01
19	8.79211E+13	-2.17223E+05	7.19279E-14	4.25721E+09	2.08963E-04	8.82620E+15	4.64169E+32	4.39350E+31	8.13594E+01
20	9.70174E+13	-2.06075E+05	6.23972E-14	4.03380E+09	1.71207E-04	8.48936E+15	4.64492E+32	4.40054E+31	7.70900E+01
21	1.06767E+14	-1.95540E+05	5.43403E-14	3.82761E+09	1.41098E-04	8.16826E+15	4.64784E+32	4.40848E+31	7.31494E+01
22	1.17216E+14	-1.85703E+05	4.74799E-14	3.63658E+09	1.16866E-04	7.86323E+15	4.65050E+32	4.41744E+31	6.94986E+01
23	1.28416E+14	-1.76785E+05	4.15039E-14	3.45901E+09	9.72155E-05	7.57347E+15	4.65294E+32	4.42753E+31	6.61050E+01
24	1.40419E+14	-1.68245E+05	3.65455E-14	3.29346E+09	8.11758E-05	7.29789E+15	4.65518E+32	4.43887E+31	6.29412E+01
25	1.53234E+14	-1.60233E+05	3.21716E-14	3.13870E+09	6.80073E-05	7.03542E+15	4.65725E+32	4.45162E+31	5.99837E+01
26	1.67073E+14	-1.52707E+05	2.83742E-14	2.99359E+09	5.71401E-05	6.78511E+15	4.65915E+32	4.46593E+31	5.72123E+01
27	1.81351E+14	-1.45629E+05	2.50652E-14	2.85751E+09	4.81307E-05	6.54609E+15	4.66092E+32	4.48198E+31	5.46098E+01
28	1.97691E+14	-1.38957E+05	2.21724E-14	2.72937E+09	4.06305E-05	6.31760E+15	4.66255E+32	4.49996E+31	5.21610E+01
29	2.14668E+14	-1.32590E+05	1.96359E-14	2.60858E+09	3.43635E-05	6.09899E+15	4.66407E+32	4.52008E+31	4.98526E+01
30	2.32863E+14	-1.25774E+05	1.74058E-14	2.49454E+09	2.91094E-05	5.88967E+15	4.66548E+32	4.54257E+31	4.76731E+01
31	2.52365E+14	-1.21193E+05	1.54403E-14	2.38670E+09	2.46915E-05	5.68914E+15	4.66679E+32	4.56769E+31	4.56122E+01
32	2.73265E+14	-1.15929E+05	1.37340E-14	2.28460E+09	2.09559E-05	5.49697E+15	4.66801E+32	4.59572E+31	4.36609E+01
33	2.95668E+14	-1.10962E+05	1.21674E-14	2.18781E+09	1.73192E-05	5.31276E+15	4.66914E+32	4.62695E+31	4.18111E+01
34	3.19679E+14	-1.06275E+05	1.08050E-14	2.09595E+09	1.51538E-05	5.13618E+15	4.67020E+32	4.66172E+31	4.00558E+01
35	3.45412E+14	-1.01653E+05	9.59535E-15	2.00871E+09	1.28926E-05	4.96694E+15	4.67118E+32	4.70038E+31	3.83884E+01
36	3.72994E+14	-9.76814E+04	8.51985E-15	1.92577E+09	1.09716E-05	4.80478E+15	4.67209E+32	4.74332E+31	3.68033E+01
37	4.02555E+14	-9.37462E+04	7.56263E-15	1.84686E+09	9.33740E-06	4.64948E+15	4.67294E+32	4.79093E+31	3.52954E+01
38	4.34239E+14	-9.00410E+04	6.71000E-15	1.77175E+09	7.94588E-06	4.50084E+15	4.67372E+32	4.84366E+31	3.38599E+01
39	4.68197E+14	-8.65484E+04	5.95009E-15	1.70022E+09	6.76013E-06	4.35868E+15	4.67444E+32	4.90199E+31	3.24929E+01
40	5.04593E+14	-8.32595E+04	5.27258E-15	1.63207E+09	5.74920E-06	4.22285E+15	4.67511E+32	4.96640E+31	3.11904E+01
41	5.43602E+14	-8.01639E+04	4.66848E-15	1.56711E+09	4.88711E-06	4.09318E+15	4.67572E+32	5.03743E+31	2.99491E+01
42	5.85411E+14	-7.72516E+04	4.12992E-15	1.50520E+09	4.15191E-06	3.96954E+15	4.67629E+32	5.11563E+31	2.87658E+01
43	6.30221E+14	-7.45125E+04	3.64995E-15	1.44618E+09	3.52505E-06	3.85179E+15	4.67680E+32	5.20158E+31	2.76379E+01
44	6.78249E+14	-7.19370E+04	3.22246E-15	1.38991E+09	2.99076E-06	3.73979E+15	4.67726E+32	5.29591E+31	2.65626E+01
45	7.29724E+14	-6.95153E+04	2.84200E-15	1.33628E+09	2.53561E-06	3.63342E+15	4.67768E+32	5.39926E+31	2.55376E+01
46	7.84895E+14	-6.72379E+04	2.50372E-15	1.28517E+09	2.14815E-06	3.53254E+15	4.67804E+32	5.51232E+31	2.45608E+01
47	8.44026E+14	-6.50952E+04	2.20327E-15	1.23647E+09	1.81858E-06	3.43705E+15	4.67837E+32	5.63578E+31	2.36301E+01
48	9.07402E+14	-6.30781E+04	1.93573E-15	1.19009E+09	1.53850E-06	3.34684E+15	4.67865E+32	5.77040E+31	2.27437E+01
49	9.75328E+14	-6.11774E+04	1.70658E-15	1.14593E+09	1.30070E-06	3.26182E+15	4.67889E+32	5.91696E+31	2.18999E+01
50	1.04813E+15	-5.93844E+04	1.49164E-15	1.10392E+09	1.09899E-06	3.18192E+15	4.67909E+32	6.07628E+31	2.10970E+01
51	1.12616E+15	-5.76907E+04	1.30760E-15	1.06397E+09	9.28061E-07	3.10708E+15	4.67925E+32	6.24922E+31	2.03335E+01
52	1.20979E+15	-5.60884E+04	1.14408E-15	1.02602E+09	7.83353E-07	3.03729E+15	4.67937E+32	6.43668E+31	1.96082E+01
53	1.29942E+15	-5.45700E+04	1.00050E-15	9.89984E+08	6.60954E-07	2.97256E+15	4.67945E+32	6.63960E+31	1.89196E+01
54	1.39549E+15	-5.31233E+04	8.74125E-16	9.55812E+08	5.57514E-07	2.91293E+15	4.67950E+32	6.85900E+31	1.82665E+01
55	1.49846E+15	-5.17570E+04	7.63039E-16	9.23442E+08	4.70164E-07	2.85847E+15	4.67952E+32	7.09590E+31	1.76479E+01
56	1.60881E+15	-5.04500E+04	6.65505E-16	8.92816E+08	3.96453E-07	2.80929E+15	4.67950E+32	7.35143E+31	1.70626E+01
57	1.72709E+15	-4.92019E+04	5.79963E-16	8.63883E+08	3.34290E-07	2.76554E+15	4.67945E+32	7.62674E+31	1.65097E+01
58	1.85386E+15	-4.80075E+04	5.05034E-16	8.36593E+08	2.81894E-07	2.72740E+15	4.67938E+32	7.92305E+31	1.59881E+01
59	1.98974E+15	-4.68527E+04	4.39455E-16	8.10897E+08	2.37750E-07	2.69509E+15	4.67928E+32	8.24166E+31	1.54970E+01
60	2.13536E+15	-4.57630E+04	3.82119E-16	7.86750E+08	2.00570E-07	2.66886E+15	4.67915E+32	8.58392E+31	1.50356E+01

61	2.29144E+15	-4.47048E+04	3.32038E-16	7.64106E+08	1.69263E-07	2.64898E+15	4.67901E+32	8.95125E+31	1.46028E+01
62	2.45873E+15	-4.36845E+04	2.88330E-16	7.42922E+08	1.42904E-07	2.63576E+15	4.67884E+32	9.34515E+31	1.41980E+01
63	2.53802E+15	-4.27001E+04	2.50218E-16	7.23152E+08	1.20712E-07	2.62955E+15	4.67867E+32	9.76720E+31	1.38202E+01
64	2.83018E+15	-4.17477E+04	2.17010E-16	7.04752E+08	1.02027E-07	2.63071E+15	4.67848E+32	1.02191E+32	1.34685E+01
65	3.03614E+15	-4.08254E+04	1.88099E-16	6.87674E+08	8.62897E-08	2.63961E+15	4.67829E+32	1.07025E+32	1.31421E+01
66	3.25689E+15	-3.99308E+04	1.62946E-16	6.71869E+08	7.30318E-08	2.65668E+15	4.67807E+32	1.12193E+32	1.28401E+01
67	3.49348E+15	-3.90619E+04	1.41077E-16	6.57288E+08	6.18575E-08	2.68232E+15	4.67786E+32	1.17714E+32	1.25614E+01
68	3.74705E+15	-3.82168E+04	1.22078E-16	6.43878E+08	5.24343E-08	2.71699E+15	4.67765E+32	1.23608E+32	1.23051E+01
69	4.01884E+15	-3.73938E+04	1.05582E-16	6.31583E+08	4.44825E-08	2.76112E+15	4.67744E+32	1.29897E+32	1.20702E+01
70	4.31013E+15	-3.65913E+04	9.12678E-17	6.20347E+08	3.77675E-08	2.81518E+15	4.67724E+32	1.36603E+32	1.18554E+01
71	4.62234E+15	-3.58078E+04	7.88550E-17	6.10111E+08	3.20923E-08	2.87964E+15	4.67704E+32	1.43748E+32	1.16598E+01
72	4.95695E+15	-3.50413E+04	6.80973E-17	6.00815E+08	2.72916E-08	2.95498E+15	4.67685E+32	1.51358E+32	1.14822E+01
73	5.31559E+15	-3.42919E+04	5.87793E-17	5.92398E+08	2.32270E-08	3.04169E+15	4.67667E+32	1.59458E+32	1.13213E+01
74	5.69998E+15	-3.35569E+04	5.07129E-17	5.84799E+08	1.97823E-08	3.14028E+15	4.67650E+32	1.68074E+32	1.11761E+01
75	6.11196E+15	-3.28354E+04	4.37338E-17	5.77957E+08	1.68602E-08	3.25123E+15	4.67634E+32	1.77235E+32	1.10453E+01
76	6.55351E+15	-3.21253E+04	3.76987E-17	5.71813E+08	1.43790E-08	3.37509E+15	4.67619E+32	1.86971E+32	1.09279E+01
77	7.02676E+15	-3.14284E+04	3.24927E-17	5.66309E+08	1.22702E-08	3.51238E+15	4.67605E+32	1.97312E+32	1.08227E+01
78	7.53399E+15	-3.07403E+04	2.79768E-17	5.61390E+08	1.04763E-08	3.66364E+15	4.67593E+32	2.08291E+32	1.07287E+01
79	8.07763E+15	-3.00611E+04	2.40364E-17	5.57002E+08	8.94895E-09	3.82946E+15	4.67582E+32	2.19941E+32	1.06449E+01
80	8.66030E+15	-2.93895E+04	2.07290E-17	5.53095E+08	7.64748E-09	4.01040E+15	4.67573E+32	2.32298E+32	1.05702E+01
81	9.28480E+15	-2.87245E+04	1.78328E-17	5.49623E+08	6.53768E-09	4.20709E+15	4.67564E+32	2.45400E+32	1.05038E+01
82	9.95413E+15	-2.80651E+04	1.53356E-17	5.46541E+08	5.59066E-09	4.42015E+15	4.67557E+32	2.59285E+32	1.04449E+01
83	1.06715E+16	-2.74100E+04	1.31834E-17	5.43809E+08	4.78201E-09	4.65023E+15	4.67551E+32	2.73994E+32	1.03927E+01
84	1.14404E+15	-2.67585E+04	1.13292E-17	5.41390E+08	4.09117E-09	4.89802E+15	4.67546E+32	2.89570E+32	1.03465E+01
85	1.22645E+16	-2.61095E+04	9.73240E-18	5.39251E+08	3.50064E-09	5.16421E+15	4.67541E+32	3.06058E+32	1.03056E+01
86	1.31477E+16	-2.54624E+04	8.35770E-18	5.37360E+08	2.99561E-09	5.44950E+15	4.67538E+32	3.23505E+32	1.02695E+01
87	1.40943E+15	-2.48153E+04	7.17460E-18	5.35690E+08	2.56357E-09	5.75462E+15	4.67535E+32	3.41958E+32	1.02376E+01
88	1.51089E+15	-2.41735E+04	6.15668E-18	5.34216E+08	2.19379E-09	6.08025E+15	4.67533E+32	3.61469E+32	1.02094E+01
89	1.61964E+16	-2.35245E+04	5.28111E-18	5.32915E+08	1.87723E-09	6.42704E+15	4.67532E+32	3.82090E+32	1.01845E+01
90	1.73619E+16	-2.28780E+04	4.52812E-18	5.31767E+08	1.60609E-09	6.79555E+15	4.67531E+32	4.03875E+32	1.01626E+01
91	1.86110E+15	-2.22311E+04	3.88061E-18	5.30755E+08	1.37382E-09	7.18619E+15	4.67531E+32	4.26880E+32	1.01433E+01
92	1.99497E+16	-2.15841E+04	3.32382E-18	5.29863E+08	1.17471E-09	7.59919E+15	4.67531E+32	4.51160E+32	1.01262E+01
93	2.13349E+16	-2.09381E+04	2.84495E-18	5.29075E+08	1.00397E-09	8.03454E+15	4.67532E+32	4.76771E+32	1.01111E+01
94	2.29228E+16	-2.02951E+04	2.43290E-18	5.28380E+08	8.57434E-10	8.49206E+15	4.67532E+32	5.03768E+32	1.00979E+01
95	2.45712E+16	-1.96538E+04	2.07808E-18	5.27766E+08	7.31531E-10	8.97159E+15	4.67533E+32	5.32199E+32	1.00861E+01
96	2.63380E+16	-1.90353E+04	1.77215E-18	5.27224E+08	6.23197E-10	9.47343E+15	4.67535E+32	5.62104E+32	1.00758E+01
97	2.82315E+16	-1.84338E+04	1.50794E-18	5.26745E+08	5.29800E-10	9.99932E+15	4.67536E+32	5.93509E+32	1.00666E+01
98	3.02610E+16	-1.78679E+04	1.27931E-18	5.26322E+08	4.49112E-10	1.05539E+16	4.67533E+32	6.26417E+32	1.00585E+01
99	3.24362E+16	-1.73553E+04	1.08119E-18	5.25947E+08	3.79287E-10	1.11463E+16	4.67540E+32	6.60790E+32	1.00514E+01
100	3.47575E+16	-1.69163E+04	9.09587E-19	5.25618E+08	3.18898E-10	1.17921E+16	4.67543E+32	6.96574E+32	1.00451E+01
101	3.72662E+16	-1.65574E+04	7.61615E-19	5.25328E+08	2.66870E-10	1.25123E+16	4.67546E+32	7.33638E+32	1.00395E+01
102	3.99443E+16	-1.63115E+04	6.35338E-19	5.25074E+08	2.22512E-10	1.33292E+16	4.67550E+32	7.71853E+32	1.00347E+01
103	4.28146E+16	-1.61253E+04	5.29277E-19	5.24852E+08	1.85284E-10	1.42575E+16	4.67554E+32	8.11108E+32	1.00304E+01
104	4.58910E+16	-1.59567E+04	4.41795E-19	5.24660E+08	1.54603E-10	1.52943E+16	4.67558E+32	8.51375E+32	1.00268E+01
105	4.91833E+16	-1.57385E+04	3.70646E-19	5.24492E+08	1.29672E-10	1.64167E+16	4.67563E+32	8.92763E+32	1.00236E+01
106	5.27222E+16	-1.54145E+04	3.13060E-19	5.24346E+08	1.09485E-10	1.75900E+16	4.67566E+32	9.35517E+32	1.00208E+01
107	5.65399E+16	-1.49590E+04	2.60202E-19	5.24219E+08	9.30786E-11	1.87820E+16	4.67569E+32	9.79983E+32	1.00183E+01
108	6.05694E+16	-1.43763E+04	2.27598E-19	5.24107E+08	7.95642E-11	1.99733E+16	4.67572E+32	1.02654E+33	1.00162E+01
109	6.49204E+16	-1.36897E+04	1.95338E-19	5.24009E+08	6.82780E-11	2.11569E+16	4.67574E+32	1.07555E+33	1.00143E+01
110	6.95838E+16	-1.29225E+04	1.68040E-19	5.23922E+08	5.87225E-11	2.23316E+16	4.67575E+32	1.12734E+33	1.00127E+01
111	7.45819E+16	-1.20944E+04	1.44725E-19	5.23845E+08	5.05656E-11	2.34943E+16	4.67575E+32	1.18221E+33	1.00112E+01
112	7.99388E+16	-1.12173E+04	1.24698E-19	5.23776E+08	4.35610E-11	2.46338E+16	4.67576E+32	1.24038E+33	1.00099E+01
113	8.56803E+16	-1.02970E+04	1.07400E-19	5.23715E+08	3.75170E-11	2.57257E+16	4.67575E+32	1.30210E+33	1.00087E+01
114	9.18340E+16	-9.33493E+03	9.24445E-20	5.23660E+08	3.22902E-11	2.67257E+16	4.67575E+32	1.36755E+33	1.00077E+01
115	9.84294E+16	-8.32932E+03	7.94853E-20	5.23610E+08	2.77586E-11	2.75577E+16	4.67573E+32	1.43692E+33	1.00067E+01
116	1.05498E+17	-7.27615E+03	6.82422E-20	5.23564E+08	2.38315E-11	2.80911E+16	4.67572E+32	1.51036E+33	1.00058E+01
117	1.13075E+17	-6.16940E+03	5.84810E-20	5.23522E+08	2.04225E-11	2.80905E+16	4.67569E+32	1.58799E+33	1.00050E+01
118	1.21195E+17	-5.00023E+03	5.00139E-20	5.23481E+08	1.74610E-11	2.70848E+16	4.67566E+32	1.66990E+33	1.00042E+01
119	1.29898E+17	-3.74039E+03	4.28694E-20	5.23439E+08	1.49658E-11	2.41885E+16	4.67562E+32	1.75615E+33	1.00034E+01
120	1.38631E+17	-2.49699E+03	3.69774E-20	5.23372E+08	1.29089E-11	1.31582E+16	4.67558E+32	1.84068E+33	1.00022E+01
121	1.47305E+17	-1.25572E+03	3.20558E-20	5.23313E+08	1.11890E-11	1.31582E+16	4.67554E+32	1.92335E+33	1.00010E+01
122	1.56008E+17	0.	3.20558E-20	5.23260E+08	1.11890E-11	1.31582E+16	4.67550E+32	2.00401E+33	1.00000E+01

APPENDIX B

```
*IDENT FIX
*DELETE SV.23
      DATA LFILM,KPR,NM/10,1,20/
*DELETE SV.313
      DATA (RCV(J),J=1,200)/200*8.02232E-09/
*DELETE SV.370,SV.373
      RHO(J)=2.4E-09
      P(J)=1.99543E+03
      IF (J .LE. 5) P(J)=5.37152E+14
*DELETE SV.613,SV.624
      CND(J)=0.5*(MUVISC(J-1)+MUVISC(J))/PR
*DELETE SV.611
      DATA PR/100./
*DELETE SV.616,SV.617
      MUVISC(J)=2.4E+07
*DELETE SV.527
*DELETE SV.78
*INSERT SV.509
      IF (IUMAX .GT. -1) RETURN
*INSERT SV.26
      G=0.
*DELETE SV.22
      DATA PDVCEN/0.51/
*INSERT SV.26
      CALL UNDROP
```

```
10/26/77 EXPORT VEGA BLAST WAVE
JBAR                60   NDT            300
DT        4.000E-001 DX        1.667E+011 GRDVEL      0.0
RMIN      0.000E+000 RMAX      9.000E+012
DONR MASS  1.00      DONR MOM   1.00
GAMMA          1.667 UT1                  UTMAX
VLAM      0.2        DTMAX     +8.000E-01 DTK       0.20
 .70000  .27000
    1-4.48-3.80-3.20-2.86-2.72-2.67-2.64-2.63-2.63-2.62-2.62-2.62-2.61-2.60
    2-2.60-2.59-2.58-2.55-2.54-2.52-2.49-2.46-2.42-5.54-4.59-4.59-4.59-4.59
    3-4.59-4.59-4.59
    4-4.73-4.71-4.59-4.14-3.52-3.04-2.80-2.69-2.55-2.63-2.61-2.60-2.59-2.57
    5-2.55-2.52-2.49-2.44-2.39-2.33-2.26-2.18-2.09-5.32-4.41-4.41-4.41-4.41
    6-4.41-4.41-4.41
    7-4.53-4.51-4.48-4.41-4.29-4.05-3.60-3.12-2.83-2.69-2.62-2.57-2.53-2.48
    8-2.43-2.36-2.29-2.20-2.09-1.98-1.85-1.72-1.58-5.09-4.23-4.23-4.23-4.23
    9-4.23-4.23-4.23
   10-4.44-4.41-4.38-4.31-4.21-4.08-3.90-3.64-3.28-2.90-2.60-2.41-2.25-2.13
   11-2.01-1.88-1.73-1.59-1.43-1.28-1.12 -.96 -.80-4.87-4.05-4.05-4.05-4.05
   12-4.05-4.05-4.05
   13-4.31-4.29-4.32-4.24-4.10-3.92-3.68-3.39-3.06-2.72-2.38-2.07-1.82-1.62
   14-1.45-1.27-1.08 -.90 -.71 -.52 -.33 -.14  .00-4.65-3.87-3.87-3.87-3.87
   15-3.87-3.87-3.87
   16-4.13-4.14-4.23-4.12-3.94-3.68-3.37-3.04-2.69-2.35-2.03-1.72-1.44-1.20
   17 -.98 -.76 -.53 -.30 -.08  .15  .38  .61  .66-4.43-3.70-3.70-3.70-3.70
   18-3.70-3.70-3.70
   19-3.96-3.99-4.03-3.92-3.71-3.39-3.03-2.69-2.35-2.04-1.73-1.43-1.13 -.86
   20 -.60 -.33 -.06  .21  .47  .74 1.01 1.26 1.06-4.21-3.52-3.52-3.52-3.52
   21-3.52-3.52-3.52
   22-3.31-3.40-3.56-3.52-3.37-3.12-2.82-2.51-2.17-1.82-1.47-1.13 -.80 -.51
   23 -.24  .05  .33  .61  .89 1.17 1.46 1.72 1.25-3.99-3.34-3.34-3.34-3.34
   24-3.34-3.34-3.34
   25-2.63-2.79-2.95-2.98-2.93-2.78-2.55-2.28-1.96-1.59-1.21 -.84 -.50 -.20
   26  .08  .37  .66  .96 1.25 1.54 1.83 2.08 1.39-3.77-3.16-3.16-3.16-3.16
   27-3.16-3.16-3.16
   28-1.90-2.06-2.24-2.37-2.39-2.27-2.06-1.81-1.53-1.23 -.91 -.58 -.26  .05
   29  .36  .67  .98 1.29 1.60 1.91 2.22 2.45 1.51-3.55-2.98-2.98-2.98-2.98
   30-2.98-2.98-2.98
   31-1.27-1.39-1.49-1.61-1.66-1.56-1.39-1.18 -.96 -.72 -.47 -.20  .09  .38
   32  .68  .97 1.28 1.58 1.88 2.18 2.47 2.65 1.61-3.33-2.80-2.80-2.80-2.80
```

```
33-2.80-2.80-2.80
34 -.79 -.79 -.77 -.79 -.80 -.73 -.62 -.47 -.30 -.10  .11  .33  .56  .81
35 1.05 1.32 1.59 1.85 2.12 2.38 2.64 2.78 1.71-3.11-2.62-2.62-2.52-2.62
36-2.62-2.52-2.62
37 -.40 -.32 -.23 -.16 -.08 -.01  .07  .19  .33  .49  .67  .86 1.06 1.29
38 1.52 1.76 2.01 2.25 2.49 2.73 2.96 3.01 1.82-2.89-2.44-2.44-2.44-2.44
39-2.44-2.44-2.44
40 -.44 -.26 -.07  .18  .42  .59  .74  .86  .97 1.10 1.24 1.39 1.55 1.76
41 1.97 2.18 2.40 2.62 2.83 3.05 3.25 3.19 1.92-2.66-2.26-2.26-2.26-2.26
42-2.26-2.26-2.26
43 -.47 -.28 -.08  .22  .55  .89 1.19 1.39 1.54 1.66 1.77 1.90 2.05 2.21
44 2.38 2.58 2.78 2.97 3.17 3.36 3.52 3.35 2.02-2.44-2.08-2.08-2.08-2.08
45-2.08-2.08-2.08
46 -.47 -.40 -.31  .01  .43  .86 1.28 1.62 1.90 2.09 2.24 2.37 2.50 2.63
47 2.78 2.95 3.12 3.31 3.49 3.67 3.80 3.49 2.12-2.22-1.90-1.90-1.90-1.90
48-1.90-1.90-1.90
49 -.47 -.47 -.48 -.18  .24  .68 1.14 1.59 2.00 2.31 2.56 2.74 2.88 3.01
50 3.14 3.28 3.44 3.60 3.78 3.97 4.07 3.62 2.23-2.00-1.72-1.72-1.72-1.72
51-1.72-1.72-1.72
52 -.47 -.47 -.49 -.25  .09  .49  .93 1.42 1.90 2.33 2.69 2.96 3.16 3.32
53 3.45 3.58 3.72 3.87 4.04 4.23 4.30 3.73 2.33-1.78-1.54-1.54-1.54-1.54
54-1.54-1.54-1.54
55 -.47 -.47 -.47 -.30 -.04  .29  .70 1.19 1.71 2.22 2.68 3.04 3.32 3.54
56 3.71 3.85 3.98 4.12 4.28 4.43 4.43 3.80 2.43-1.56-1.36-1.36-1.36-1.36
57-1.36-1.36-1.36
58 -.47 -.47 -.47 -.35 -.15  .15  .53 1.01 1.53 2.07 2.58 3.01 3.37 3.66
59 3.89 4.07 4.21 4.36 4.50 4.57 4.49 3.86 2.52-1.34-1.19-1.19-1.19-1.19
60-1.19-1.19-1.19
61 -.47 -.47 -.47 -.39 -.23  .03  .38  .83 1.34 1.89 2.43 2.91 3.33 3.71
62 4.02 4.24 4.41 4.58 4.70 4.70 4.53 3.92 2.52-1.12-1.01-1.01-1.01-1.01
63-1.01-1.01-1.01
64 -.47 -.47 -.47 -.40 -.26 -.04  .27  .69 1.18 1.73 2.28 2.79 3.26 3.69
65 4.06 4.34 4.57 4.78 4.92 4.94 4.72 4.02 2.72 -.90 -.83 -.83 -.83 -.83
66 -.83 -.83 -.83
67 -.47 -.47 -.47 -.40 -.28 -.10  .17  .56 1.04 1.57 2.13 2.66 3.17 3.64
68 4.05 4.41 4.69 4.94 5.11 5.14 4.87 4.11 2.82 -.68 -.65 -.65 -.65 -.65
69 -.65 -.65 -.65
70 -.47 -.47 -.47 -.41 -.29 -.14  .09  .46  .91 1.43 1.99 2.53 3.05 3.56
71 4.02 4.43 4.77 5.06 5.27 5.32 5.00 4.19 2.93 -.46 -.47 -.47 -.47 -.47
72 -.47 -.47 -.47
```

73	-.47	-.47	-.47	-.42	-.32	-.18	.03	.38	.82	1.33	1.88	2.42	2.95	3.46
74	3.95	4.40	4.79	5.11	5.35	5.41	5.08	4.27	3.03	-.24	-.29	-.29	-.29	-.29
75	-.29	-.29	-.29											
76	-.47	-.47	-.47	-.44	-.36	-.23	-.02	.32	.75	1.26	1.80	2.33	2.85	3.38
77	3.88	4.34	4.76	5.10	5.34	5.39	5.09	4.33	3.12	-.01	-.11	-.11	-.11	-.11
78	-.11	-.11	-.11											
79	-.47	-.47	-.47	-.46	-.40	-.28	-.07	.26	.68	1.18	1.72	2.24	2.76	3.28
80	3.78	4.26	4.68	5.05	5.30	5.32	5.07	4.38	3.22	.21	.07	.07	.07	.07
81	.07	.07	.07											
82	-.47	-.47	-.47	-.47	-.44	-.32	-.12	.20	.60	1.10	1.63	2.14	2.65	3.16
83	3.67	4.15	4.58	4.95	5.20	5.22	5.00	4.42	3.32	.43	.25	.25	.25	.25
84	.25	.25	.25											
85	-.47	-.47	-.47	-.49	-.47	-.36	-.16	.14	.52	1.00	1.52	2.02	2.52	3.04
86	3.54	4.01	4.44	4.82	5.07	5.06	4.88	4.43	3.41	.65	.43	.43	.43	.43
87	.43	.43	.43											
88	-.47	-.47	-.47	-.49	-.48	-.39	-.23	.01	.35	.80	1.31	1.82	2.34	2.87
89	3.39	3.87	4.30	4.67	4.92	4.93	4.81	4.45	3.51	.87	.61	.61	.61	.61
90	.61	.61	.61											
91	-.47	-.47	-.47	-.49	-.48	-.42	-.30	-.11	.17	.60	1.10	1.61	2.15	2.70
92	3.22	3.71	4.14	4.50	4.76	4.80	4.73	4.46	3.60	1.09	.79	.79	.79	.79
93	.79	.79	.79											
94	-.47	-.47	-.47	-.48	-.47	-.44	-.36	-.22	.01	.39	.87	1.39	1.94	2.50
95	3.04	3.54	3.97	4.34	4.59	4.68	4.66	4.47	3.69	1.31	.97	.97	.97	.97
96	.97	.97	.97											
97	-.47	-.47	-.47	-.48	-.47	-.46	-.41	-.30	-.09	.25	.68	1.18	1.72	2.29
98	2.85	3.36	3.81	4.19	4.47	4.58	4.59	4.44	3.77	1.53	1.15	1.15	1.15	1.15
99	1.15	1.15	1.15											
100	-.47	-.47	-.47	-.47	-.47	-.47	-.44	-.35	-.17	.12	.51	.98	1.50	2.07
101	2.64	3.17	3.65	4.05	4.35	4.49	4.52	4.39	3.82	1.75	1.32	1.32	1.32	1.32
102	1.32	1.32	1.32											
103	-.47	-.47	-.47	-.47	-.47	-.49	-.47	-.39	-.23	.01	.34	.78	1.29	1.85
104	2.43	2.98	3.48	3.91	4.23	4.39	4.43	4.30	3.84	1.97	1.50	1.20	.71	-.27
105	-1.20	-2.29	-3.39											
106	-.47	-.47	-.47	-.47	-.47	-.48	-.49	-.46	-.40	-.30	-.13	.16	.56	1.07
107	1.63	2.22	2.76	3.21	3.54	3.74	3.82	3.79	3.65	2.79	2.20	1.75	1.19	.24
108	-.70	-1.77	-2.86											
109	-.47	-.47	-.47	-.47	-.47	-.47	-.47	-.47	-.47	-.44	-.37	-.22	.02	.38
110	.83	1.36	1.91	2.39	2.77	3.01	3.15	3.18	3.18	3.11	2.78	2.27	1.67	.74
111	-.19	-1.25	-2.33											
112	-.47	-.47	-.47	-.47	-.47	-.47	-.47	-.48	-.48	-.48	-.46	-.42	-.31	-.14

121	113	.13	.54	1.02	1.53	1.99	2.31	2.54	2.64	2.71	2.83	2.91	2.69	2.15	1.25
122	114	.32	-.74	-1.81											
123	115	-.47	-.47	-.47	-.47	-.47	-.47	-.47	-.47	-.47	-.47	-.47	-.47	-.45	-.41
124	116	-.29	-.06	.27	.70	1.17	1.60	1.96	2.19	2.36	2.52	2.70	2.81	2.55	1.74
125	117	.81	-.24	-1.29											
126	118	-.47	-.47	-.47	-.47	-.47	-.47	-.47	-.47	-.47	-.47	-.47	-.47	-.46	-.46
127	119	-.42	-.36	-.22	.06	.43	.92	1.40	1.77	2.06	2.23	2.36	2.52	2.57	2.12
128	120	1.29	.26	-.79											
129	121	-.47	-.47	-.47	-.47	-.47	-.47	-.47	-.47	-.47	-.47	-.47	-.47	-.47	-.47
130	122	-.47	-.45	-.39	-.25	-.03	.34	.77	1.23	1.64	1.89	2.05	2.16	2.24	2.22
131	123	1.70	.75	-.30											
132	124	-.47	-.47	-.47	-.47	-.47	-.47	-.47	-.47	-.47	-.47	-.47	-.47	-.47	-.47
133	125	-.47	-.47	-.44	-.40	-.30	-.10	.19	.59	1.01	1.31	1.53	1.65	1.74	1.89
134	126	1.84	1.18	.19											
135	127	-.47	-.47	-.47	-.47	-.47	-.47	-.47	-.47	-.47	-.47	-.47	-.47	-.47	-.47
136	128	-.48	-.48	-.47	-.47	-.43	-.37	-.23	.01	.30	.59	.85	1.01	1.15	1.33
137	129	1.50	1.41	.65											
138	130	-.48	-.48	-.48	-.48	-.48	-.48	-.48	-.48	-.48	-.48	-.48	-.48	-.48	-.48
139	131	-.48	-.48	-.48	-.48	-.48	-.47	-.44	-.35	-.21	-.02	.20	.39	.57	.74
140	132	.93	1.15	.97											
141	133	-.48	-.48	-.48	-.48	-.48	-.48	-.48	-.48	-.48	-.48	-.48	-.48	-.48	-.48
142	134	-.48	-.48	-.48	-.48	-.48	-.48	-.47	-.46	-.43	-.35	-.24	-.09	.07	.22
143	135	.41	.66	.86											
144	136	-.49	-.49	-.49	-.49	-.49	-.49	-.49	-.49	-.49	-.49	-.49	-.49	-.49	-.49
145	137	-.49	-.49	-.49	-.49	-.49	-.49	-.49	-.49	-.49	-.47	-.43	-.35	-.26	-.15
146	138	-.01	.20	.43											
147	139	-.50	-.50	-.50	-.50	-.50	-.50	-.50	-.50	-.50	-.50	-.50	-.50	-.50	-.50
148	140	-.50	-.50	-.50	-.50	-.50	-.50	-.50	-.50	-.50	-.50	-.49	-.47	-.43	-.37
149	141	-.28	-.14	.03											
150	142	-.51	-.51	-.51	-.51	-.51	-.51	-.51	-.51	-.51	-.51	-.51	-.51	-.51	-.51
151	143	-.51	-.51	-.51	-.51	-.51	-.51	-.51	-.51	-.51	-.52	-.52	-.52	-.50	-.48
152	144	-.44	-.36	-.26											
153	145	-.53	-.53	-.53	-.53	-.53	-.53	-.53	-.53	-.53	-.53	-.53	-.53	-.53	-.53
154	146	-.53	-.53	-.53	-.53	-.53	-.53	-.53	-.53	-.53	-.53	-.53	-.53	-.53	-.53
155	147	-.51	-.49	-.43											
156	148	-.56	-.56	-.56	-.56	-.56	-.56	-.56	-.56	-.56	-.56	-.56	-.56	-.56	-.56
157	149	-.56	-.56	-.56	-.56	-.56	-.56	-.56	-.56	-.56	-.56	-.56	-.56	-.56	-.56
158	150	-.56	-.55	-.53											
159	151	-.61	-.61	-.61	-.61	-.61	-.61	-.61	-.61	-.61	-.61	-.61	-.61	-.61	-.61
160	152	-.61	-.61	-.61	-.61	-.61	-.61	-.61	-.61	-.61	-.61	-.61	-.61	-.61	-.61
161	153	-.61	-.60	-.60											

APPENDIX C

```
*IDENT PROB
*DELETE SV.23
      DATA LFILM,KPR,NM/50,5,200/
*DELETE SV.313
      DATA (RCV(J),J=1,200)/200*4.E-09/
*DELETE SV.259
      U(JP2)=U(JP1)+DELU
      U(JP3)=U(JP2)+DELU
      RHO(1)=3.674E-21
      EI(JP2)=2.*EI(JP1)-EI(JBAR)
*DELETE SV.261
      EI(1)=2.65E+14
*DELETE SV.370,SV.373
      RHO(J)=3.674E-21
      EI(J)=2.65E+14
      P(J)=(GAMMA-1.)*RHO(J)*EI(J)
*DELETE SV.375
*DELETE SV.618,SV.624
      CND(J)=0.5*(MUVISC(J)+MUVISC(J-1))/PR
*DELETE SV.180
      AA(K+1,L-5)=-1.
*DELETE SV.78
*DELETE SV.527
*DELETE SV.228
*DELETE SV.374
      U(J)=UT1
*DELETE SV.87
      SUM=1.33E+25
*DELETE SV.90
      DPHI(JP2)=SUM/X(JP2)**2
*DELETE SV.204
      RHOL(1)=3.674E-21
      EI(1)=2.65E+14
      UT(JP2)=UT(JP1)+DELU
      UT(JP3)=UT(JP2)+DELU
      EI(JP2)=2.*EI(JP1)-EI(JBAR)
*DELETE SV.552
      DO 10 J=2,JP3
*INSERT SV.296
      SUBROUTINE ASOLN(X,P,EI,RHO,U,GAMMA,JP1)
```

```
      DIMENSION X(1),P(1),EI(1),RHO(1),U(1)
      JP2=JP1+1
      GNOT=1.33E+26
      ANA=RHO(1)*U(2)*X(2)*X(2)
      ANB=EI(1)+0.5*U(2)*U(2)+P(1)/RHO(1)-GNOT/X(2)
      ANC=P(1)/RHO(1)**GAMMA
      D2=GAMMA*ANC/(GAMMA-1.)
      D3=GAMMA-1.
      D4=SQRT(ANA**2*0.5)
      WRITE (6,6) ANA,ANB,ANC,D2,D3,D4
    6 FORMAT (1X,*A AND D*,7E15.6)
      DO 1 J=3,JP2
      ROLD=RHO(J)
      DO 2 IT=1,200
      RHO(J)=D4/(X(J)*X(J)*SQRT(ANB-D2*RHO(J)**D3+GNOT/X(J)))
      IF (ABS(RHO(J)-ROLD) .LE. 1.E-10*ROLD) GO TO 3
      ROLD=RHO(J)
    2 CONTINUE
      WRITE (6,4) J,ROLD,RHO(J)
    4 FORMAT (1X,*ITER FAILURE*,I5,2E15.6)
    3 CONTINUE
      P(J)=ANC*RHO(J)**GAMMA
      EI(J)=P(J)/(D3*RHO(J))
      U(J)=ANA/(X(J)*X(J)*RHO(J))
      WRITE (6,5) J,RHO(J),P(J),EI(J),U(J)
    5 FORMAT (1X,*A SOLN*,I5,4E13.6)
      END FILE 6
    1 CONTINUE
      RETURN
      END
*INSERT SV.376
      CALL ASOLN (X,P,EI,RHO,U,GAMMA,JP1)
*DELETE SV.511
      DATA PR/1.E+05/
*INSERT SV.27
      DELU=U(JP2)-U(JP1)
*DELETE SV.185
      B(K+1)=DELU
*INSERT SV.617
     $ *1.E-12
```

```
*DELETE SV.132
      AA(4,7)=X(2)*X(2)
      AA(4,12)=-X(3)*X(3)
*DELETE SV.229
*INSERT SV.210
      RHOT=RHOL(J)
      EIT=EI(J)
      IF (J .NE. 2) GO TO 151
      RHOT=RHOL(1)
      EIT=EI(1)
  151 CONTINUE
*DELETE SV.214
     1RHOT)-UD(J+1)*AJ(J+1)*((1.+DUB2)*RHOL(J)+(1.-DUB2)*RHOL(J+1)))
*DELETE SV.215
     1+(1.-DUB1)*RHOT*EIT)-UD(J+1)*AJ(J+1)*((1.+DUB2)*RHOL(J)*EI(J)
*IDENT SHOK
*INSERT PROB.10
      IF (T.LT.TSHOK .OR. T.GE.TSHOK+7560.) GO TO 1006
      RHOL(1)=RHOL(1)*3.864
      EI(1)=EI(1)*25.47
      UT(2)=1.57E+08
 1006 CONTINUE
*INSERT PROB.26
      IF (T.LT.TSHOK .OR. T.GE.TSHOK+7560.) GO TO 1007
      RHOL(1)=RHOL(1)*3.864
      EI(1)=EI(1)*25.47
      U(2)=1.57E+08
 1007 CONTINUE
*INSERT SV.22
      DATA TSHOK/2.E+05/
*IDENT RADCO
*DELETE PROB.22,PROB.23
      U(JP3)=U(JP2)
*DELETE PROB.11,PROB.12
      UT(JP3)=UT(JP2)
*DELETE PROB.7
      AA(K+1,L-5)=-DT*U(JP2)/(X(JP2)-X(JP1))
*DELETE SV.184
      AA(K+1,L)=1.-AA(K+1,L-5)
*DELETE PROB.8
```

```
      B(K+1)=U(JP2)
*INSERT SV.26
      CALL UNDROP
```

```
10/26/77 EXPORT VEGA SOLAR WIND
JBAR                 140   NDT           5000
DT          1.000E+002 DX        1.500E+010 GRDVEL      0.0
RMIN        1.250E+012 RMAX      2.000E+013
DONR MASS  0.50        DONR MOM   0.50
GAMMA            1.667 UT1       +3.140E+07 UTMAX
VLAM        0.2        DTMAX     +1.000E+04 DTK      0.20
 .70000  .27000
    1-4.48-3.80-3.20-2.86-2.72-2.67-2.64-2.63-2.63-2.62-2.62-2.62-2.61-2.60
    2-2.60-2.59-2.58-2.56-2.54-2.52-2.49-2.46-2.42-5.54-4.59-4.59-4.59-4.59
    3-4.59-4.59-4.59
    4-4.73-4.71-4.59-4.14-3.52-3.04-2.80-2.69-2.65-2.63-2.61-2.60-2.59-2.57
    5-2.55-2.52-2.49-2.44-2.39-2.33-2.26-2.18-2.09-5.32-4.41-4.41-4.41-4.41
    6-4.41-4.41-4.41
    7-4.53-4.51-4.48-4.41-4.29-4.05-3.60-3.12-2.83-2.69-2.62-2.57-2.53-2.48
    8-2.43-2.36-2.29-2.20-2.09-1.98-1.85-1.72-1.58-5.09-4.23-4.23-4.23-4.23
    9-4.23-4.23-4.23
   10-4.44-4.41-4.38-4.31-4.21-4.08-3.90-3.64-3.28-2.90-2.60-2.41-2.25-2.13
   11-2.01-1.88-1.73-1.59-1.43-1.28-1.12 -.96 -.80-4.87-4.05-4.05-4.05-4.05
   12-4.05-4.05-4.05
   13-4.31-4.29-4.32-4.24-4.10-3.92-3.68-3.39-3.06-2.72-2.38-2.07-1.82-1.62
   14-1.45-1.27-1.08 -.90 -.71 -.52 -.33 -.14  .00-4.65-3.87-3.87-3.87-3.87
   15-3.87-3.87-3.87
   16-4.13-4.14-4.23-4.12-3.94-3.68-3.37-3.04-2.69-2.35-2.03-1.72-1.44-1.20
   17 -.98 -.76 -.53 -.30 -.08  .15  .38  .61  .66-4.43-3.70-3.70-3.70-3.70
   18-3.70-3.70-3.70
   19-3.96-3.99-4.03-3.92-3.71-3.39-3.03-2.69-2.35-2.04-1.73-1.43-1.13 -.86
   20 -.60 -.33 -.06  .21  .47  .74 1.01 1.26 1.06-4.21-3.52-3.52-3.52-3.52
   21-3.52-3.52-3.52
   22-3.31-3.40-3.56-3.52-3.37-3.12-2.82-2.51-2.17-1.82-1.47-1.13 -.80 -.51
   23 -.24  .05  .33  .61  .89 1.17 1.46 1.72 1.25-3.99-3.34-3.34-3.34-3.34
   24-3.34-3.34-3.34
   25-2.63-2.79-2.95-2.98-2.93-2.78-2.55-2.28-1.96-1.59-1.21 -.84 -.50 -.20
   26  .08  .37  .66  .96 1.25 1.54 1.83 2.08 1.39-3.77-3.16-3.16-3.16-3.16
   27-3.16-3.16-3.16
   28-1.90-2.06-2.24-2.37-2.39-2.27-2.06-1.81-1.53-1.23 -.91 -.58 -.26  .05
   29  .35  .67  .98 1.29 1.60 1.91 2.22 2.45 1.51-3.55-2.98-2.98-2.98-2.98
   30-2.98-2.98-2.98
   31-1.27-1.39-1.49-1.61-1.66-1.56-1.39-1.18 -.96 -.72 -.47 -.20  .09  .38
   32  .68  .97 1.28 1.58 1.88 2.18 2.47 2.66 1.61-3.33-2.80-2.80-2.80-2.80
```

```
33-2.80-2.80-2.80
34 -.79 -.79 -.77 -.79 -.80 -.73 -.62 -.47 -.30 -.10  .11  .33  .56  .81
35 1.06 1.32 1.59 1.85 2.12 2.38 2.64 2.78 1.71-3.11-2.62-2.62-2.62-2.62
36-2.62-2.62-2.62
37 -.40 -.32 -.23 -.16 -.08 -.01  .07  .19  .33  .49  .67  .86 1.06 1.29
38 1.52 1.76 2.01 2.25 2.49 2.73 2.96 3.01 1.82-2.89-2.44-2.44-2.44-2.44
39-2.44-2.44-2.44
40 -.44 -.26 -.07  .18  .42  .59  .74  .86  .97 1.10 1.24 1.39 1.56 1.76
41 1.97 2.18 2.40 2.62 2.83 3.05 3.25 3.19 1.92-2.66-2.26-2.26-2.26-2.26
42-2.26-2.26-2.26
43 -.47 -.28 -.08  .22  .55  .89 1.19 1.39 1.54 1.66 1.77 1.90 2.05 2.21
44 2.38 2.58 2.78 2.97 3.17 3.36 3.52 3.35 2.02-2.44-2.08-2.08-2.08-2.08
45-2.08-2.08-2.08
46 -.47 -.40 -.31  .01  .43  .86 1.28 1.62 1.90 2.09 2.24 2.37 2.50 2.63
47 2.78 2.95 3.12 3.31 3.49 3.67 3.80 3.49 2.12-2.22-1.90-1.90-1.90-1.90
48-1.90-1.90-1.90
49 -.47 -.47 -.48 -.18  .24  .68 1.14 1.59 2.00 2.31 2.56 2.74 2.88 3.01
50 3.14 3.28 3.44 3.60 3.78 3.97 4.07 3.62 2.23-2.00-1.72-1.72-1.72-1.72
51-1.72-1.72-1.72
52 -.47 -.47 -.49 -.26  .09  .49  .93 1.42 1.90 2.33 2.69 2.96 3.16 3.32
53 3.45 3.58 3.72 3.87 4.04 4.23 4.30 3.73 2.33-1.78-1.54-1.54-1.54-1.54
54-1.54-1.54-1.54
55 -.47 -.47 -.47 -.30 -.04  .29  .70 1.19 1.71 2.22 2.68 3.04 3.32 3.54
56 3.71 3.85 3.98 4.12 4.28 4.43 4.43 3.80 2.43-1.56-1.36-1.36-1.36-1.35
57-1.36-1.36-1.36
58 -.47 -.47 -.47 -.35 -.15  .15  .53 1.01 1.53 2.07 2.58 3.01 3.37 3.66
59 3.89 4.07 4.21 4.36 4.50 4.57 4.49 3.86 2.52-1.34-1.19-1.19-1.19-1.19
60-1.19-1.19-1.19
61 -.47 -.47 -.47 -.39 -.23  .03  .38  .83 1.34 1.89 2.43 2.91 3.33 3.71
62 4.02 4.24 4.41 4.58 4.70 4.70 4.53 3.92 2.62-1.12-1.01-1.01-1.01-1.01
63-1.01-1.01-1.01
64 -.47 -.47 -.47 -.40 -.26 -.04  .27  .69 1.18 1.73 2.28 2.79 3.26 3.69
65 4.06 4.34 4.57 4.78 4.92 4.94 4.72 4.02 2.72 -.90 -.83 -.83 -.83 -.83
66 -.83 -.83 -.83
67 -.47 -.47 -.47 -.40 -.28 -.10  .17  .55 1.04 1.57 2.13 2.66 3.17 3.64
68 4.06 4.41 4.69 4.94 5.11 5.14 4.87 4.11 2.82 -.68 -.65 -.65 -.65 -.65
69 -.65 -.65 -.65
70 -.47 -.47 -.47 -.41 -.29 -.14  .09  .46  .91 1.43 1.99 2.53 3.05 3.56
71 4.02 4.43 4.77 5.06 5.27 5.32 5.00 4.19 2.93 -.46 -.47 -.47 -.47 -.47
72 -.47 -.47 -.47
```

73	-.47	-.47	-.47	-.42	-.32	-.18	.03	.38	.82	1.33	1.88	2.42	2.95	3.46
74	3.95	4.40	4.79	5.11	5.35	5.41	5.08	4.27	3.03	-.24	-.29	-.29	-.29	-.29
75	-.29	-.29	-.29											
76	-.47	-.47	-.47	-.44	-.36	-.23	-.02	.32	.75	1.26	1.80	2.33	2.86	3.38
77	3.88	4.34	4.76	5.10	5.34	5.39	5.09	4.33	3.12	-.01	-.11	-.11	-.11	-.11
78	-.11	-.11	-.11											
79	-.47	-.47	-.47	-.46	-.40	-.28	-.07	.26	.68	1.18	1.72	2.24	2.76	3.28
80	3.78	4.26	4.68	5.05	5.30	5.32	5.07	4.38	3.22	.21	.07	.07	.07	.07
81	.07	.07	.07											
82	-.47	-.47	-.47	-.47	-.44	-.32	-.12	.20	.60	1.10	1.63	2.14	2.65	3.16
83	3.67	4.15	4.58	4.95	5.20	5.22	5.00	4.42	3.32	.43	.25	.25	.25	.25
84	.25	.25	.25											
85	-.47	-.47	-.47	-.49	-.47	-.36	-.16	.14	.52	1.00	1.52	2.02	2.52	3.04
86	3.54	4.01	4.44	4.82	5.07	5.06	4.88	4.43	3.41	.65	.43	.43	.43	.43
87	.43	.43	.43											
88	-.47	-.47	-.47	-.49	-.48	-.39	-.23	.01	.35	.80	1.31	1.82	2.34	2.87
89	3.39	3.87	4.30	4.67	4.92	4.93	4.81	4.45	3.51	.87	.61	.61	.61	.61
90	.61	.61	.61											
91	-.47	-.47	-.47	-.49	-.48	-.42	-.30	-.11	.17	.60	1.10	1.61	2.15	2.70
92	3.22	3.71	4.14	4.50	4.76	4.80	4.73	4.46	3.60	1.09	.79	.79	.79	.79
93	.79	.79	.79											
94	-.47	-.47	-.47	-.48	-.47	-.44	-.36	-.22	.01	.39	.87	1.39	1.94	2.50
95	3.04	3.54	3.97	4.34	4.59	4.68	4.66	4.47	3.69	1.31	.97	.97	.97	.97
96	.97	.97	.97											
97	-.47	-.47	-.47	-.48	-.47	-.46	-.41	-.30	-.09	.25	.68	1.18	1.72	2.29
98	2.85	3.36	3.81	4.19	4.47	4.58	4.59	4.44	3.77	1.53	1.15	1.15	1.15	1.15
99	1.15	1.15	1.15											
100	-.47	-.47	-.47	-.47	-.47	-.47	-.44	-.35	-.17	.12	.51	.98	1.50	2.07
101	2.64	3.17	3.65	4.05	4.35	4.49	4.52	4.39	3.82	1.75	1.32	1.32	1.32	1.32
102	1.32	1.32	1.32											
103	-.47	-.47	-.47	-.47	-.47	-.49	-.47	-.39	-.23	.01	.34	.78	1.29	1.85
104	2.43	2.98	3.48	3.91	4.23	4.39	4.43	4.30	3.84	1.97	1.50	1.20	.71	-.27
105	-1.20	-2.29	-3.39											
106	-.47	-.47	-.47	-.47	-.47	-.48	-.49	-.46	-.40	-.30	-.13	.16	.56	1.07
107	1.63	2.22	2.76	3.21	3.54	3.74	3.82	3.79	3.65	2.79	2.20	1.75	1.19	.24
108	-.70	-1.77	-2.85											
109	-.47	-.47	-.47	-.47	-.47	-.47	-.47	-.47	-.47	-.44	-.37	-.22	.02	.38
110	.83	1.36	1.91	2.39	2.77	3.01	3.15	3.18	3.18	3.11	2.78	2.27	1.67	.74
111	-.19	-1.25	-2.33											
112	-.47	-.47	-.47	-.47	-.47	-.47	-.47	-.48	-.48	-.48	-.46	-.42	-.31	-.14

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121	113	.13	.54	1.02	1.53	1.99	2.31	2.54	2.64	2.71	2.83	2.91	2.69	2.15	1.25
122	114	.32	-.74	-1.81											
123	115	-.47	-.47	-.47	-.47	-.47	-.47	-.47	-.47	-.47	-.47	-.47	-.47	-.45	-.41
124	116	-.29	-.06	.27	.70	1.17	1.60	1.96	2.19	2.36	2.52	2.70	2.81	2.55	1.74
125	117	.81	-.24	-1.29											
126	118	-.47	-.47	-.47	-.47	-.47	-.47	-.47	-.47	-.47	-.47	-.47	-.47	-.46	-.46
127	119	-.42	-.35	-.22	.06	.43	.92	1.40	1.77	2.06	2.23	2.36	2.52	2.57	2.12
128	120	1.29	.26	-.79											
129	121	-.47	-.47	-.47	-.47	-.47	-.47	-.47	-.47	-.47	-.47	-.47	-.47	-.47	-.47
130	122	-.47	-.45	-.39	-.26	-.03	.34	.77	1.23	1.64	1.89	2.05	2.16	2.24	2.22
131	123	1.70	.75	-.30											
132	124	-.47	-.47	-.47	-.47	-.47	-.47	-.47	-.47	-.47	-.47	-.47	-.47	-.47	-.47
133	125	-.47	-.47	-.44	-.40	-.30	-.10	.19	.59	1.01	1.31	1.53	1.65	1.74	1.89
134	126	1.84	1.18	.19											
135	127	-.47	-.47	-.47	-.47	-.47	-.47	-.47	-.47	-.47	-.47	-.47	-.47	-.47	-.47
136	128	-.48	-.48	-.47	-.47	-.43	-.37	-.23	.01	.30	.59	.85	1.01	1.15	1.33
137	129	1.50	1.41	.65											
138	130	-.48	-.48	-.48	-.48	-.48	-.48	-.48	-.48	-.48	-.48	-.48	-.48	-.48	-.48
139	131	-.48	-.48	-.48	-.48	-.48	-.47	-.44	-.35	-.21	-.02	.20	.39	.57	.74
140	132	.93	1.15	.97											
141	133	-.48	-.48	-.48	-.48	-.48	-.48	-.48	-.48	-.48	-.48	-.48	-.48	-.48	-.48
142	134	-.48	-.48	-.48	-.48	-.48	-.48	-.47	-.46	-.43	-.35	-.24	-.09	.07	.22
143	135	.41	.66	.86											
144	136	-.49	-.49	-.49	-.49	-.49	-.49	-.49	-.49	-.49	-.49	-.49	-.49	-.49	-.49
145	137	-.49	-.49	-.49	-.49	-.49	-.49	-.49	-.49	-.49	-.47	-.43	-.35	-.26	-.15
146	138	-.01	.20	.43											
147	139	-.50	-.50	-.50	-.50	-.50	-.50	-.50	-.50	-.50	-.50	-.50	-.50	-.50	-.50
148	140	-.50	-.50	-.50	-.50	-.50	-.50	-.50	-.50	-.50	-.50	-.49	-.47	-.43	-.37
149	141	-.28	-.14	.03											
150	142	-.51	-.51	-.51	-.51	-.51	-.51	-.51	-.51	-.51	-.51	-.51	-.51	-.51	-.51
151	143	-.51	-.51	-.51	-.51	-.51	-.51	-.51	-.51	-.51	-.52	-.52	-.52	-.50	-.48
152	144	-.44	-.36	-.26											
153	145	-.53	-.53	-.53	-.53	-.53	-.53	-.53	-.53	-.53	-.53	-.53	-.53	-.53	-.53
154	146	-.53	-.53	-.53	-.53	-.53	-.53	-.53	-.53	-.53	-.53	-.53	-.53	-.53	-.53
155	147	-.51	-.49	-.43											
156	148	-.56	-.56	-.56	-.56	-.56	-.56	-.56	-.56	-.56	-.56	-.56	-.56	-.56	-.56
157	149	-.55	-.56	-.56	-.56	-.56	-.56	-.56	-.56	-.56	-.56	-.56	-.56	-.56	-.56
158	150	-.56	-.55	-.53											
159	151	-.61	-.61	-.61	-.61	-.61	-.61	-.61	-.61	-.61	-.61	-.61	-.61	-.61	-.61
160	152	-.61	-.61	-.61	-.61	-.61	-.61	-.61	-.61	-.61	-.61	-.61	-.61	-.61	-.61
161	153	-.61	-.60	-.60											

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