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Proof of Crossplane Symmetry for a Conical Navier-Stokes Solver

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Abstract

A formal proof is given for the symmetry of a conical Navier-Stokes equation solver that has been employed in the computation of vortex asymmetries. The conical Navier-Stokes equations are presented as developed from the generalized coordinate three-dimensional Navier-Stokes equation approach. The solver is then discussed in detail. The proof is first sketched to clarify what must be shown to demonstrate symmetry. The details of the implicit and explicit side symmetry relations are then presented using in part the MACSYMA symbolic manipulation expert system.

Introduction

This report was prompted by the need to demonstrate symmetry for a conical Navier-Stokes algorithm used in studies of vortex asymmetry about cones at incidence. This issue arises because vortex asymmetry has been observed to occur "naturally" for the conical Navier-Stokes equations (i.e., without external perturbations) whereas it is apparently not observed in similar three-dimensional Navier-Stokes calculations. Vortex asymmetry is found in two of three possible solutions to the nonlinear equation set. These solutions have been found to be stable to perturbations whereas the third (symmetric) solution is thought to be unstable. In fact, the asymmetric solution is found after the solver has converged partially to the symmetric solution. It is felt that roundoff error perturbations excite the instability and redirect the solver to the asymmetric solution. However, it is also conceivable that some algorithm related asymmetries exist which produce the same result, thereby negating any conclusions drawn from solutions obtained by these solvers. It is therefore imperative that the algorithm be symmetric before computational arithmetic is employed.

The following sections report the governing equations that form the basis of this solver, the numerical method used and finally the symmetry proof.

Governing Equations

The conical thin-layer Navier-Stokes equations are obtained from discretizations of the generalized coordinate three-dimensional thin-layer Navier-Stokes equations. A grid is chosen such that the ξ-direction is along rays from the cone tip. Properties are then assumed constant along these rays. In their most general sense the thin-layer Navier-Stokes equations may be written

$$\frac{\partial Q}{\partial \tau} + \frac{\partial F_i}{\partial \xi} + \frac{\partial (G_i - S_v)}{\partial \eta} + \frac{\partial H_i}{\partial \zeta} = 0 \qquad (1)$$

where

$$Q = \begin{bmatrix} \rho \\ \rho u \\ \rho v \\ \rho w \\ e \end{bmatrix} \quad F_i = \frac{1}{J}\begin{bmatrix} \rho U \\ \rho u U + \xi_x p \\ \rho v U + \xi_y p \\ \rho w U + \xi_z p \\ (e+p)U \end{bmatrix} \quad G_i = \frac{1}{J}\begin{bmatrix} \rho V \\ \rho u V + \eta_x p \\ \rho v V + \eta_y p \\ \rho w V + \eta_z p \\ (e+p)V \end{bmatrix}$$

$$H_i = \frac{1}{J}\begin{bmatrix} \rho W \\ \rho u W + \zeta_x p \\ \rho v W + \zeta_y p \\ \rho w W + \zeta_z p \\ (e+p)W \end{bmatrix} \quad S_v = \frac{M_\infty \mu}{Re_L J}\begin{bmatrix} 0 \\ \eta_x \sigma_x + \eta_y \tau_{xy} + \eta_z \tau_{xz} \\ \eta_x \tau_{xy} + \eta_y \sigma_y + \eta_z \tau_{yz} \\ \eta_x \tau_{xz} + \eta_y \tau_{yz} + \eta_z \sigma_z \\ \bar{u} S_{v_2} + \bar{v} S_{v_3} + \bar{w} S_{v_4} - \eta_x q_x - \eta_y q_y - \eta_z q_z \end{bmatrix}$$

$$\begin{aligned} U &= \xi_x u + \xi_y v + \xi_z w \\ V &= \eta_x u + \eta_y v + \eta_z w \\ W &= \zeta_x u + \zeta_y v + \zeta_z w \end{aligned}$$

with $\bar{u}, \bar{v}$ & $\bar{w}$ as average velocities between cells and $\sigma_x, \sigma_y, \sigma_z, \tau_{xy}, \tau_{xz}$ & τ_{yz} having their usual definitions.

A steady form of the above equations is found by neglecting the time derivative of the conserved variables. The resulting equations are solved on a single crossflow (η,ζ) plane grid in which the ξ-direction lines are rays from the cone tip or origin. The conical equations result when constant property boundary conditions are enforced in the radial direction, as described later in the numerical method section. It should be noted that these boundary conditions are necessary only because a three-dimensional solver has been modified to form the conical solver. Boundary conditions are needed only on the surface and far field boundaries for the conical Navier-Stokes equations.

Numerical Method

An implicit upwind symmetric factorization finite volume scheme was employed to solve the above equations. The basic algorithm consists of the implicit or left hand side (LHS) and the explicit or right hand side (RHS) in the form

$$LHS(Q^n)\,\Delta^n Q = RHS(Q^n) \qquad (2)$$

An iteration proceeds from a known Q^n to Q^{n+1} by solving equation (2) for $\Delta^n Q$ and using

$$Q^{n+1} = Q^n + \Delta^n Q$$

RHS

The RHS is differenced using Roe's [Roe] flux difference splitting (FDS) and the Van Albada [VanAl] limiter through Van Leer's [VanLe] MUSCL approach. A convenient way of writing the FDS is presented by Vatsa, Thomas and Wedan [VTW], who detail the contribution of the ξ-direction fluxes as

$$\frac{\partial F}{\partial \xi} = \frac{F_{i+1/2} - F_{i-1/2}}{\Delta \xi}$$

where

$$F_{i+1/2} = \frac{1}{2}\left[F(Q_L) + F(Q_R) - |\tilde{A}|(Q_R - Q_L)\right]_{i+1/2}$$

and Q_L and Q_R are functions of neighboring points as described later in the limiter section and $|\tilde{A}|$ is the diagonalized matrix

$$|\tilde{A}| = T|\Lambda|T^{-1}$$

formed from the Roe averaged variables (a function of Q_L and Q_R) with Λ the diagonal eigenvalue matrix, T the matrix of left eigenvectors of A and T^{-1} the matrix of right eigenvectors of A. Note that these matrices are also used for the LHS but in a slightly different form. The actual matrices can be found in several places including the Vatsa, Thomas and Wedan reference or through the MACSYMA outputs to be presented in a later section.

Flux Limiters

Of interest at this point is how Q_L and Q_R are chosen. In this work Van Leer's [VanLe] MUSCL approach is utilized with the Van Albada [VanAl] flux limiter. The MUSCL approach can be utilized with many limiters, as such, it can be written as

$$Q_L = Q_i + \frac{1}{4}\left\{(1-\kappa)\hat{\Delta}_{i-1/2} + (1+\kappa)\tilde{\Delta}_{i+1/2}\right\}$$

$$Q_R = Q_{i+1} - \frac{1}{4}\left\{(1+\kappa)\hat{\Delta}_{i+1/2} + (1-\kappa)\tilde{\Delta}_{i+3/2}\right\}$$

The Van Albada limiter is obtained by setting $\kappa = 1$

$$Q_L = Q_i + \frac{1}{2}\tilde{\Delta}_{i+1/2}$$

$$Q_R = Q_{i+1} - \frac{1}{2}\hat{\Delta}_{i+1/2} = Q_{i+1} - \frac{1}{2}\tilde{\Delta}_{i+3/2}$$

and

$$\tilde{\Delta}_{i+1/2} = \frac{\Delta_{i-1/2}\left[\Delta^2_{i+1/2} + \epsilon\right] + \Delta_{i+1/2}\left[\Delta^2_{i-1/2} + \epsilon\right]}{\Delta^2_{i+1/2} + \Delta^2_{i-1/2} + 2\epsilon}$$

where $$\Delta_{i+1/2} = Q_{i+1} - Q_i$$

The value of ϵ is typically taken to be a small number to avoid spurious zero divisions.

The above describes how the inviscid terms of the RHS are calculated. The viscous terms are included through central differencing of S_v. This completely describes the algorithm solved via the implicit system. Details of the algorithm can be obtained through the references or by examining the input to MACSYMA for the symmetry checks.

LHS

The LHS can be described by discretizing equation (1) using a simple implicit scheme

$$\frac{\Delta^n Q}{\Delta\tau} + \frac{\partial F_i^{n+1}}{\partial\xi} + \frac{\partial(G_i^{n+1} - S_v^{n+1})}{\partial\eta} + \frac{\partial H_i^{n+1}}{\partial\zeta} = 0 \tag{3}$$

Subtracting the n-level steady terms from both sides and dropping the viscous terms from the LHS gives

$$\begin{aligned}\frac{\Delta^n Q}{\Delta\tau} + \frac{\partial(F_i^{n+1} - F_i^{n})}{\partial\xi} + \frac{\partial(G_i^{n+1} - G_i^{n})}{\partial\eta} + \frac{\partial(H_i^{n+1} - H_i^{n})}{\partial\zeta} \\ = -\left[\frac{\partial F_i^{n}}{\partial\xi} + \frac{\partial(G_i^{n} - S_v^{n})}{\partial\eta} + \frac{\partial H_i^{n}}{\partial\zeta}\right] = -RHS^n\end{aligned} \tag{4}$$

and linearizing the inviscid fluxes about the n^{th} level

$$F_i^{n+1} \approx F_i^n + \left.\frac{\partial F_i}{\partial Q}\right|_n \Delta Q^n = F_i^n + A^n \Delta^n Q \tag{5}$$

$$G_i^{n+1} \approx G_i^n + \left.\frac{\partial G_i}{\partial Q}\right|_n \Delta Q^n = G_i^n + B^n \Delta^n Q \tag{6}$$

$$H_i^{n+1} \approx H_i^n + \left.\frac{\partial H_i}{\partial Q}\right|_n \Delta Q^n = H_i^n + C^n \Delta^n Q \tag{7}$$

The above describes how the inviscid terms of the RHS are calculated. The viscous terms are included through central differencing of S_v. This completely describes the algorithm solved via the implicit system. Details of the algorithm can be obtained through the references or by examining the input to MACSYMA for the symmetry checks.

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$$\frac{\Delta^n Q}{\Delta\tau} + \frac{\partial F_i^{n+1}}{\partial\xi} + \frac{\partial(G_i^{n+1} - S_v^{n+1})}{\partial\eta} + \frac{\partial H_i^{n+1}}{\partial\zeta} = 0 \tag{3}$$

Subtracting the n-level steady terms from both sides and dropping the viscous terms, S_v^{n+1} and S_v^n, from the LHS gives

$$\frac{\Delta^n Q}{\Delta\tau} + \frac{\partial(F_i^{n+1} - F_i^n)}{\partial\xi} + \frac{\partial(G_i^{n+1} - G_i^n)}{\partial\eta} + \frac{\partial(H_i^{n+1} - H_i^n)}{\partial\zeta} \tag{4}$$
$$= -\left[\frac{\partial F_i^n}{\partial\xi} + \frac{\partial(G_i^n - S_v^n)}{\partial\eta} + \frac{\partial H_i^n}{\partial\zeta}\right] = -RHS^n$$

and linearizing the inviscid fluxes about the n^{th} level

$$F_i^{n+1} \approx F_i^n + \left.\frac{\partial F_i}{\partial Q}\right|_n \Delta Q^n = F_i^n + A^n\Delta^n Q \tag{5}$$

$$G_i^{n+1} \approx G_i^n + \left.\frac{\partial G_i}{\partial Q}\right|_n \Delta Q^n = G_i^n + B^n\Delta^n Q \tag{6}$$

$$H_i^{n+1} \approx H_i^n + \left.\frac{\partial H_i}{\partial Q}\right|_n \Delta Q^n = H_i^n + C^n\Delta^n Q \tag{7}$$

results in

$$\frac{\Delta^n Q}{\Delta\tau} + \frac{\partial}{\partial\xi}(A^n \Delta^n Q) + \frac{\partial}{\partial\eta}(B^n \Delta^n Q) + \frac{\partial}{\partial\zeta}(C^n \Delta^n Q) = -RHS^n$$

or, in operator notation

$$\left[\frac{I}{\Delta\tau} + \left(\frac{\partial A}{\partial\xi}\right)^n + \left(\frac{\partial B}{\partial\eta}\right)^n + \left(\frac{\partial C}{\partial\zeta}\right)^n\right]\Delta^n Q = -RHS^n \qquad (8)$$

Finally, multiplying by $\Delta\tau$ gives

$$\left[I + \Delta\tau\left\{\left(\frac{\partial A}{\partial\xi}\right)^n + \left(\frac{\partial B}{\partial\eta}\right)^n + \left(\frac{\partial C}{\partial\zeta}\right)^n\right\}\right]\Delta^n Q = -\Delta\tau RHS^n \qquad (9)$$

where RHS^n is obtained as described above. It is important to note that the scheme is now "semi" implicit since the viscous terms are lagged. However, this does not affect the solution at convergence since it is defined as a zero RHS to machine accuracy. Next the LHS is differenced using the Steger-Warming flux vector splitting (FVS). The scheme can be written

$$\left(I + \Delta\tau\left\{\nabla_\xi A^+ + \Delta_\xi A^- + \nabla_\eta B^+ + \Delta_\eta B^- + \nabla_\zeta C^+ + \Delta_\zeta C^-\right\}\right)\Delta^n Q$$
$$= -\Delta\tau RHS^n \qquad (10)$$

Where $A^\pm, B^\pm, C^\pm$ are the generalized coordinate Steger-Warming [StegWar] FVS Jacobians; $\Delta\xi$, $\Delta\eta$, $\Delta\zeta$ are assumed to be unity; and Δ_ξ and ∇_ξ, etc., are the standard two point forward and backward difference operators

$$\Delta_\xi(\ ) = (\ )_{i+1,j,k} - (\ )_{i,j,k}$$
$$\nabla_\xi(\ ) = (\ )_{i,j,k} - (\ )_{i-1,j,k}$$

It should be noted that the bracketed terms are acting as operators on $\Delta^n Q$ (i.e., $\Delta_\xi A^- \Delta^n Q = [A^- \Delta^n Q]_{i+1,j,k} - [A^- \Delta^n Q]_{i,j,k}$). Details of the Jacobian matrices can be found in the references or can be inferred from the proof. The above produces a block septa-diagonal system which is not easy to solve. However, the system can be approximately factored so that two block tetra-diagonal systems result

$$\left(I + \Delta\tau\left\{\nabla_\xi A^+ + \nabla_\eta B^+ + \Delta_\eta B^-\right\}\right) \left(I + \Delta\tau\left\{\Delta_\xi A^- + \nabla_\zeta C^+ + \Delta_\zeta C^-\right\}\right)\Delta^n Q = -\Delta\tau RHS^n \tag{11}$$

This system can then be solved in two steps

$$\left(I + \Delta\tau\left\{\nabla_\xi A^+ + \nabla_\eta B^+ + \Delta_\eta B^-\right\}\right)Q^* = -\Delta\tau RHS^n \tag{12a}$$

$$\left(I + \Delta\tau\left\{\Delta_\xi A^- + \nabla_\zeta C^+ + \Delta_\zeta C^-\right\}\right)\Delta^n Q = Q^* \tag{12b}$$

by employing a block tri-diagonal solver while sweeping the ξ-direction in (η,ζ)-planes. For three dimensional problems, forward sweeps are used for equation (12a) and backward sweeps for equation (12b). It is important to note that the above system is symmetric in ζ since both C^+ and C^- are in the same factor. This will become more apparent in the symmetry proof.

The conical solver uses equation (12) in a somewhat abbreviated form. That is, only one plane of cells is considered, therefore,

$$\Delta_\xi A^- \approx -A^-_{i,j,k}$$
$$\nabla_\xi A^- \approx A^-_{i,j,k}$$

This approximation essentially assumes that $\Delta^n Q=0$ for the off plane terms (although they are computed through the conical flow boundary condition.) This term can be removed to improve algorithm efficiency, but has no detrimental effect on the solution. It was retained in the current solver. In any event, it has no bearing on algorithm symmetry as will be shown in the proof.

The conical LHS is as described above and is always solved on a conical grid.

Symmetry Proof

The MACSYMA symbolic manipulation expert system was used to determine the symmetry of the above algorithm. The proof is first sketched in a general sense to provide an overview and then the details are presented.

General Proof

As presented earlier, the conical solver was developed from a generalized coordinate three dimensional solver by simplifying the algorithm when applied on a conical grid. If Cartesian coordinates are used to describe the physical space, the x-direction corresponds to the cone axis; the y-direction is vertical, such that incidence is achieved by a pitch up in the (x,y) plane; and the z-direction is orthogonal to the (x,y) plane. In the computational space the ξ-direction lines are rays from the cone tip and the (η,ζ) plane is perpendicular to the cone axis, with the η-direction normal to the axis and the ζ-direction azimuthal.

For this geometry and grid, symmetry in the crossplane requires that the mirror image grid points (i,j,k) and $(\hat{i},\hat{j},\hat{k})$ at locations (x,y,z) and (x,y,-z), respectively, must have

$$Q_{ijk} = MQ_{\hat{i}\hat{j}\hat{k}}$$

where

$$Q = \begin{bmatrix} \rho \\ \rho u \\ \rho v \\ \rho w \\ e \end{bmatrix} \qquad and \qquad M = \begin{bmatrix} 1 & 0 & 0 & 0 & 0 \\ 0 & 1 & 0 & 0 & 0 \\ 0 & 0 & 1 & 0 & 0 \\ 0 & 0 & 0 & -1 & 0 \\ 0 & 0 & 0 & 0 & 1 \end{bmatrix}$$

Clearly, $M = M^{-1}$.

Furthermore, the metrics are related in the following manner

$$
\begin{aligned}
\left(\frac{\xi_x}{J}\right)_{i,j,k} &= \left(\frac{\xi_x}{J}\right)_{\hat{i},\hat{j},\hat{k}} \\
\left(\frac{\xi_y}{J}\right)_{i,j,k} &= \left(\frac{\xi_y}{J}\right)_{\hat{i},\hat{j},\hat{k}} = 0 \\
\left(\frac{\xi_z}{J}\right)_{i,j,k} &= \left(\frac{\xi_z}{J}\right)_{\hat{i},\hat{j},\hat{k}} = 0 \\
\left(\frac{\eta_x}{J}\right)_{i,j,k} &= \left(\frac{\eta_x}{J}\right)_{\hat{i},\hat{j},\hat{k}} \\
\left(\frac{\eta_y}{J}\right)_{i,j,k} &= \left(\frac{\eta_y}{J}\right)_{\hat{i},\hat{j},\hat{k}} \\
\left(\frac{\eta_z}{J}\right)_{i,j,k} &= -\left(\frac{\eta_z}{J}\right)_{\hat{i},\hat{j},\hat{k}} \\
\left(\frac{\zeta_x}{J}\right)_{i,j,k} &= -\left(\frac{\zeta_x}{J}\right)_{\hat{i},\hat{j},\hat{k}} \\
\left(\frac{\zeta_y}{J}\right)_{i,j,k} &= -\left(\frac{\zeta_y}{J}\right)_{\hat{i},\hat{j},\hat{k}} \\
\left(\frac{\zeta_z}{J}\right)_{i,j,k} &= \left(\frac{\zeta_z}{J}\right)_{\hat{i},\hat{j},\hat{k}}
\end{aligned}
$$

Hence, the cell contravariant velocities

$$
\begin{aligned}
U &= \xi_x u + \xi_y v + \xi_z w \\
V &= \eta_x u + \eta_y v + \eta_z w \\
W &= \zeta_x u + \zeta_y v + \zeta_z w
\end{aligned}
$$

are related as per

$$U_{i,j,k} = U_{\hat{i}\hat{j}\hat{k}}, \quad V_{i,j,k} = V_{\hat{i},\hat{j}\hat{k}}, \quad W_{i,j,k} = -W_{\hat{i}\hat{j}\hat{k}}$$

To prove symmetry we start with the assumption that the solution from the previous iteration (n-1) is symmetric (for n=1, this implies the initial condition is symmetric), hence

$$RHS^{n}_{i,j,k} = M\,RHS^{n}_{\hat{i}\hat{j}\hat{k}} \qquad (13)$$

Consequently, we expect the intermediate "solution" obtained by solving equation (12a) to be symmetric

$$Q^{*}_{i,j,k} = M\,Q^{*}_{\hat{i},\hat{j}\hat{k}} \qquad (14)$$

and hence, the final solution is also symmetric because the change obtained by solving equation (12b) is symmetric

$$\Delta^{n}Q_{i,j,k} = M\,\Delta^{n}Q_{\hat{i},\hat{j},\hat{k}} \qquad (15)$$

RHS

Referring to equation (1) it is easy to show that a simple central difference of the RHS is symmetric since

$$\begin{aligned} F_{i,j,k} &= MF_{\hat{i}\hat{j}\hat{k}} \\ G_{i,j,k} &= MG_{\hat{i}\hat{j}\hat{k}} \\ H_{i,j,k} &= -MH_{\hat{i}\hat{j}\hat{k}} \end{aligned}$$

and because the azimuthal ordering prescribes the correspondence $(i,j,k+1)$ to $(\hat{i},\hat{j},\hat{k}-1)$ and $(i,j,k-1)$ to $(\hat{i},\hat{j},\hat{k}+1)$

$$H_{i,j,k\pm 1} = -MH_{\hat{i}\hat{j}\hat{k}\mp 1}$$

therefore,

$$\left(\frac{\partial F}{\partial \xi}\right)_{ijk} = M\left(\frac{\partial F}{\partial \xi}\right)_{\hat{i}\hat{j}\hat{k}}$$
$$\left(\frac{\partial G}{\partial \eta}\right)_{ijk} = M\left(\frac{\partial G}{\partial \eta}\right)_{\hat{i}\hat{j}\hat{k}}$$
$$\left(\frac{\partial H}{\partial \zeta}\right)_{ijk} = M\left(\frac{\partial H}{\partial \zeta}\right)_{\hat{i}\hat{j}\hat{k}}$$

This relationship can also be demonstrated for the flux limited Roe FDS discretization, but it is not visually apparent from the equations. It should be noted that the azimuthal ordering oddity significantly complicates the MACSYMA comparison because it requires the identification of the corresponding terms a priori, since the performance of MACSYMA is related to the complexity of the expressions. The MACSYMA derived proof for the RHS requires two steps; demonstrate symmetry for the flux limited variables and then symmetry for the remaining terms. A separate proof is given for each direction as this reduces the MACSYMA workload to a manageable size. These proofs are found in the RHS Proof section following the general proof.

LHS

The LHS expressions also contain the ζ-direction oddity, however, symmetry is easily demonstrated because the following relationships can be proved

$$A^{\pm}_{ijk}M = MA^{\pm}_{\hat{i}\hat{j}\hat{k}} \tag{16}$$
$$B^{\pm}_{ijk}M = MB^{\pm}_{\hat{i}\hat{j}\hat{k}} \tag{17}$$
$$C^{\pm}_{ijk}M = -MC^{\mp}_{\hat{i}\hat{j}\hat{k}} \tag{18}$$

In addition, we have

$$C^{\pm}_{ijk\pm1}M = -MC^{\mp}_{\hat{i}\hat{j}\hat{k}\mp1} \tag{19}$$

due to the azimuthal direction ordering reversal. These relations will be proven in the LHS Proof section. It should be clear that symmetry cannot be guaranteed in the algorithm unless C^{+} and C^{-} appear in the same factor.

Given the above relationships consider equation (12a) at point (i,j,k) with the operators expanded

$$\begin{aligned} Q^*_{ij,k} + \Delta\tau\Big([A^+Q^*]_{i,j,k} - [A^+Q^*]_{i-1,j,k} + [B^+Q^*]_{ij,k} - [B^+Q^*]_{i,j-1,k} \\ + [B^-Q^*]_{i,j+1,k} - [B^-Q^*]_{ij,k}\Big) = RHS^n_{ij,k} \end{aligned} \tag{20}$$

and at the point $(\hat{i},\hat{j},\hat{k})$

$$\begin{aligned} Q^*_{\hat{i}\hat{j}\hat{k}} + \Delta\tau\Big[A^+Q^*]_{\hat{i},\hat{j},\hat{k}} - [A^+Q^*]_{\hat{i}-1,\hat{j},\hat{k}} + [B^+Q^*]_{\hat{i}\hat{j}\hat{k}} - [B^+Q^*]_{\hat{i},\hat{j}-1,\hat{k}} \\ + [B^-Q^*]_{\hat{i}\hat{j}+1,\hat{k}} - [B^-Q^*]_{\hat{i},\hat{j},\hat{k}}\Big) = RHS^n_{\hat{i}\hat{j}\hat{k}} \end{aligned} \tag{21}$$

Pre-multiply equation (21) by M and use equation (13) to obtain

$$\begin{aligned} MQ^*_{\hat{i},\hat{j},\hat{k}} + \Delta\tau\Big([MA^+Q^*]_{\hat{i},\hat{j},\hat{k}} - [MA^+Q^*]_{\hat{i}-1,\hat{j},\hat{k}} + [MB^+Q^*]_{\hat{i},\hat{j},\hat{k}} - [MB^+Q^*]_{\hat{i},\hat{j}-1,\hat{k}} \\ + [MB^-Q^*]_{\hat{i},\hat{j}+1,\hat{k}} - [MB^-Q^*]_{\hat{i}\hat{j}\hat{k}}\Big) = RHS^n_{i,j,k} \end{aligned} \tag{22}$$

Using relations (16)-(18) in equation (22) gives

$$\begin{aligned} MQ^*_{\hat{i}\hat{j}\hat{k}} + \Delta\tau\Big(A^+_{i,j,k}MQ^*_{\hat{i}\hat{j}\hat{k}} - A^+_{i-1,j,k}MQ^*_{\hat{i}-1,\hat{j},\hat{k}} + B^+_{i,j,k}MQ^*_{\hat{i}\hat{j}\hat{k}} \\ -B^+_{i,j-1,k}MQ^*_{\hat{i},\hat{j}-1,\hat{k}} + B^-_{i,j+1,k}MQ^*_{\hat{i},\hat{j}+1,\hat{k}} - B^-_{i,j,k}MQ^*_{\hat{i},\hat{j},\hat{k}}\Big) = RHS^n_{i,j,k} \end{aligned} \tag{23}$$

Subtracting equation (23) from (20) yields

$$\begin{aligned} [Q^*_{ij,k} - MQ^*_{\hat{i}\hat{j}\hat{k}}] + \Delta\tau\Big(A^+_{i,j,k}[Q^*_{ij,k} - MQ^*_{\hat{i}\hat{j}\hat{k}}] - A^+_{i-1,j,k}[Q^*_{i-1,j,k} - MQ^*_{\hat{i}-1,\hat{j},\hat{k}}] \\ + B^+_{i,j,k}[Q^*_{i,j,k} - MQ^*_{\hat{i}\hat{j}\hat{k}}] - B^+_{i,j-1,k}[Q^*_{i,j-1,k} - MQ^*_{\hat{i},\hat{j}-1,\hat{k}}] \\ + B^-_{i,j+1,k}[Q^*_{i,j+1,k} - MQ^*_{\hat{i},\hat{j}+1,\hat{k}}] - B^-_{i,j,k}[Q^*_{i,j,k} - MQ^*_{\hat{i},\hat{j},\hat{k}}]\Big) = 0 \end{aligned}$$

The first, second, fourth and seventh terms within brackets imply equation (14)

$$Q^*_{i,j,k} = MQ^*_{\hat{i}\hat{j}\hat{k}}$$

Similarly, the third term implies

$$Q^*_{i-1,j,k} = MQ^*_{\hat{i}-1\hat{j}\hat{k}}$$

and the fifth and sixth terms imply

$$Q^*_{i,j\pm1,k} = MQ^*_{\hat{i}\hat{j}\pm\hat{k}}$$

which, given equations (16)-(18), proves the symmetry of the intermediate step.

Consider next the discretized equation (12b) at the point (i,j,k)

$$\Delta^n Q_{i,j,k} + \Delta\tau\Big([A^-\Delta^n Q]_{i+1,j,k} - [A^-\Delta^n Q]_{i,j,k} + [C^+\Delta^n Q]_{i,j,k} - [C^+\Delta^n Q]_{i,j,k-1} + [C^-\Delta^n Q]_{i,j,k+1} - [C^-\Delta^n Q]_{i,j,k}\Big) = Q^*_{i,j,k} \quad (24)$$

and at point $(\hat{i}\hat{j}\hat{k})$

$$\Delta^n Q_{\hat{i}\hat{j}\hat{k}} + \Delta\tau\Big([A^-\Delta^n Q]_{\hat{i}+1,\hat{j}\hat{k}} - [A^-\Delta^n Q]_{\hat{i}\hat{j}\hat{k}} + [C^+\Delta^n Q]_{\hat{i}\hat{j}\hat{k}} - [C^+\Delta^n Q]_{\hat{i}\hat{j}\hat{k}-1} + [C^-\Delta^n Q]_{\hat{i}\hat{j},\hat{k}+1} - [C^-\Delta^n Q]_{\hat{i}\hat{j}\hat{k}}\Big) = Q^*_{\hat{i}\hat{j},\hat{k}} \quad (25)$$

Pre-multiply equation (25) by M and use equation (14) to obtain

$$M\Delta^n Q_{\hat{i}\hat{j}\hat{k}} + \Delta\tau\Big([MA^-\Delta^n Q]_{\hat{i}+1\hat{j}\hat{k}} - [MA^-\Delta^n Q]_{\hat{i}\hat{j},\hat{k}} + [MC^+\Delta^n Q]_{\hat{i}\hat{j},\hat{k}} - [MC^+\Delta^n Q]_{\hat{i}\hat{j}\hat{k}-1} + [MC^-\Delta^n Q]_{\hat{i}\hat{j}\hat{k}+1} - [MC^-\Delta^n Q]_{\hat{i}\hat{j}\hat{k}}\Big) = Q^*_{i,j,k} \quad (26)$$

Using relations (16)-(19) in equation (26) gives

$$M\Delta^n Q_{\hat{i}\hat{j}\hat{k}} + \Delta\tau\Big(A^-_{i+1,j,k} M\Delta^n Q_{\hat{i}+1\hat{j},\hat{k}} - A^-_{i,j,k} M\Delta^n Q_{\hat{i}\hat{j},\hat{k}} - C^-_{i,j,k}\Delta^n Q_{\hat{i}\hat{j}\hat{k}} + C^-_{i,j,k-1} M\Delta^n Q_{\hat{i}\hat{j}\hat{k}-1} - C^+_{i,j,k+1} M\Delta^n Q_{\hat{i}\hat{j}\hat{k}+1} + C^+_{i,j,k} M\Delta^n Q_{\hat{i}\hat{j}\hat{k}}\Big) = Q^*_{i,j,k} \quad (27)$$

Subtracting equation (27) from equation (24) yields

$$
\begin{aligned}
&[\Delta^n Q_{i,j,k} - M\Delta^n Q_{\hat{i},\hat{j},\hat{k}}] \qquad\qquad (28)\\
&\quad + \Delta\tau\Big(A^-_{i+1,j,k}[\Delta^n Q_{i+1,j,k} - M\Delta^n Q_{\hat{i}+1,\hat{j},\hat{k}}] - A^-_{i,j,k}[\Delta^n Q_{i,j,k} - M\Delta^n Q_{\hat{i},\hat{j},\hat{k}}]\\
&\quad - C^-_{i,j,k}[\Delta^n Q_{i,j,k} - M\Delta^n Q_{\hat{i},\hat{j},\hat{k}}] + C^-_{i,j,k+1}[\Delta^n Q_{i,j,k+1} - M\Delta^n Q_{\hat{i},\hat{j},\hat{k}-1}]\\
&\quad - C^+_{i,j,k-1}[\Delta^n Q_{i,j,k-1} - M\Delta^n Q_{\hat{i},\hat{j},\hat{k}+1}] + C^+_{i,j,k}[\Delta^n Q_{i,j,k} - M\Delta^n Q_{\hat{i},\hat{j},\hat{k}}]\Big) = 0
\end{aligned}
$$

The first, third, fourth and seventh terms within brackets imply equation (15)

$$\Delta^n Q_{i,j,k} = M\Delta^n Q_{\hat{i}\hat{j}\hat{k}}$$

Similarly, the second term implies

$$\Delta^n Q_{i+1,j,k} = M\Delta^n Q_{\hat{i}+1,\hat{j},\hat{k}}$$

and the fifth and sixth terms imply

$$\Delta^n Q_{i,j,k\pm 1} = M\Delta^n Q_{\hat{i}\hat{j}\hat{k}\mp 1}$$

which is what needs to be proved. Using logic similar to that above this property holds for all (i, j, k) in the linear system and the algorithm is found to be symmetric.

RHS Proof

Proof of symmetry for the RHS requires that equation (13) be demonstrated. The RHS discretization is detailed in the Numerical Method section as it is applied to the steady form of equation (1). It is quite clear from that discussion that the discretization is rather complicated, therefore, the symmetry of the flux terms for each direction are demonstrated separately. The ξ-direction term is relatively straightforward and requires no additional manipulation, however, the η and ζ-direction terms are much more involved and the MACSYMA system was utilized.

ξ- Direction

Recall that the ξ-direction flux term may be written

$$\frac{\partial F_i}{\partial \xi} = \frac{F_{i+1/2} - F_{i-1/2}}{\Delta \xi}$$

where

$$F_{i+1/2} = \frac{1}{2}\left[F(Q_R) + F(Q_L) - |\tilde{A}|(Q_R - Q_L)\right]_{i+1/2}$$

The conical Navier-Stokes solver employs a conical grid and the assumption that properties are constant in the ξ-direction. Therefore, $Q_R - Q_L = 0$ and the scheme reverts to simple central difference in this direction. However, it is important to recognize that the flux contribution is not zero since $F(Q_R) \neq F(Q_L)$ due to the grid. In addition, for the conical grid, equation (1) gives

$$F_i = \frac{1}{J}\begin{bmatrix} \rho U \\ \rho u U + \xi_x p \\ \rho v U \\ \rho w U \\ (e+p)U \end{bmatrix}$$

In which only w has opposite sign when comparing points (i,j,k) and $(\hat{i},\hat{j},\hat{k})$.

It is therefore easy to see that

$$F_{i,j,k} = M F_{\hat{i},\hat{j},\hat{k}} \tag{29}$$

Hence,

$$\left(\frac{\partial F_i}{\partial \xi}\right)_{i,j,k} = M\left(\frac{\partial F_i}{\partial \xi}\right)_{\hat{i},\hat{j},\hat{k}}$$

η-Direction

Unfortunately, it is not as easy to demonstrate symmetry for the η-direction. In this case we must show that

$$\left(\frac{\partial (G_i - S_v)}{\partial \eta}\right)_{i,j,k} = M\left(\frac{\partial (G_i - S_v)}{\partial \eta}\right)_{\hat{i},\hat{j},\hat{k}}$$

Recall that

$$\left(\frac{\partial G_i}{\partial \eta}\right)_{i,j,k} = \frac{G_{i,j+1/2,k} - G_{i,j-1/2,k}}{\Delta \eta}$$

and

$$G_{i,j+1/2,k} = \frac{1}{2}\left[G(Q_R) + G(Q_L) - |\tilde{B}|\,(Q_R - Q_L)\right] \tag{30}$$

Then since $G_{i,j-1/2,k}$ is defined in a similar manner it is sufficient to show that

$$G_{i,j+1/2,k} = M G_{\hat{i},\hat{j}+1/2,\hat{k}} \tag{31}$$

and since central differences are used for the viscous terms

$$S_{v_{i,j,k}} = MS_{v_{\hat{i},\hat{j},\hat{k}}} \tag{32}$$

The MACSYMA symbolic manipulation system was utilized to demonstrate these relations. However, even in this simplified form MACSYMA requires further simplification. This can be accomplished by first demonstrating

$$\begin{aligned} Q_{R_{i,j+1/2,k}} &= MQ_{R_{\hat{i},\hat{j}+1/2,\hat{k}}} \\ Q_{L_{i,j+1/2,k}} &= MQ_{L_{\hat{i},\hat{j}+1/2,\hat{k}}} \end{aligned} \tag{33}$$

and then using these results to prove equation (30). The proof is therefore separated into a proof of equation (33), followed by a proof of equation (31) and finally a proof of equation (32). These proofs are accomplished respectively through the MACSYMA scripts Gflux1.max, Gflux2.mac and Gflux3.mac whose recorded inputs and results are found in files Gflux1, Gflux2 and Gflux3 in Appendix A. Note that all of the MACSYMA routines are included in the appendix for clarity. In addition, all demonstrate a zero difference between the selected terms, therefore, symmetry is proved when a null vector or matrix results. The routines themselves were written based on the actual code using identical variable names. Because of this, a few variable names are used several times. The code variables are identified with the notation discussed earlier in the Numerical Method section. It should be clear that the proofs for each direction are sequential, therefore, the results from the first in a series are used in the following series.

Gflux1 proves that given

$$\begin{aligned} dq_{i,j,k} &= \Delta_{i,j+1/2,k} = Q_{i,j+1,k} - Q_{i,j,k} = M(Q_{\hat{i},\hat{j}+1,\hat{k}} - Q_{\hat{i},\hat{j},\hat{k}}) = M\Delta_{\hat{i},\hat{j}+1/2,\hat{k}} = Mdq_{\hat{i},\hat{j},\hat{k}} \\ dqm1_{i,j,k} &= \Delta_{i,j-1/2,k} = Q_{i,j,k} - Q_{i,j-1,k} = M(Q_{\hat{i},\hat{j},\hat{k}} - Q_{\hat{i},\hat{j}-1,\hat{k}}) = M\Delta_{\hat{i},\hat{j}-1/2,\hat{k}} = Mdqm1_{\hat{i},\hat{j},\hat{k}} \\ dqp1_{i,j,k} &= \Delta_{i,j+3/2,k} = Q_{i,j+2,k} - Q_{i,j+1,k} = M(Q_{\hat{i},\hat{j}+2,\hat{k}} - Q_{\hat{i},\hat{j}+1,\hat{k}}) = M\Delta_{\hat{i},\hat{j}+3/2,\hat{k}} = Mdqp1_{\hat{i},\hat{j},\hat{k}} \\ qp_{i,j,k} &= Q_{R_{i,j+1/2,k}} = Q_{i,j+1,k} = MQ_{\hat{i},\hat{j}+1,\hat{k}} = MQ_{R_{\hat{i},\hat{j}+1/2,\hat{k}}} = Mqp_{\hat{i},\hat{j},\hat{k}} \\ qm_{i,j,k} &= Q_{L_{i,j+1/2,k}} = Q_{i,j,k} = MQ_{\hat{i},\hat{j},\hat{k}} = MQ_{L_{\hat{i},\hat{j}+1/2,\hat{k}}} = Mqm_{\hat{i},\hat{j},\hat{k}} \end{aligned}$$

the following holds

$$spl_{i,j,k} = \hat{\Delta}_{i,j+1/2,k} = M\hat{\Delta}_{\hat{i},\hat{j}+1/2,\hat{k}} = M\,sp2_{\hat{i},\hat{j},\hat{k}}$$
$$sml_{i,j,k} = \tilde{\Delta}_{i,j+1/2,k} = M\tilde{\Delta}_{\hat{i},\hat{j}+1/2,\hat{k}} = M\,sm2_{\hat{i},\hat{j},\hat{k}}$$

Note that the variables qp, qm and dq are then overwritten in the code to form higher order expressions for Q_R and Q_L using

$$\begin{aligned} qp_{i,j,k} &= Q_{i,j+1,k} - \frac{1}{2}spl_{i,j,k} = Q_{R_{i,j+1/2,k}} \\ &= M(Q_{\hat{i},\hat{j}+1,\hat{k}} - \frac{1}{2}sp2_{\hat{i},\hat{j},\hat{k}}) = MQ_{R_{\hat{i},\hat{j}+1/2,\hat{k}}} \\ qp_{i,j,k} &= Mqp_{\hat{i},\hat{j},\hat{k}} \end{aligned} \tag{34}$$

and

$$\begin{aligned} qm_{i,j,k} &= Q_{i,j,k} + \frac{1}{2}sml_{i,j,k} = Q_{L_{i,j+1/2,k}} \\ &= M(Q_{\hat{i},\hat{j},\hat{k}} + \frac{1}{2}sm2_{\hat{i},\hat{j},\hat{k}}) = MQ_{L_{\hat{i},\hat{j}+1/2,\hat{k}}} \\ qm_{i,j,k} &= Mqm_{\hat{i},\hat{j},\hat{k}} \end{aligned} \tag{35}$$

So that the symmetry relation for $dq = Q_R - Q_L$ is given by

$$\begin{aligned} dq_{i,j,k} &= qp_{i,j,k} - qm_{i,j,k} \\ &= M(qp_{\hat{i},\hat{j},\hat{k}} - qm_{\hat{i},\hat{j},\hat{k}}) \\ &= Mdq_{\hat{i},\hat{j},\hat{k}} \end{aligned} \tag{36}$$

Equations (34)-(36) are then used in Gflux2 to prove equation (31). Gflux3 completes the η-direction demonstrations by proving equation (32) using the variable gs in place of S_v.

ζ-Direction

The last direction is the most difficult because of the azimuthal ordering. It is easy to see that

$$\begin{aligned} k-2 &\leftrightarrow \hat{k}+2 \\ k-1 &\leftrightarrow \hat{k}+1 \\ k &\leftrightarrow \hat{k} \\ k+1 &\leftrightarrow \hat{k}-1 \\ k+2 &\leftrightarrow \hat{k}-2 \end{aligned}$$

Once again, the desired symmetry property is

$$\left(\frac{\partial H_i}{\partial \zeta}\right)_{i,j,k} = M\left(\frac{\partial H_i}{\partial \zeta}\right)_{\hat{i},\hat{j},\hat{k}}$$

where

$$\left(\frac{\partial H_i}{\partial \zeta}\right)_{i,j,k} = \frac{H_{i,j,k+1/2} - H_{i,j,k-1/2}}{\Delta\zeta}$$

and Roe's FDS gives

$$H_{i,j,k+1/2} = \frac{1}{2}\left[H(Q_R) + H(Q_L) - |\tilde{C}|\,(Q_R - Q_L)\right]_{i,j,k+1/2} \qquad (37)$$

Therefore, the symmetry relation that must be proved is

$$H_{i,j,k+1/2} = -M H_{\hat{i},\hat{j},\hat{k}-1/2} \qquad (38)$$

Once again, the first proof, Hflux1, shows that given

$$
\begin{aligned}
dq_{ij,k} &= \Delta_{i,j,k+1/2} = Q_{i,j,k+1} - Q_{i,j,k} = M(Q_{\hat{i}\hat{j}\hat{k}-1} - Q_{\hat{i}\hat{j}\hat{k}}) = -M\Delta_{\hat{i}\hat{j}\hat{k}-1/2} = -Mdq_{\hat{i}\hat{j}\hat{k}-1} \\
dqp1_{i,j,k} &= \Delta_{i,j,k+3/2} = Q_{i,j,k+2} - Q_{i,j,k+1} = M(Q_{\hat{i}\hat{j}\hat{k}-2} - Q_{\hat{i}\hat{j}\hat{k}-1}) = -M\Delta_{\hat{i}\hat{j},\hat{k}-3/2} = -Mdqm1_{\hat{i}\hat{j}\hat{k}-1} \\
dqm1_{i,j,k} &= \Delta_{i,j,k-1/2} = Q_{i,j,k} - Q_{i,j,k-1} = M(Q_{\hat{i}\hat{j}\hat{k}} - Q_{\hat{i}\hat{j}\hat{k}+1}) = -M\Delta_{\hat{i}\hat{j}\hat{k}+1/2} = -Mdqp1_{\hat{i}\hat{j}\hat{k}-1} \\
qp_{i,j,k} &= Q_{i,j,k+1} = MQ_{\hat{i}\hat{j}\hat{k}-1} = Mqm_{\hat{i}\hat{j}\hat{k}-1} \\
qm_{i,j,k} &= Q_{i,j,k} = MQ_{\hat{i}\hat{j}\hat{k}} = Mqp_{\hat{i}\hat{j}\hat{k}-1}
\end{aligned}
$$

the following holds

$$
\begin{aligned}
sp1_{i,j,k} &= \hat{\Delta}_{i,j,k+1/2} = -M\hat{\Delta}_{\hat{i}\hat{j},\hat{k}-1/2} = -Msm2_{\hat{i}\hat{j}\hat{k}-1} \\
sm1_{i,j,k} &= \tilde{\Delta}_{i,j,k+1/2} = -M\tilde{\Delta}_{\hat{i}\hat{j},\hat{k}-1/2} = -Msp2_{\hat{i}\hat{j}\hat{k}-1}
\end{aligned}
$$

Then since

$$
\begin{aligned}
qp_{i,j,k} &= Q_{i,j,k+1} - \frac{1}{2}sp1_{i,j,k} = Q_{R_{i,j,k+1/2}} \\
&= M(Q_{\hat{i}\hat{j}\hat{k}-1} + \frac{1}{2}sm2_{\hat{i}\hat{j},\hat{k}-1}) = MQ_{L\hat{i}\hat{j},\hat{k}-1/2} \\
qp_{i,j,k} &= M\,qm_{\hat{i}\hat{j},\hat{k}-1} \qquad (39)
\end{aligned}
$$

similarly

$$
\begin{aligned}
qm_{i,j,k} &= Q_{i,j,k} + \frac{1}{2}sm1_{i,j,k} \\
&= M(Q_{\hat{i}\hat{j}\hat{k}} - \frac{1}{2}sp2_{\hat{i}\hat{j}\hat{k}-1}) \\
qm_{i,j,k} &= Mqp_{\hat{i}\hat{j}\hat{k}-1} \qquad (40)
\end{aligned}
$$

So the symmetry relation for $dq = Q_R - Q_L$ is given by

$$\begin{aligned} dq_{i,j,k} &= qp_{i,j,k} - qm_{i,j,k} \\ &= M(qm_{\hat{i},\hat{j},\hat{k}-1} - qp_{\hat{i},\hat{j},\hat{k}-1}) \\ &= -M dq_{\hat{i},\hat{j},\hat{k}-1} \end{aligned} \tag{41}$$

Equations (39)-(41) are then used in Hflux2 to prove equation (38).

Equations (29), (31), (32) and (38) collectively prove equation (13) and symmetry is demonstrated from the RHS.

LHS Proof

The LHS proof is somewhat simpler to describe because a major portion of it has been presented in the General Proof section. Equations (16) - (18) must be proved to demonstrate the symmetry of the LHS. IN addition, the expressions to be evaluated are considerably more complicated than their RHS counterparts. Because of this the eigenvalues were included in a less general form (i.e., without absolute values) for specific sub- and supersonic cases.

Again the MACSYMA symbolic manipulation routine was used and the resulting scripts are included in Appendix A. The files have the following naming convention

$A^{+}_{ij,k}M = MA^{+}_{\hat{i},\hat{j},\hat{k}}$	- apsup	- supersonic
	- apsub	- subsonic
$A^{-}_{ij,k}M = MA^{-}_{\hat{i},\hat{j},\hat{k}}$	- amsup	- supersonic
	- amsub	- subsonic
$B^{+}_{ij,k}M = MB^{+}_{\hat{i},\hat{j},\hat{k}}$	- bpsup	- supersonic
	- bpsub	- subsonic
$B^{-}_{ij,k}M = MB^{-}_{\hat{i},\hat{j},\hat{k}}$	- bmsup	- supersonic
	- bmsub	- subsonic
$C^{+}_{i,j,k}M = -MC^{-}_{\hat{i},\hat{j},\hat{k}}$	- ccsup1	- supersonic
	- ccsub1	- subsonic

Note that only one set of identities must be shown for the ζ-direction since the inverse is included in those presented. It should be recognized that sub- and supersonic flows can occur in both the plus and minus coordinate directions. These cases were tested and identical results were obtained. They were deleted from the current report to save space. The interested reader can verify the proof by simple alterations to the MACSYMA scripts included in the appendix.

Given the above proofs the symmetry properties of the LHS are established and hence the algorithm is shown to be symmetric for conical grids.

Summary

The symmetry of a conical Navier-Stokes equation solver was proved through the use of analytical and symbolic techniques. The MACSYMA symbolic manipulation software was utilized. MACSYMA routines are included to allow the interested reader to verify the results.

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Appendix A

- GFLUX1
- GFLUX2
- GFLUX3
- HFLUX1
- HFLUX2
- APSUP
- APSUB
- AMSUP
- AMSUB
- BPSUP
- BPSUB
- BMSUP
- BMSUB
- CCSUP1
- CCSUB1

```
(C3) diff:matrix([0],[0],[0],[0],[0])$
(C4) g:matrix([0],[0],[0],[0],[0])$
(C5) gijk:matrix([0],[0],[0],[0],[0])$
(C6) ghatijk:matrix([0],[0],[0],[0],[0])$
(C7) sp:matrix([0],[0],[0],[0],[0],[0])$
(C8) null:matrix([0],[0],[0],[0],[0],[0])$
(C9) xy2:matrix([0],[0],[0],[0],[0],[0])$
(C10) x2y:matrix([0],[0],[0],[0],[0],[0])$
(C11) xpy:matrix([0],[0],[0],[0],[0],[0])$
(C12) sp1:matrix([0],[0],[0],[0],[0],[0])$
(C13) sp2:matrix([0],[0],[0],[0],[0],[0])$
(C14) sm1:matrix([0],[0],[0],[0],[0],[0])$
(C15) sm2:matrix([0],[0],[0],[0],[0],[0])$
(C16) ax:etx$
(C17) ay:ety$
(C18) az:etz$
(C19) dq:matrix([rp1-r],[rup1-ru],[rvp1-rv],[rwp1-rw],[ep1-e],[pp1
-p])$
(C20) dqm1:matrix([r-rm1],[ru-rum1],[rv-rvm1],[rw-rwm1],[e-em1],[p
-pm1])$
(C21) dqp1:matrix([rp2-rp1],[rup2-rup1],[rvp2-rvp1],[rwp2-rwp1],[e
p2-ep1],[pp2-pp1])$
(C22) qp:matrix([rp1],[rup1],[rvp1],[rwp1],[ep1],[pp1])$
(C23) qm:matrix([r],[ru],[rv],[rw],[e],[p])$
(C24) for i: 1 thru 6 do
xy2[i]: dqm1[i]*(dq[i]*dq[i]+eps)$
(C25) for i:1 thru 6 do
x2y[i]: dq[i]*(dqm1[i]*dqm1[i]+eps)$
(C26) for i:1 thru 6 do
xpy[i]: dqm1[i]*dqm1[i] + dq[i]*dq[i]$
(C27) for i:1 thru 6 do
sm1[i]:(x2y[i]+xy2[i])/(xpy[i]+2*eps)$
(C28) for i: 1 thru 6 do
xy2[i]: dqp1[i]*(dq[i]*dq[i]+eps)$
(C29) for i:1 thru 6 do
x2y[i]: dq[i]*(dqp1[i]*dqp1[i]+eps)$
(C30) for i:1 thru 6 do
xpy[i]: dqp1[i]*dqp1[i] + dq[i]*dq[i]$
(C31) for i:1 thru 6 do
sp1[i]:(x2y[i]+xy2[i])/(xpy[i]+2*eps)$
(C32) m:matrix([1,0,0,0,0,0],[0,1,0,0,0,0],[0,0,1,0,0,0],[0,0,0,-1
,0,0],[0,0,0,0,1,0]
,[0,0,0,0,0,1])$
(C33) ax:etx$
(C34) ay:ety$
(C35) az:-etz$
(C36) dq:m.dq$
(C37) dqm1:m.dqm1$
(C38) dqp1:m.dqp1$
(C39) qp:m.qp$
(C40) qm:m.qm$
```

```
(C41) for i: 1 thru 6 do
xy2[i]: dqm1[i]*(dq[i]*dq[i]+eps)$
(C42) for i:1 thru 6 do
x2y[i]: dq[i]*(dqm1[i]*dqm1[i]+eps)$
(C43) for i:1 thru 6 do
xpy[i]: dqm1[i]*dqm1[i] + dq[i]*dq[i]$
(C44) for i:1 thru 6 do
sm2[i]:(x2y[i]+xy2[i])/(xpy[i]+2*eps)$
(C45) for i: 1 thru 6 do
xy2[i]: dqp1[i]*(dq[i]*dq[i]+eps)$
(C46) for i:1 thru 6 do
x2y[i]: dq[i]*(dqp1[i]*dqp1[i]+eps)$
(C47) for i:1 thru 6 do
xpy[i]: dqp1[i]*dqp1[i] + dq[i]*dq[i]$
(C48) for i:1 thru 6 do
sp2[i]:(x2y[i]+xy2[i])/(xpy[i]+2*eps)$
(C49) diff1:sp1-m.sp2$
(C50) diff1:ratexpand(diff1);
                                             [ 0 ]
                                             [   ]
                                             [ 0 ]
                                             [   ]
                                             [ 0 ]
(D50)                                        [   ]
                                             [ 0 ]
                                             [   ]
                                             [ 0 ]
                                             [   ]
                                             [ 0 ]
(C51) diff2:sm1-m.sm2$
(C52) diff2:ratexpand(diff2);
                                             [ 0 ]
                                             [   ]
                                             [ 0 ]
                                             [   ]
                                             [ 0 ]
(D52)                                        [   ]
                                             [ 0 ]
                                             [   ]
                                             [ 0 ]
                                             [   ]
                                             [ 0 ]
(C53) closefile(gflux1)$
```

```
(C3) diff:matrix([0],[0],[0],[0],[0])$
(C4) g:matrix([0],[0],[0],[0],[0])$
(C5) gijk:matrix([0],[0],[0],[0],[0])$
(C6) ghatijk:matrix([0],[0],[0],[0],[0])$
(C7) sp:matrix([0],[0],[0],[0],[0],[0])$
(C8) dq:matrix([0],[0],[0],[0],[0])$
(C9) null:matrix([0],[0],[0],[0],[0],[0])$
(C10) xy2:matrix([0],[0],[0],[0],[0],[0])$
(C11) x2y:matrix([0],[0],[0],[0],[0],[0])$
(C12) xpy:matrix([0],[0],[0],[0],[0],[0])$
(C13) sp1:matrix([0],[0],[0],[0],[0])$
(C14) sp2:matrix([0],[0],[0],[0],[0])$
(C15) sm1:matrix([0],[0],[0],[0],[0])$
(C16) sm2:matrix([0],[0],[0],[0],[0])$
(C17) ax:etx$
(C18) ay:ety$
(C19) az:etz$
(C20) axt:ax/sada$
(C21) ayt:ay/sada$
(C22) azt:az/sada$
(C23) dq:matrix([dq1],[dq2],[dq3],[dq4],[dq5])$
(C24) qp:matrix([qp1],[qp2],[qp3],[qp4],[qp5],[qp6])$
(C25) qm:matrix([qm1],[qm2],[qm3],[qm4],[qm5],[qm6])$
(C26) axt:ax/sada$
(C27) ayt:ay/sada$
(C28) azt:az/sada$
(C29) e1:tt*sada$
(C30) e4:e1+csad$
(C31) e5:e1-csad$
(C32) be1:matrix([0.5*(e1+abs(e1)),0,0,0,0],
[0,0.5*(e1+abs(e1)),0,0,0],
[0,0,0.5*(e1+abs(e1)),0,0],
[0,0,0,0.5*(e4+abs(e4)),0],
[0,0,0,0,0.5*(e5+abs(e5))])$
(C33) be2:matrix([0.5*(e1-abs(e1)),0,0,0,0],
[0,0.5*(e1-abs(e1)),0,0,0],
[0,0,0.5*(e1-abs(e1)),0,0],
[0,0,0,0.5*(e4-abs(e4)),0],
[0,0,0,0,0.5*(e5-abs(e5))])$
(C34) a:q1/(sqrt(2)*c)$
(C35) c1:0.5*rqrq$
(C36) c2:c*c/gm1$
(C37) br:matrix([axt,ayt,azt,a,a],
[q2*axt,q2*ayt-q1*azt,q2*azt+q1*ayt,a*(q2+c*axt),a*(q2-c*axt)],
[q3*axt+q1*azt,q3*ayt,q3*azt-q1*axt,a*(q3+c*ayt),a*(q3-c*ayt)],
[q4*axt-q1*ayt,q4*ayt+q1*axt,q4*azt,a*(q4+c*azt),a*(q4-c*azt)],
[c1*axt+q1*(q3*azt-q4*ayt),c1*ayt+q1*(q4*axt-q2*azt),
c1*azt+q1*(q2*ayt-q3*axt),a*(c1+c2+c*tt),a*(c1+c2-c*tt)])$
(C38) phi:0.5*gm1*rqrq$
(C39) c2:c*c$
(C40) b:1/(sqrt(2)*rc)$
```

```
(C41) c1:1-phi/c2$
(C42) c3:gm1/c2$
(C43) bl:matrix([axt*c1+q6*(q4*ayt-q3*azt),axt*q2*c3,axt*q3*c3+azt
*q6,
axt*q4*c3-ayt*q6,-axt*c3],
[ayt*c1+q6*(q2*azt-q4*axt),ayt*q2*c3-azt*q6,ayt*q3*c3,
ayt*q4*c3+axt*q6,-ayt*c3],
[azt*c1+q6*(q3*axt-q2*ayt),azt*q2*c3+ayt*q6,azt*q3*c3-axt*q6,
azt*q4*c3,-azt*c3],
[b*(phi-c*tt),b*(c*axt-q2*gm1),b*(c*ayt-q3*gm1),b*(c*azt-q4*gm1),
b*gm1],
[b*(phi+c*tt),-b*(c*axt+q2*gm1),-b*(c*ayt+q3*gm1),-b*(c*azt+q4*gm1
),
b*gm1])$
(C44) sp:bl.dq$
(C45) sp2:be1.sp$
(C46) sp:bl.dq$
(C47) sm2:be2.sp$
(C48) g:br.sm2-br.sp2$
(C49) tl:(qm[2]*ax+qm[3]*ay+qm[4]*az)/qm[1]$
(C50) g[1]:qm[1]*tl+g[1]$
(C51) g[2]:qm[2]*tl+ax*qm[6]+g[2]$
(C52) g[3]:qm[3]*tl+ay*qm[6]+g[3]$
(C53) g[4]:qm[4]*tl+az*qm[6]+g[4]$
(C54) g[5]:(qm[5]+qm[6])*tl+g[5]$
(C55) tl:(qp[2]*ax+qp[3]*ay+qp[4]*az)/qp[1]$
(C56) gijk[1]:0.5*(qp[1]*tl+g[1])$
(C57) gijk[2]:0.5*(qp[2]*tl+ax*qp[6]+g[2])$
(C58) gijk[3]:0.5*(qp[3]*tl+ay*qp[6]+g[3])$
(C59) gijk[4]:0.5*(qp[4]*tl+az*qp[6]+g[4])$
(C60) gijk[5]:0.5*((qp[5]+qp[6])*tl+g[5])$
(C61) m:matrix([1,0,0,0,0],[0,1,0,0,0],[0,0,1,0,0],[0,0,0,-1,0],[0
,0,0,0,1])$
(C62) m2:matrix([1,0,0,0,0,0],[0,1,0,0,0,0],[0,0,1,0,0,0],[0,0,0,-
1,0,0],
[0,0,0,0,1,0],[0,0,0,0,0,1])$
(C63) ax:etx$
(C64) ay:ety$
(C65) az:-etz$
(C66) axt:ax/sada$
(C67) ayt:ay/sada$
(C68) azt:az/sada$
(C69) rw:-rw$
(C70) rwp1:-rwp1$
(C71) rwp2:-rwp2$
(C72) rwm1:-rwm1$
(C73) dq:m.dq$
(C74) qp:m2.qp$
(C75) qm:m2.qm$
(C76) q4:-q4$
(C77) e1:tt*sada$
```

```
(C78) e4:e1+csad$
(C79) e5:e1-csad$
(C80) be1:matrix([0.5*(e1+abs(e1)),0,0,0,0],
[0,0.5*(e1+abs(e1)),0,0,0],
[0,0,0.5*(e1+abs(e1)),0,0],
[0,0,0,0.5*(e4+abs(e4)),0],
[0,0,0,0,0.5*(e5+abs(e5))])$
(C81) be2:matrix([0.5*(e1-abs(e1)),0,0,0,0],
[0,0.5*(e1-abs(e1)),0,0,0],
[0,0,0.5*(e1-abs(e1)),0,0],
[0,0,0,0.5*(e4-abs(e4)),0],
[0,0,0,0,0.5*(e5-abs(e5))])$
(C82) a:q1/(sqrt(2)*c)$
(C83) c1:0.5*rqrq$
(C84) c2:c*c/gm1$
(C85) br:matrix([axt,ayt,azt,a,a],
[q2*axt,q2*ayt-q1*azt,q2*azt+q1*ayt,a*(q2+c*axt),a*(q2-c*axt)],
[q3*axt+q1*azt,q3*ayt,q3*azt-q1*axt,a*(q3+c*ayt),a*(q3-c*ayt)],
[q4*axt-q1*ayt,q4*ayt+q1*axt,q4*azt,a*(q4+c*azt),a*(q4-c*azt)],
[c1*axt+q1*(q3*azt-q4*ayt),c1*ayt+q1*(q4*axt-q2*azt),
c1*azt+q1*(q2*ayt-q3*axt),a*(c1+c2+c*tt),a*(c1+c2-c*tt)])$
(C86) phi:0.5*gm1*rqrq$
(C87) c2:c*c$
(C88) b:1/(sqrt(2)*rc)$
(C89) c1:1-phi/c2$
(C90) c3:gm1/c2$
(C91) bl:matrix([axt*c1+q6*(q4*ayt-q3*azt),axt*q2*c3,axt*q3*c3+azt
*q6,
axt*q4*c3-ayt*q6,-axt*c3],
[ayt*c1+q6*(q2*azt-q4*axt),ayt*q2*c3-azt*q6,ayt*q3*c3,
ayt*q4*c3+axt*q6,-ayt*c3],
[azt*c1+q6*(q3*axt-q2*ayt),azt*q2*c3+ayt*q6,azt*q3*c3-axt*q6,
azt*q4*c3,-azt*c3],
[b*(phi-c*tt),b*(c*axt-q2*gm1),b*(c*ayt-q3*gm1),b*(c*azt-q4*gm1),
b*gm1],
[b*(phi+c*tt),-b*(c*axt+q2*gm1),-b*(c*ayt+q3*gm1),-b*(c*azt+q4*gm1
),
b*gm1]])$
(C92) sp:bl.dq$
(C93) sp2:be1.sp$
(C94) sp:bl.dq$
(C95) sm2:be2.sp$
(C96) g:br.sm2-br.sp2$
(C97) tl:(qm[2]*ax+qm[3]*ay+qm[4]*az)/qm[1]$
(C98) g[1]:qm[1]*tl+g[1]$
(C99) g[2]:qm[2]*tl+ax*qm[6]+g[2]$
(C100) g[3]:qm[3]*tl+ay*qm[6]+g[3]$
(C101) g[4]:qm[4]*tl+az*qm[6]+g[4]$
(C102) g[5]:(qm[5]+qm[6])*tl+g[5]$
(C103) tl:(qp[2]*ax+qp[3]*ay+qp[4]*az)/qp[1]$
(C104) ghatijk[1]:0.5*(qp[1]*tl+g[1])$
```

```
(C105) ghatijk[2]:0.5*(qp[2]*tl+ax*qp[6]+g[2])$
(C106) ghatijk[3]:0.5*(qp[3]*tl+ay*qp[6]+g[3])$
(C107) ghatijk[4]:0.5*(qp[4]*tl+az*qp[6]+g[4])$
(C108) ghatijk[5]:0.5*((qp[5]+qp[6])*tl+g[5])$
(C109) diff:gijk-m.ghatijk$
(C110) diff:ratexpand(diff);
                                          [ 0 ]
                                          [   ]
                                          [ 0 ]
                                          [   ]
(D110)                                    [ 0 ]
                                          [   ]
                                          [ 0 ]
                                          [   ]
                                          [ 0 ]
(C111) closefile(gflux2)$
```

```
(C3) diff:matrix([0],[0],[0],[0],[0])$
(C4) gsijk:matrix([0],[0],[0],[0],[0])$
(C5) gshijk:matrix([0],[0],[0],[0],[0])$
(C6) ax:etx$
(C7) ay:ety$
(C8) az:etz$
(C9) axt:ax/sada$
(C10) ayt:ay/sada$
(C11) azt:az/sada$
(C12) ra:.5*(r+rp1)$
(C13) pa:.5*(p+pp1)$
(C14) emu:(gam*abs(pa/ra))**0.666$
(C15) cons:fsmach/rel$
(C16) rpr:pr*emu$
(C17) vav:0.5*(volp1+vol)$
(C18) u2:rup1/rp1-ru/r$
(C19) v2:rvp1/rp1-rv/r$
(C20) w2:rwp1/rp1-rw/r$
(C21) t2:gam*(pp1/rp1-p/r)$
(C22) sigx:0.667*emu*cons*(2.*u2*ax-v2*ay-w2*az)/vav$
(C23) sigy:0.667*emu*cons*(2.*v2*ay-u2*ax-w2*az)/vav$
(C24) sigz:0.667*emu*cons*(2.*w2*az-u2*ax-v2*ay)/vav$
(C25) txy:emu*cons*(u2*ay+v2*ax)/vav$
(C26) txz:emu*cons*(u2*az+w2*ax)/vav$
(C27) tyz:emu*cons*(v2*az+w2*ay)/vav$
(C28) qx:-cons*rpr*rgm1*t2*ax/vav$
(C29) qy:-cons*rpr*rgm1*t2*ay/vav$
(C30) qz:-cons*rpr*rgm1*t2*az/vav$
(C31) gsijk[1,1]:0.0$
(C32) gsijk[2,1]:ax*sigx+ay*txy+az*txz$
(C33) gsijk[3,1]:ax*txy+ay*sigy+az*tyz$
(C34) gsijk[4,1]:ax*txz+ay*tyz+az*sigz$
(C35) ua:0.5*(rup1/rp1+ru/r)$
(C36) va:0.5*(rvp1/rp1+rv/r)$
(C37) wa:0.5*(rwp1/rp1+rw/r)$
(C38) gsijk[5,1]:ua*gsijk[2,1]+va*gsijk[3,1]+wa*gsijk[4,1]-qx*ax-q
y*ay-qz*az$
(C39) m:matrix([1,0,0,0,0],[0,1,0,0,0],[0,0,1,0,0],[0,0,0,-1,0],[0
,0,0,0,1])$
(C40) ax:etx$
(C41) ay:ety$
(C42) az:-etz$
(C43) axt:ax/sada$
(C44) ayt:ay/sada$
(C45) azt:az/sada$
(C46) rw:-rw$
(C47) rwp1:-rwp1$
(C48) rwm1:-rwm1$
(C49) ra:.5*(r+rp1)$
(C50) pa:.5*(p+pp1)$
(C51) emu:(gam*abs(pa/ra))**0.666$
```

```
(C52) cons:fsmach/rel$
(C53) rpr:pr*emu$
(C54) vav:0.5*(volp1+vol)$
(C55) u2:rup1/rp1-ru/r$
(C56) v2:rvp1/rp1-rv/r$
(C57) w2:rwp1/rp1-rw/r$
(C58) t2:gam*(pp1/rp1-p/r)$
(C59) sigx:0.667*emu*cons*(2.*u2*ax-v2*ay-w2*az)/vav$
(C60) sigy:0.667*emu*cons*(2.*v2*ay-u2*ax-w2*az)/vav$
(C61) sigz:0.667*emu*cons*(2.*w2*az-u2*ax-v2*ay)/vav$
(C62) txy:emu*cons*(u2*ay+v2*ax)/vav$
(C63) txz:emu*cons*(u2*az+w2*ax)/vav$
(C64) tyz:emu*cons*(v2*az+w2*ay)/vav$
(C65) qx:-cons*rpr*rgm1*t2*ax/vav$
(C66) qy:-cons*rpr*rgm1*t2*ay/vav$
(C67) qz:-cons*rpr*rgm1*t2*az/vav$
(C68) gshijk[1,1]:0.0$
(C69) gshijk[2,1]:ax*sigx+ay*txy+az*txz$
(C70) gshijk[3,1]:ax*txy+ay*sigy+az*tyz$
(C71) gshijk[4,1]:ax*txz+ay*tyz+az*sigz$
(C72) ua:0.5*(rup1/rp1+ru/r)$
(C73) va:0.5*(rvp1/rp1+rv/r)$
(C74) wa:0.5*(rwp1/rp1+rw/r)$
(C75) gshijk[5,1]:ua*gshijk[2,1]+va*gshijk[3,1]+wa*gshijk[4,1]-qx*
ax-qy*ay-qz*az$
(C76) diff:gsijk-m.gshijk$
(C77) diff:ratexpand(diff);
                                              [ 0 ]
                                              [   ]
                                              [ 0 ]
                                              [   ]
(D77)                                         [ 0 ]
                                              [   ]
                                              [ 0 ]
                                              [   ]
                                              [ 0 ]

(C78) closefile(gflux3)$
```

```
(C3) diff:matrix([0],[0],[0],[0],[0])$
(C4) h:matrix([0],[0],[0],[0],[0])$
(C5) hijk:matrix([0],[0],[0],[0],[0])$
(C6) hhatijk:matrix([0],[0],[0],[0],[0])$
(C7) null:matrix([0],[0],[0],[0],[0],[0])$
(C8) xy2:matrix([0],[0],[0],[0],[0],[0])$
(C9) x2y:matrix([0],[0],[0],[0],[0],[0])$
(C10) xpy:matrix([0],[0],[0],[0],[0],[0])$
(C11) sp1:matrix([0],[0],[0],[0],[0],[0])$
(C12) sp2:matrix([0],[0],[0],[0],[0],[0])$
(C13) sm1:matrix([0],[0],[0],[0],[0],[0])$
(C14) sm2:matrix([0],[0],[0],[0],[0],[0])$
(C15) ax:ztx$
(C16) ay:zty$
(C17) az:ztz$
(C18) dq:matrix([rp1-r],[rup1-ru],[rvp1-rv],[rwp1-rw],[ep1-e],[pp1
-p])$
(C19) dqm1:matrix([r-rm1],[ru-rum1],[rv-rvm1],[rw-rwm1],[e-em1],[p
-pm1])$
(C20) dqp1:matrix([rp2-rp1],[rup2-rup1],[rvp2-rvp1],[rwp2-rwp1],[e
p2-ep1],[pp2-pp1])$
(C21) qp:matrix([rp1],[rup1],[rvp1],[rwp1],[ep1],[pp1])$
(C22) qm:matrix([r],[ru],[rv],[rw],[e],[p])$
(C23) for i: 1 thru 6 do
xy2[i]: dqm1[i]*(dq[i]*dq[i]+eps)$
(C24) for i:1 thru 6 do
x2y[i]: dq[i]*(dqm1[i]*dqm1[i]+eps)$
(C25) for i:1 thru 6 do
xpy[i]: dqm1[i]*dqm1[i] + dq[i]*dq[i]$
(C26) for i:1 thru 6 do
sm1[i]:(x2y[i]+xy2[i])/(xpy[i]+2*eps)$
(C27) for i: 1 thru 6 do
xy2[i]: dqp1[i]*(dq[i]*dq[i]+eps)$
(C28) for i:1 thru 6 do
x2y[i]: dq[i]*(dqp1[i]*dqp1[i]+eps)$
(C29) for i:1 thru 6 do
xpy[i]: dqp1[i]*dqp1[i] + dq[i]*dq[i]$
(C30) for i:1 thru 6 do
sp1[i]:(x2y[i]+xy2[i])/(xpy[i]+2*eps)$
(C31) m:matrix([1,0,0,0,0,0],[0,1,0,0,0,0],[0,0,1,0,0,0],[0,0,0,-1
,0,0],[0,0,0,0,1,0]
,[0,0,0,0,0,1])$
(C32) ax:-ztx$
(C33) ay:-zty$
(C34) az:ztz$
(C35) dqo:dq$
(C36) dqm1o:dqm1$
(C37) dqp1o:dqp1$
(C38) qpo:qp$
(C39) qmo:qm$
(C40) dq:-M.dqo$
```

```
(C41) dqm1:-M.dqp1o$
(C42) dqp1:-M.dqm1o$
(C43) qp:M.qm$
(C44) qm:M.qp$
(C45) for i: 1 thru 6 do
xy2[i]: dqm1[i]*(dq[i]*dq[i]+eps)$
(C46) for i:1 thru 6 do
x2y[i]: dq[i]*(dqm1[i]*dqm1[i]+eps)$
(C47) for i:1 thru 6 do
xpy[i]: dqm1[i]*dqm1[i] + dq[i]*dq[i]$
(C48) for i:1 thru 6 do
sm2[i]:(x2y[i]+xy2[i])/(xpy[i]+2*eps)$
(C49) for i: 1 thru 6 do
xy2[i]: dqp1[i]*(dq[i]*dq[i]+eps)$
(C50) for i:1 thru 6 do
x2y[i]: dq[i]*(dqp1[i]*dqp1[i]+eps)$
(C51) for i:1 thru 6 do
xpy[i]: dqp1[i]*dqp1[i] + dq[i]*dq[i]$
(C52) for i:1 thru 6 do
sp2[i]:(x2y[i]+xy2[i])/(xpy[i]+2*eps)$
(C53) diff1:sp1+m.sm2$
(C54) diff1:ratexpand(diff1);
                                            [ 0 ]
                                            [   ]
                                            [ 0 ]
                                            [   ]
                                            [ 0 ]
                                            [   ]
(D54)                                       [ 0 ]
                                            [   ]
                                            [ 0 ]
                                            [   ]
                                            [ 0 ]
(C55) diff2:sm1+m.sp2$
(C56) diff2:ratexpand(diff2);
                                            [ 0 ]
                                            [   ]
                                            [ 0 ]
                                            [   ]
                                            [ 0 ]
                                            [   ]
(D56)                                       [ 0 ]
                                            [   ]
                                            [ 0 ]
                                            [   ]
                                            [ 0 ]
(C57) closefile(hflux1)$
```

```
(C3) diff:matrix([0],[0],[0],[0],[0])$
(C4) h:matrix([0],[0],[0],[0],[0])$
(C5) hijk:matrix([0],[0],[0],[0],[0])$
(C6) hhatijk:matrix([0],[0],[0],[0],[0])$
(C7) sp:matrix([0],[0],[0],[0],[0],[0])$
(C8) dq:matrix([0],[0],[0],[0],[0])$
(C9) null:matrix([0],[0],[0],[0],[0],[0])$
(C10) xy2:matrix([0],[0],[0],[0],[0],[0])$
(C11) x2y:matrix([0],[0],[0],[0],[0],[0])$
(C12) xpy:matrix([0],[0],[0],[0],[0],[0])$
(C13) sp1:matrix([0],[0],[0],[0],[0])$
(C14) sp2:matrix([0],[0],[0],[0],[0])$
(C15) sm1:matrix([0],[0],[0],[0],[0])$
(C16) sm2:matrix([0],[0],[0],[0],[0])$
(C17) ax:ztx$
(C18) ay:zty$
(C19) az:ztz$
(C20) axt:ax/sada$
(C21) ayt:ay/sada$
(C22) azt:az/sada$
(C23) dq:matrix([dq1],[dq2],[dq3],[dq4],[dq5])$
(C24) qp:matrix([qp1],[qp2],[qp3],[qp4],[qp5],[qp6])$
(C25) qm:matrix([qm1],[qm2],[qm3],[qm4],[qm5],[qm6])$
(C26) e1:tt*sada$
(C27) e4:e1+csad$
(C28) e5:e1-csad$
(C29) be1:matrix([0.5*(e1+abs(e1)),0,0,0,0],
[0,0.5*(e1+abs(e1)),0,0,0],
[0,0,0.5*(e1+abs(e1)),0,0],
[0,0,0,0.5*(e4+abs(e4)),0],
[0,0,0,0,0.5*(e5+abs(e5))])$
(C30) be2:matrix([0.5*(e1-abs(e1)),0,0,0,0],
[0,0.5*(e1-abs(e1)),0,0,0],
[0,0,0.5*(e1-abs(e1)),0,0],
[0,0,0,0.5*(e4-abs(e4)),0],
[0,0,0,0,0.5*(e5-abs(e5))])$
(C31) a:q1/(sqrt(2)*c)$
(C32) c1:0.5*rqrq$
(C33) c2:c*c/gm1$
(C34) br:matrix([axt,ayt,azt,a,a],
[q2*axt,q2*ayt-q1*azt,q2*azt+q1*ayt,a*(q2+c*axt),a*(q2-c*axt)],
[q3*axt+q1*azt,q3*ayt,q3*azt-q1*axt,a*(q3+c*ayt),a*(q3-c*ayt)],
[q4*axt-q1*ayt,q4*ayt+q1*axt,q4*azt,a*(q4+c*azt),a*(q4-c*azt)],
[c1*axt+q1*(q3*azt-q4*ayt),c1*ayt+q1*(q4*axt-q2*azt),
c1*azt+q1*(q2*ayt-q3*axt),a*(c1+c2+c*tt),a*(c1+c2-c*tt)])$
(C35) phi:0.5*gm1*rqrq$
(C36) c2:c*c$
(C37) b:1/(sqrt(2)*rc)$
(C38) c1:1-phi/c2$
(C39) c3:gm1/c2$
(C40) bl:matrix([axt*c1+q6*(q4*ayt-q3*azt),axt*q2*c3,axt*q3*c3+azt
```

```
*q6,
axt*q4*c3-ayt*q6,-axt*c3],
[ayt*c1+q6*(q2*azt-q4*axt),ayt*q2*c3-azt*q6,ayt*q3*c3,
ayt*q4*c3+axt*q6,-ayt*c3],
[azt*c1+q6*(q3*axt-q2*ayt),azt*q2*c3+ayt*q6,azt*q3*c3-axt*q6,
azt*q4*c3,-azt*c3],
[b*(phi-c*tt),b*(c*axt-q2*gm1),b*(c*ayt-q3*gm1),b*(c*azt-q4*gm1),
b*gm1],
[b*(phi+c*tt),-b*(c*axt+q2*gm1),-b*(c*ayt+q3*gm1),-b*(c*azt+q4*gm1
),
b*gm1])$
(C41) sp:bl.dq$
(C42) sp2:be1.sp$
(C43) sp:bl.dq$
(C44) sm2:be2.sp$
(C45) h:br.sm2-br.sp2$
(C46) tl:(qm[2]*ax+qm[3]*ay+qm[4]*az)/qm[1]$
(C47) h[1]:qm[1]*tl+h[1]$
(C48) h[2]:qm[2]*tl+ax*qm[6]+h[2]$
(C49) h[3]:qm[3]*tl+ay*qm[6]+h[3]$
(C50) h[4]:qm[4]*tl+az*qm[6]+h[4]$
(C51) h[5]:(qm[5]+qm[6])*tl+h[5]$
(C52) tl:(qp[2]*ax+qp[3]*ay+qp[4]*az)/qp[1]$
(C53) hijk[1]:0.5*(qp[1]*tl+h[1])$
(C54) hijk[2]:0.5*(qp[2]*tl+ax*qp[6]+h[2])$
(C55) hijk[3]:0.5*(qp[3]*tl+ay*qp[6]+h[3])$
(C56) hijk[4]:0.5*(qp[4]*tl+az*qp[6]+h[4])$
(C57) hijk[5]:0.5*((qp[5]+qp[6])*tl+h[5])$
(C58) m:matrix([1,0,0,0,0],[0,1,0,0,0],[0,0,1,0,0],[0,0,0,-1,0],[0
,0,0,0,1])$
(C59) m2:matrix([1,0,0,0,0,0],[0,1,0,0,0,0],[0,0,1,0,0,0],[0,0,0,-
1,0,0],
[0,0,0,0,1,0],[0,0,0,0,0,1])$
(C60) ax:-ztx$
(C61) ay:-zty$
(C62) az:ztz$
(C63) axt:ax/sada$
(C64) ayt:ay/sada$
(C65) azt:az/sada$
(C66) dqo:dq$
(C67) qpo:qp$
(C68) qmo:qm$
(C69) dq:-m.dqo$
(C70) qp:m2.qmo$
(C71) qm:m2.qpo$
(C72) q4:-q4$
(C73) tt:-tt$
(C74) e1:tt*sada$
(C75) e4:e1+csad$
(C76) e5:e1-csad$
(C77) be1:matrix([0.5*(e1+abs(e1)),0,0,0,0],
```

```
[0,0.5*(e1+abs(e1)),0,0,0],
[0,0,0.5*(e1+abs(e1)),0,0],
[0,0,0,0.5*(e4+abs(e4)),0],
[0,0,0,0,0.5*(e5+abs(e5))])$
(C78) be2:matrix([0.5*(e1-abs(e1)),0,0,0,0],
[0,0.5*(e1-abs(e1)),0,0,0],
[0,0,0.5*(e1-abs(e1)),0,0],
[0,0,0,0.5*(e4-abs(e4)),0],
[0,0,0,0,0.5*(e5-abs(e5))])$
(C79) a:q1/(sqrt(2)*c)$
(C80) c1:0.5*rqrq$
(C81) c2:c*c/gm1$
(C82) br:matrix([axt,ayt,azt,a,a],
[q2*axt,q2*ayt-q1*azt,q2*azt+q1*ayt,a*(q2+c*axt),a*(q2-c*axt)],
[q3*axt+q1*azt,q3*ayt,q3*azt-q1*axt,a*(q3+c*ayt),a*(q3-c*ayt)],
[q4*axt-q1*ayt,q4*ayt+q1*axt,q4*azt,a*(q4+c*azt),a*(q4-c*azt)],
[c1*axt+q1*(q3*azt-q4*ayt),c1*ayt+q1*(q4*axt-q2*azt),
c1*azt+q1*(q2*ayt-q3*axt),a*(c1+c2+c*tt),a*(c1+c2-c*tt)])$
(C83) phi:0.5*gm1*rqrq$
(C84) c2:c*c$
(C85) b:1/(sqrt(2)*rc)$
(C86) c1:1-phi/c2$
(C87) c3:gm1/c2$
(C88) bl:matrix([axt*c1+q6*(q4*ayt-q3*azt),axt*q2*c3,axt*q3*c3+azt
*q6,
axt*q4*c3-ayt*q6,-axt*c3],
[ayt*c1+q6*(q2*azt-q4*axt),ayt*q2*c3-azt*q6,ayt*q3*c3,
ayt*q4*c3+axt*q6,-ayt*c3],
[azt*c1+q6*(q3*axt-q2*ayt),azt*q2*c3+ayt*q6,azt*q3*c3-axt*q6,
azt*q4*c3,-azt*c3],
[b*(phi-c*tt),b*(c*axt-q2*gm1),b*(c*ayt-q3*gm1),b*(c*azt-q4*gm1),
b*gm1],
[b*(phi+c*tt),-b*(c*axt+q2*gm1),-b*(c*ayt+q3*gm1),-b*(c*azt+q4*gm1
),
b*gm1])$
(C89) sp:bl.dq$
(C90) sp2:be1.sp$
(C91) sp:bl.dq$
(C92) sm2:be2.sp$
(C93) h:br.sm2-br.sp2$
(C94) tl:(qm[2]*ax+qm[3]*ay+qm[4]*az)/qm[1]$
(C95) h[1]:qm[1]*tl+h[1]$
(C96) h[2]:qm[2]*tl+ax*qm[6]+h[2]$
(C97) h[3]:qm[3]*tl+ay*qm[6]+h[3]$
(C98) h[4]:qm[4]*tl+az*qm[6]+h[4]$
(C99) h[5]:(qm[5]+qm[6])*tl+h[5]$
(C100) tl:(qp[2]*ax+qp[3]*ay+qp[4]*az)/qp[1]$
(C101) hhatijk[1]:0.5*(qp[1]*tl+h[1])$
(C102) hhatijk[2]:0.5*(qp[2]*tl+ax*qp[6]+h[2])$
(C103) hhatijk[3]:0.5*(qp[3]*tl+ay*qp[6]+h[3])$
(C104) hhatijk[4]:0.5*(qp[4]*tl+az*qp[6]+h[4])$
```

```
(C105) hhatijk[5]:0.5*((qp[5]+qp[6])*tl+h[5])$
(C106) diff:hijk+m.hhatijk$
(C107) diff:ratexpand(diff);
                                                   [ 0 ]
                                                   [   ]
                                                   [ 0 ]
                                                   [   ]
(D107)                                             [ 0 ]
                                                   [   ]
                                                   [ 0 ]
                                                   [   ]
                                                   [ 0 ]
(C108) closefile(hflux2)$
```

```
(C3) ap1:matrix([0,0,0,0,0],[0,0,0,0,0],[0,0,0,0,0],[0,0,0,0,0],[0
,0,0,0,0])$
(C4) ap2:matrix([0,0,0,0,0],[0,0,0,0,0],[0,0,0,0,0],[0,0,0,0,0],[0
,0,0,0,0])$
(C5) m:matrix([1,0,0,0,0],[0,1,0,0,0],[0,0,1,0,0],[0,0,0,-1,0],[0,
0,0,0,1])$
(C6) diff:matrix([0,0,0,0,0],[0,0,0,0,0],[0,0,0,0,0],[0,0,0,0,0],[
0,0,0,0,0])$
(C7) sign:1$
(C8) cgg1:(gam-1)/gam$
(C9) cgg2:1/(2*gam)$
(C10) xiy:0.0$
(C11) xiz:0.0$
(C12) sada:sqrt(xix**2+xiy**2+xiz**2)$
(C13) axt:xix/sada$
(C14) ayt:xiy/sada$
(C15) azt:xiz/sada$
(C16) rqrq:q2**2+q3**2+q4**2$
(C17) q6:1/q1$
(C18) pr:(gam-1)*(q5-0.5*rqrq*q6)$
(C19) prgam:pr*gam$
(C20) pp:q5+pr$
(C21) c:sqrt(prgam*q6)$
(C22) tt:(q2*axt+q3*ayt+q4*azt)*q6$
(C23) rc:q1*c$
(C24) csad:c*sada$
(C25) e1:tt*sada$
(C26) e4:e1+csad$
(C27) e5:e1-csad$
(C28) ev1:0.5*(e1+sign*abs(e1))$
(C29) ev4:0.5*(e4+sign*abs(e4))$
(C30) ev5:0.5*(e5+sign*abs(e5))$
(C31) cg1:cgg1$
(C32) cg2:cgg2$
(C33) cg3:cgg2$
(C34) d1q1:-ev1*q6$
(C35) d1q2:xix*q6$
(C36) d1q3:xiy*q6$
(C37) d1q4:xiz*q6$
(C38) d1q5:0.0$
(C39) coe:gam*(gam-1)/(2*rc)$
(C40) gm1q6:(gam-1)*q6$
(C41) drcq1:coe*q5$
(C42) drcq2:-coe*q2$
(C43) drcq3:-coe*q3$
(C44) drcq4:-coe*q4$
(C45) drcq5:coe*q1$
(C46) dcq1:(drcq1-c)*q6$
(C47) dcq2:drcq2*q6$
(C48) dcq3:drcq3*q6$
(C49) dcq4:drcq4*q6$
```

```
(C50) dcq5:drcq5*q6$
(C51) depq1:0.5*gm1q6*rqrq*q6$
(C52) depq2:-q2*gm1q6$
(C53) depq3:-q3*gm1q6$
(C54) depq4:-q4*gm1q6$
(C55) depq5:gam$
(C56) dttq1:-tt*q6$
(C57) dttq2:axt*q6$
(C58) dttq3:ayt*q6$
(C59) dttq4:azt*q6$
(C60) dttq5:0.0$
(C61) d4q1:sada*(dttq1+dcq1)$
(C62) d4q2:sada*(dttq2+dcq2)$
(C63) d4q3:sada*(dttq3+dcq3)$
(C64) d4q4:sada*(dttq4+dcq4)$
(C65) d4q5:sada*dcq5$
(C66) d5q1:sada*(dttq1-dcq1)$
(C67) d5q2:sada*(dttq2-dcq2)$
(C68) d5q3:sada*(dttq3-dcq3)$
(C69) d5q4:sada*(dttq4-dcq4)$
(C70) d5q5:-d4q5$
(C71) a411:ev4+q1*d4q1$
(C72) a511:ev5+q1*d5q1$
(C73) ap1[1,1]:cg2*a411+cg3*a511$
(C74) ap1[1,2]:(cg1*d1q2+cg2*d4q2+cg3*d5q2)*q1$
(C75) ap1[1,3]:(cg1*d1q3+cg2*d4q3+cg3*d5q3)*q1$
(C76) ap1[1,4]:(cg1*d1q4+cg2*d4q4+cg3*d5q4)*q1$
(C77) ap1[1,5]:(cg2*d4q5+cg3*d5q5)*q1$
(C78) rcaxt:rc*axt$
(C79) ev4ax:ev4*axt$
(C80) ev5ax:ev5*axt$
(C81) coe1:q2+rcaxt$
(C82) coe:q2-rcaxt$
(C83) a121:q2*d1q1$
(C84) a421:ev4ax*drcq1+coe1*d4q1$
(C85) a521:-ev5ax*drcq1+coe*d5q1$
(C86) ap1[2,1]:cg1*a121+cg2*a421+cg3*a521$
(C87) a122:q2*d1q2+ev1$
(C88) a422:ev4+ev4ax*drcq2+coe1*d4q2$
(C89) a522:ev5-ev5ax*drcq2+coe*d5q2$
(C90) ap1[2,2]:cg1*a122+cg2*a422+cg3*a522$
(C91) a123:q2*d1q3$
(C92) a423:ev4ax*drcq3+coe1*d4q3$
(C93) a523:-ev5ax*drcq3+coe*d5q3$
(C94) ap1[2,3]:cg1*a123+cg2*a423+cg3*a523$
(C95) a124:q2*d1q4$
(C96) a424:ev4ax*drcq4+coe1*d4q4$
(C97) a524:-ev5ax*drcq4+coe*d5q4$
(C98) ap1[2,4]:cg1*a124+cg2*a424+cg3*a524$
(C99) a125:q2*d1q5$
(C100) a425:ev4ax*drcq5+coe1*d4q5$
```

```
(C101) a525:-ev5ax*drcq5+coe*d5q5$
(C102) ap1[2,5]:cg1*a125+cg2*a425+cg3*a525$
(C103) rcayt:rc*ayt$
(C104) ev4ay:ev4*ayt$
(C105) ev5ay:ev5*ayt$
(C106) coe1:q3+rcayt$
(C107) coe:q3-rcayt$
(C108) a131:q3*d1q1$
(C109) a431:ev4ay*drcq1+coe1*d4q1$
(C110) a531:-ev5ay*drcq1+coe*d5q1$
(C111) ap1[3,1]:cg1*a131+cg2*a431+cg3*a531$
(C112) a132:q3*d1q2$
(C113) a432:ev4ay*drcq2+coe1*d4q2$
(C114) a532:-ev5ay*drcq2+coe*d5q2$
(C115) ap1[3,2]:cg1*a132+cg2*a432+cg3*a532$
(C116) a133:q3*d1q3+ev1$
(C117) a433:ev4+ev4ay*drcq3+coe1*d4q3$
(C118) a533:ev5-ev5ay*drcq3+coe*d5q3$
(C119) ap1[3,3]:cg1*a133+cg2*a433+cg3*a533$
(C120) a134:q3*d1q4$
(C121) a434:ev4ay*drcq4+coe1*d4q4$
(C122) a534:-ev5ay*drcq4+coe*d5q4$
(C123) ap1[3,4]:cg1*a134+cg2*a434+cg3*a534$
(C124) a135:q3*d1q5$
(C125) a435:ev4ay*drcq5+coe1*d4q5$
(C126) a535:-ev5ay*drcq5+coe*d5q5$
(C127) ap1[3,5]:cg1*a135+cg2*a435+cg3*a535$
(C128) rcazt:rc*azt$
(C129) ev4az:ev4*azt$
(C130) ev5az:ev5*azt$
(C131) coe1:q4+rcazt$
(C132) coe:q4-rcazt$
(C133) a141:q4*d1q1$
(C134) a441:ev4az*drcq1+coe1*d4q1$
(C135) a541:-ev5az*drcq1+coe*d5q1$
(C136) ap1[4,1]:cg1*a141+cg2*a441+cg3*a541$
(C137) a142:q4*d1q2$
(C138) a442:ev4az*drcq2+coe1*d4q2$
(C139) a542:-ev5az*drcq2+coe*d5q2$
(C140) ap1[4,2]:cg1*a142+cg2*a442+cg3*a542$
(C141) a143:q4*d1q3$
(C142) a443:ev4az*drcq3+coe1*d4q3$
(C143) a543:-ev5az*drcq3+coe*d5q3$
(C144) ap1[4,3]:cg1*a143+cg2*a443+cg3*a543$
(C145) a144:q4*d1q4+ev1$
(C146) a444:ev4+ev4az*drcq4+coe1*d4q4$
(C147) a544:ev5-ev5az*drcq4+coe*d5q4$
(C148) ap1[4,4]:cg1*a144+cg2*a444+cg3*a544$
(C149) a145:q4*d1q5$
(C150) a445:ev4az*drcq5+coe1*d4q5$
(C151) a545:-ev5az*drcq5+coe*d5q5$
```

```
(C152) ap1[4,5]:cg1*a145+cg2*a445+cg3*a545$
(C153) rctt:rc*tt$
(C154) coe:0.5*(q2**2+q3**2+q4**2)*q6$
(C155) rt:rc*dttq1+tt*drcq1$
(C156) a151:2*coe*d1q1$
(C157) a451:ev4*(depq1+rt)+(pp+rctt)*d4q1$
(C158) a551:ev5*(depq1-rt)+(pp-rctt)*d5q1$
(C159) ap1[5,1]:cg1*a151+cg2*a451+cg3*a551$
(C160) rt:rc*dttq2+tt*drcq2$
(C161) a152:coe*d1q2-d1q1*q2$
(C162) a452:ev4*(depq2+rt)+(pp+rctt)*d4q2$
(C163) a552:ev5*(depq2-rt)+(pp-rctt)*d5q2$
(C164) ap1[5,2]:cg1*a152+cg2*a452+cg3*a552$
(C165) rt:rc*dttq3+tt*drcq3$
(C166) a153:coe*d1q3-d1q1*q3$
(C167) a453:ev4*(depq3+rt)+(pp+rctt)*d4q3$
(C168) a553:ev5*(depq3-rt)+(pp-rctt)*d5q3$
(C169) ap1[5,3]:cg1*a153+cg2*a453+cg3*a553$
(C170) rt:rc*dttq4+tt*drcq4$
(C171) a154:coe*d1q4-d1q1*q4$
(C172) a454:ev4*(depq4+rt)+(pp+rctt)*d4q4$
(C173) a554:ev5*(depq4-rt)+(pp-rctt)*d5q4$
(C174) ap1[5,4]:cg1*a154+cg2*a454+cg3*a554$
(C175) rt:tt*drcq5$
(C176) a155:coe*d1q5$
(C177) a455:ev4*(depq5+rt)+(pp+rctt)*d4q5$
(C178) a555:ev5*(depq5-rt)+(pp-rctt)*d5q5$
(C179) ap1[5,5]:cg1*a155+cg2*a455+cg3*a555$
(C180) q1:q1$
(C181) q2:q2$
(C182) q3:q3$
(C183) q4:-q4$
(C184) q5:q5$
(C185) sign:1$
(C186) cgg1:(gam-1)/gam$
(C187) cgg2:1/(2*gam)$
(C188) sada:sqrt(xix**2+xiy**2+xiz**2)$
(C189) axt:xix/sada$
(C190) ayt:xiy/sada$
(C191) azt:xiz/sada$
(C192) rqrq:q2**2+q3**2+q4**2$
(C193) q6:1/q1$
(C194) pr:(gam-1)*(q5-0.5*rqrq*q6)$
(C195) prgam:pr*gam$
(C196) pp:q5+pr$
(C197) c:sqrt(prgam*q6)$
(C198) tt:(q2*axt+q3*ayt+q4*azt)*q6$
(C199) rc:q1*c$
(C200) csad:c*sada$
(C201) e1:tt*sada$
(C202) e4:e1+csad$
```

```
(C203) e5:e1-csad$
(C204) ev1:0.5*(e1+sign*abs(e1))$
(C205) ev4:0.5*(e4+sign*abs(e4))$
(C206) ev5:0.5*(e5+sign*abs(e5))$
(C207) cg1:cgg1$
(C208) cg2:cgg2$
(C209) cg3:cgg2$
(C210) d1q1:-ev1*q6$
(C211) d1q2:xix*q6$
(C212) d1q3:xiy*q6$
(C213) d1q4:xiz*q6$
(C214) d1q5:0.0$
(C215) coe:gam*(gam-1)/(2*rc)$
(C216) gm1q6:(gam-1)*q6$
(C217) drcq1:coe*q5$
(C218) drcq2:-coe*q2$
(C219) drcq3:-coe*q3$
(C220) drcq4:-coe*q4$
(C221) drcq5:coe*q1$
(C222) dcq1:(drcq1-c)*q6$
(C223) dcq2:drcq2*q6$
(C224) dcq3:drcq3*q6$
(C225) dcq4:drcq4*q6$
(C226) dcq5:drcq5*q6$
(C227) depq1:0.5*gm1q6*rqrq*q6$
(C228) depq2:-q2*gm1q6$
(C229) depq3:-q3*gm1q6$
(C230) depq4:-q4*gm1q6$
(C231) depq5:gam$
(C232) dttq1:-tt*q6$
(C233) dttq2:axt*q6$
(C234) dttq3:ayt*q6$
(C235) dttq4:azt*q6$
(C236) dttq5:0.0$
(C237) d4q1:sada*(dttq1+dcq1)$
(C238) d4q2:sada*(dttq2+dcq2)$
(C239) d4q3:sada*(dttq3+dcq3)$
(C240) d4q4:sada*(dttq4+dcq4)$
(C241) d4q5:sada*dcq5$
(C242) d5q1:sada*(dttq1-dcq1)$
(C243) d5q2:sada*(dttq2-dcq2)$
(C244) d5q3:sada*(dttq3-dcq3)$
(C245) d5q4:sada*(dttq4-dcq4)$
(C246) d5q5:-d4q5$
(C247) a411:ev4+q1*d4q1$
(C248) a511:ev5+q1*d5q1$
(C249) ap2:matrix([0,0,0,0,0],[0,0,0,0,0],[0,0,0,0,0],[0,0,0,0,0],
[0,0,0,0,0])$
(C250) ap2[1,1]:cg2*a411+cg3*a511$
(C251) ap2[1,2]:(cg1*d1q2+cg2*d4q2+cg3*d5q2)*q1$
(C252) ap2[1,3]:(cg1*d1q3+cg2*d4q3+cg3*d5q3)*q1$
```

```
(C253) ap2[1,4]:(cg1*d1q4+cg2*d4q4+cg3*d5q4)*q1$
(C254) ap2[1,5]:(cg2*d4q5+cg3*d5q5)*q1$
(C255) rcaxt:rc*axt$
(C256) ev4ax:ev4*axt$
(C257) ev5ax:ev5*axt$
(C258) coe1:q2+rcaxt$
(C259) coe:q2-rcaxt$
(C260) a121:q2*d1q1$
(C261) a421:ev4ax*drcq1+coe1*d4q1$
(C262) a521:-ev5ax*drcq1+coe*d5q1$
(C263) ap2[2,1]:cg1*a121+cg2*a421+cg3*a521$
(C264) a122:q2*d1q2+ev1$
(C265) a422:ev4+ev4ax*drcq2+coe1*d4q2$
(C266) a522:ev5-ev5ax*drcq2+coe*d5q2$
(C267) ap2[2,2]:cg1*a122+cg2*a422+cg3*a522$
(C268) a123:q2*d1q3$
(C269) a423:ev4ax*drcq3+coe1*d4q3$
(C270) a523:-ev5ax*drcq3+coe*d5q3$
(C271) ap2[2,3]:cg1*a123+cg2*a423+cg3*a523$
(C272) a124:q2*d1q4$
(C273) a424:ev4ax*drcq4+coe1*d4q4$
(C274) a524:-ev5ax*drcq4+coe*d5q4$
(C275) ap2[2,4]:cg1*a124+cg2*a424+cg3*a524$
(C276) a125:q2*d1q5$
(C277) a425:ev4ax*drcq5+coe1*d4q5$
(C278) a525:-ev5ax*drcq5+coe*d5q5$
(C279) ap2[2,5]:cg1*a125+cg2*a425+cg3*a525$
(C280) rcayt:rc*ayt$
(C281) ev4ay:ev4*ayt$
(C282) ev5ay:ev5*ayt$
(C283) coe1:q3+rcayt$
(C284) coe:q3-rcayt$
(C285) a131:q3*d1q1$
(C286) a431:ev4ay*drcq1+coe1*d4q1$
(C287) a531:-ev5ay*drcq1+coe*d5q1$
(C288) ap2[3,1]:cg1*a131+cg2*a431+cg3*a531$
(C289) a132:q3*d1q2$
(C290) a432:ev4ay*drcq2+coe1*d4q2$
(C291) a532:-ev5ay*drcq2+coe*d5q2$
(C292) ap2[3,2]:cg1*a132+cg2*a432+cg3*a532$
(C293) a133:q3*d1q3+ev1$
(C294) a433:ev4+ev4ay*drcq3+coe1*d4q3$
(C295) a533:ev5-ev5ay*drcq3+coe*d5q3$
(C296) ap2[3,3]:cg1*a133+cg2*a433+cg3*a533$
(C297) a134:q3*d1q4$
(C298) a434:ev4ay*drcq4+coe1*d4q4$
(C299) a534:-ev5ay*drcq4+coe*d5q4$
(C300) ap2[3,4]:cg1*a134+cg2*a434+cg3*a534$
(C301) a135:q3*d1q5$
(C302) a435:ev4ay*drcq5+coe1*d4q5$
(C303) a535:-ev5ay*drcq5+coe*d5q5$
```

```
(C304) ap2[3,5]:cg1*a135+cg2*a435+cg3*a535$
(C305) rcazt:rc*azt$
(C306) ev4az:ev4*azt$
(C307) ev5az:ev5*azt$
(C308) coe1:q4+rcazt$
(C309) coe:q4-rcazt$
(C310) a141:q4*d1q1$
(C311) a441:ev4az*drcq1+coe1*d4q1$
(C312) a541:-ev5az*drcq1+coe*d5q1$
(C313) ap2[4,1]:cg1*a141+cg2*a441+cg3*a541$
(C314) a142:q4*d1q2$
(C315) a442:ev4az*drcq2+coe1*d4q2$
(C316) a542:-ev5az*drcq2+coe*d5q2$
(C317) ap2[4,2]:cg1*a142+cg2*a442+cg3*a542$
(C318) a143:q4*d1q3$
(C319) a443:ev4az*drcq3+coe1*d4q3$
(C320) a543:-ev5az*drcq3+coe*d5q3$
(C321) ap2[4,3]:cg1*a143+cg2*a443+cg3*a543$
(C322) a144:q4*d1q4+ev1$
(C323) a444:ev4+ev4az*drcq4+coe1*d4q4$
(C324) a544:ev5-ev5az*drcq4+coe*d5q4$
(C325) ap2[4,4]:cg1*a144+cg2*a444+cg3*a544$
(C326) a145:q4*d1q5$
(C327) a445:ev4az*drcq5+coe1*d4q5$
(C328) a545:-ev5az*drcq5+coe*d5q5$
(C329) ap2[4,5]:cg1*a145+cg2*a445+cg3*a545$
(C330) rctt:rc*tt$
(C331) coe:0.5*(q2**2+q3**2+q4**2)*q6$
(C332) rt:rc*dttq1+tt*drcq1$
(C333) a151:2*coe*d1q1$
(C334) a451:ev4*(depq1+rt)+(pp+rctt)*d4q1$
(C335) a551:ev5*(depq1-rt)+(pp-rctt)*d5q1$
(C336) ap2[5,1]:cg1*a151+cg2*a451+cg3*a551$
(C337) rt:rc*dttq2+tt*drcq2$
(C338) a152:coe*d1q2-d1q1*q2$
(C339) a452:ev4*(depq2+rt)+(pp+rctt)*d4q2$
(C340) a552:ev5*(depq2-rt)+(pp-rctt)*d5q2$
(C341) ap2[5,2]:cg1*a152+cg2*a452+cg3*a552$
(C342) rt:rc*dttq3+tt*drcq3$
(C343) a153:coe*d1q3-d1q1*q3$
(C344) a453:ev4*(depq3+rt)+(pp+rctt)*d4q3$
(C345) a553:ev5*(depq3-rt)+(pp-rctt)*d5q3$
(C346) ap2[5,3]:cg1*a153+cg2*a453+cg3*a553$
(C347) rt:rc*dttq4+tt*drcq4$
(C348) a154:coe*d1q4-d1q1*q4$
(C349) a454:ev4*(depq4+rt)+(pp+rctt)*d4q4$
(C350) a554:ev5*(depq4-rt)+(pp-rctt)*d5q4$
(C351) ap2[5,4]:cg1*a154+cg2*a454+cg3*a554$
(C352) rt:tt*drcq5$
(C353) a155:coe*d1q5$
(C354) a455:ev4*(depq5+rt)+(pp+rctt)*d4q5$
```

```
(C355) a555:ev5*(depq5-rt)+(pp-rctt)*d5q5$
(C356) ap2[5,5]:cg1*a155+cg2*a455+cg3*a555$
(C357) diff:ap1.m-m.ap2$
(C358) diff:ratexpand(diff);
                                          [ 0   0   0   0   0 ]
                                          [                   ]
                                          [ 0   0   0   0   0 ]
                                          [                   ]
(D358)                                    [ 0   0   0   0   0 ]
                                          [                   ]
                                          [ 0   0   0   0   0 ]
                                          [                   ]
                                          [ 0   0   0   0   0 ]

(C359) closefile(Apsup)$
```

```
(C3) ap1:matrix([0,0,0,0,0],[0,0,0,0,0],[0,0,0,0,0],[0,0,0,0,0],[0
,0,0,0,0])$
(C4) ap2:matrix([0,0,0,0,0],[0,0,0,0,0],[0,0,0,0,0],[0,0,0,0,0],[0
,0,0,0,0])$
(C5) m:matrix([1,0,0,0,0],[0,1,0,0,0],[0,0,1,0,0],[0,0,0,-1,0],[0,
0,0,0,1])$
(C6) diff:matrix([0,0,0,0,0],[0,0,0,0,0],[0,0,0,0,0],[0,0,0,0,0],[
0,0,0,0,0])$
(C7) sign:1$
(C8) cgg1:(gam-1)/gam$
(C9) cgg2:1/(2*gam)$
(C10) xiy:0.0$
(C11) xiz:0.0$
(C12) sada:sqrt(xix**2+xiy**2+xiz**2)$
(C13) axt:xix/sada$
(C14) ayt:xiy/sada$
(C15) azt:xiz/sada$
(C16) rqrq:q2**2+q3**2+q4**2$
(C17) q6:1/q1$
(C18) pr:(gam-1)*(q5-0.5*rqrq*q6)$
(C19) prgam:pr*gam$
(C20) pp:q5+pr$
(C21) c:sqrt(prgam*q6)$
(C22) tt:(q2*axt+q3*ayt+q4*azt)*q6$
(C23) rc:q1*c$
(C24) csad:c*sada$
(C25) e1:tt*sada$
(C26) e4:e1+csad$
(C27) e5:e1-csad$
(C28) ev1:0.5*(e1+sign*abs(e1))$
(C29) ev4:0.5*(e4+sign*abs(e4))$
(C30) ev5:0.0$
(C31) cg1:cgg1$
(C32) cg2:cgg2$
(C33) cg3:0.0$
(C34) d1q1:-ev1*q6$
(C35) d1q2:xix*q6$
(C36) d1q3:xiy*q6$
(C37) d1q4:xiz*q6$
(C38) d1q5:0.0$
(C39) coe:gam*(gam-1)/(2*rc)$
(C40) gm1q6:(gam-1)*q6$
(C41) drcq1:coe*q5$
(C42) drcq2:-coe*q2$
(C43) drcq3:-coe*q3$
(C44) drcq4:-coe*q4$
(C45) drcq5:coe*q1$
(C46) dcq1:(drcq1-c)*q6$
(C47) dcq2:drcq2*q6$
(C48) dcq3:drcq3*q6$
(C49) dcq4:drcq4*q6$
```

```
(C50)  dcq5:drcq5*q6$
(C51)  depq1:0.5*gm1q6*rqrq*q6$
(C52)  depq2:-q2*gm1q6$
(C53)  depq3:-q3*gm1q6$
(C54)  depq4:-q4*gm1q6$
(C55)  depq5:gam$
(C56)  dttq1:-tt*q6$
(C57)  dttq2:axt*q6$
(C58)  dttq3:ayt*q6$
(C59)  dttq4:azt*q6$
(C60)  dttq5:0.0$
(C61)  d4q1:sada*(dttq1+dcq1)$
(C62)  d4q2:sada*(dttq2+dcq2)$
(C63)  d4q3:sada*(dttq3+dcq3)$
(C64)  d4q4:sada*(dttq4+dcq4)$
(C65)  d4q5:sada*dcq5$
(C66)  d5q1:sada*(dttq1-dcq1)$
(C67)  d5q2:sada*(dttq2-dcq2)$
(C68)  d5q3:sada*(dttq3-dcq3)$
(C69)  d5q4:sada*(dttq4-dcq4)$
(C70)  d5q5:-d4q5$
(C71)  a411:ev4+q1*d4q1$
(C72)  a511:ev5+q1*d5q1$
(C73)  ap1[1,1]:cg2*a411+cg3*a511$
(C74)  ap1[1,2]:(cg1*d1q2+cg2*d4q2+cg3*d5q2)*q1$
(C75)  ap1[1,3]:(cg1*d1q3+cg2*d4q3+cg3*d5q3)*q1$
(C76)  ap1[1,4]:(cg1*d1q4+cg2*d4q4+cg3*d5q4)*q1$
(C77)  ap1[1,5]:(cg2*d4q5+cg3*d5q5)*q1$
(C78)  rcaxt:rc*axt$
(C79)  ev4ax:ev4*axt$
(C80)  ev5ax:ev5*axt$
(C81)  coe1:q2+rcaxt$
(C82)  coe:q2-rcaxt$
(C83)  a121:q2*d1q1$
(C84)  a421:ev4ax*drcq1+coe1*d4q1$
(C85)  a521:-ev5ax*drcq1+coe*d5q1$
(C86)  ap1[2,1]:cg1*a121+cg2*a421+cg3*a521$
(C87)  a122:q2*d1q2+ev1$
(C88)  a422:ev4+ev4ax*drcq2+coe1*d4q2$
(C89)  a522:ev5-ev5ax*drcq2+coe*d5q2$
(C90)  ap1[2,2]:cg1*a122+cg2*a422+cg3*a522$
(C91)  a123:q2*d1q3$
(C92)  a423:ev4ax*drcq3+coe1*d4q3$
(C93)  a523:-ev5ax*drcq3+coe*d5q3$
(C94)  ap1[2,3]:cg1*a123+cg2*a423+cg3*a523$
(C95)  a124:q2*d1q4$
(C96)  a424:ev4ax*drcq4+coe1*d4q4$
(C97)  a524:-ev5ax*drcq4+coe*d5q4$
(C98)  ap1[2,4]:cg1*a124+cg2*a424+cg3*a524$
(C99)  a125:q2*d1q5$
(C100) a425:ev4ax*drcq5+coe1*d4q5$
```

```
(C101) a525:-ev5ax*drcq5+coe*d5q5$
(C102) ap1[2,5]:cg1*a125+cg2*a425+cg3*a525$
(C103) rcayt:rc*ayt$
(C104) ev4ay:ev4*ayt$
(C105) ev5ay:ev5*ayt$
(C106) coe1:q3+rcayt$
(C107) coe:q3-rcayt$
(C108) a131:q3*d1q1$
(C109) a431:ev4ay*drcq1+coe1*d4q1$
(C110) a531:-ev5ay*drcq1+coe*d5q1$
(C111) ap1[3,1]:cg1*a131+cg2*a431+cg3*a531$
(C112) a132:q3*d1q2$
(C113) a432:ev4ay*drcq2+coe1*d4q2$
(C114) a532:-ev5ay*drcq2+coe*d5q2$
(C115) ap1[3,2]:cg1*a132+cg2*a432+cg3*a532$
(C116) a133:q3*d1q3+ev1$
(C117) a433:ev4+ev4ay*drcq3+coe1*d4q3$
(C118) a533:ev5-ev5ay*drcq3+coe*d5q3$
(C119) ap1[3,3]:cg1*a133+cg2*a433+cg3*a533$
(C120) a134:q3*d1q4$
(C121) a434:ev4ay*drcq4+coe1*d4q4$
(C122) a534:-ev5ay*drcq4+coe*d5q4$
(C123) ap1[3,4]:cg1*a134+cg2*a434+cg3*a534$
(C124) a135:q3*d1q5$
(C125) a435:ev4ay*drcq5+coe1*d4q5$
(C126) a535:-ev5ay*drcq5+coe*d5q5$
(C127) ap1[3,5]:cg1*a135+cg2*a435+cg3*a535$
(C128) rcazt:rc*azt$
(C129) ev4az:ev4*azt$
(C130) ev5az:ev5*azt$
(C131) coe1:q4+rcazt$
(C132) coe:q4-rcazt$
(C133) a141:q4*d1q1$
(C134) a441:ev4az*drcq1+coe1*d4q1$
(C135) a541:-ev5az*drcq1+coe*d5q1$
(C136) ap1[4,1]:cg1*a141+cg2*a441+cg3*a541$
(C137) a142:q4*d1q2$
(C138) a442:ev4az*drcq2+coe1*d4q2$
(C139) a542:-ev5az*drcq2+coe*d5q2$
(C140) ap1[4,2]:cg1*a142+cg2*a442+cg3*a542$
(C141) a143:q4*d1q3$
(C142) a443:ev4az*drcq3+coe1*d4q3$
(C143) a543:-ev5az*drcq3+coe*d5q3$
(C144) ap1[4,3]:cg1*a143+cg2*a443+cg3*a543$
(C145) a144:q4*d1q4+ev1$
(C146) a444:ev4+ev4az*drcq4+coe1*d4q4$
(C147) a544:ev5-ev5az*drcq4+coe*d5q4$
(C148) ap1[4,4]:cg1*a144+cg2*a444+cg3*a544$
(C149) a145:q4*d1q5$
(C150) a445:ev4az*drcq5+coe1*d4q5$
(C151) a545:-ev5az*drcq5+coe*d5q5$
```

```
(C152) ap1[4,5]:cg1*a145+cg2*a445+cg3*a545$
(C153) rctt:rc*tt$
(C154) coe:0.5*(q2**2+q3**2+q4**2)*q6$
(C155) rt:rc*dttq1+tt*drcq1$
(C156) a151:2*coe*d1q1$
(C157) a451:ev4*(depq1+rt)+(pp+rctt)*d4q1$
(C158) a551:ev5*(depq1-rt)+(pp-rctt)*d5q1$
(C159) ap1[5,1]:cg1*a151+cg2*a451+cg3*a551$
(C160) rt:rc*dttq2+tt*drcq2$
(C161) a152:coe*d1q2-d1q1*q2$
(C162) a452:ev4*(depq2+rt)+(pp+rctt)*d4q2$
(C163) a552:ev5*(depq2-rt)+(pp-rctt)*d5q2$
(C164) ap1[5,2]:cg1*a152+cg2*a452+cg3*a552$
(C165) rt:rc*dttq3+tt*drcq3$
(C166) a153:coe*d1q3-d1q1*q3$
(C167) a453:ev4*(depq3+rt)+(pp+rctt)*d4q3$
(C168) a553:ev5*(depq3-rt)+(pp-rctt)*d5q3$
(C169) ap1[5,3]:cg1*a153+cg2*a453+cg3*a553$
(C170) rt:rc*dttq4+tt*drcq4$
(C171) a154:coe*d1q4-d1q1*q4$
(C172) a454:ev4*(depq4+rt)+(pp+rctt)*d4q4$
(C173) a554:ev5*(depq4-rt)+(pp-rctt)*d5q4$
(C174) ap1[5,4]:cg1*a154+cg2*a454+cg3*a554$
(C175) rt:tt*drcq5$
(C176) a155:coe*d1q5$
(C177) a455:ev4*(depq5+rt)+(pp+rctt)*d4q5$
(C178) a555:ev5*(depq5-rt)+(pp-rctt)*d5q5$
(C179) ap1[5,5]:cg1*a155+cg2*a455+cg3*a555$
(C180) q1:q1$
(C181) q2:q2$
(C182) q3:q3$
(C183) q4:-q4$
(C184) q5:q5$
(C185) sign:1$
(C186) cgg1:(gam-1)/gam$
(C187) cgg2:1/(2*gam)$
(C188) sada:sqrt(xix**2+xiy**2+xiz**2)$
(C189) axt:xix/sada$
(C190) ayt:xiy/sada$
(C191) azt:xiz/sada$
(C192) rqrq:q2**2+q3**2+q4**2$
(C193) q6:1/q1$
(C194) pr:(gam-1)*(q5-0.5*rqrq*q6)$
(C195) prgam:pr*gam$
(C196) pp:q5+pr$
(C197) c:sqrt(prgam*q6)$
(C198) tt:(q2*axt+q3*ayt+q4*azt)*q6$
(C199) rc:q1*c$
(C200) csad:c*sada$
(C201) e1:tt*sada$
(C202) e4:e1+csad$
```

```
(C203) e5:e1-csad$
(C204) ev1:0.5*(e1+sign*abs(e1))$
(C205) ev4:0.5*(e4+sign*abs(e4))$
(C206) ev5:0.0$
(C207) cg1:cgg1$
(C208) cg2:cgg2$
(C209) cg3:0.0$
(C210) d1q1:-ev1*q6$
(C211) d1q2:xix*q6$
(C212) d1q3:xiy*q6$
(C213) d1q4:xiz*q6$
(C214) d1q5:0.0$
(C215) coe:gam*(gam-1)/(2*rc)$
(C216) gm1q6:(gam-1)*q6$
(C217) drcq1:coe*q5$
(C218) drcq2:-coe*q2$
(C219) drcq3:-coe*q3$
(C220) drcq4:-coe*q4$
(C221) drcq5:coe*q1$
(C222) dcq1:(drcq1-c)*q6$
(C223) dcq2:drcq2*q6$
(C224) dcq3:drcq3*q6$
(C225) dcq4:drcq4*q6$
(C226) dcq5:drcq5*q6$
(C227) depq1:0.5*gm1q6*rqrq*q6$
(C228) depq2:-q2*gm1q6$
(C229) depq3:-q3*gm1q6$
(C230) depq4:-q4*gm1q6$
(C231) depq5:gam$
(C232) dttq1:-tt*q6$
(C233) dttq2:axt*q6$
(C234) dttq3:ayt*q6$
(C235) dttq4:azt*q6$
(C236) dttq5:0.0$
(C237) d4q1:sada*(dttq1+dcq1)$
(C238) d4q2:sada*(dttq2+dcq2)$
(C239) d4q3:sada*(dttq3+dcq3)$
(C240) d4q4:sada*(dttq4+dcq4)$
(C241) d4q5:sada*dcq5$
(C242) d5q1:sada*(dttq1-dcq1)$
(C243) d5q2:sada*(dttq2-dcq2)$
(C244) d5q3:sada*(dttq3-dcq3)$
(C245) d5q4:sada*(dttq4-dcq4)$
(C246) d5q5:-d4q5$
(C247) a411:ev4+q1*d4q1$
(C248) a511:ev5+q1*d5q1$
(C249) ap2:matrix([0,0,0,0,0],[0,0,0,0,0],[0,0,0,0,0],[0,0,0,0,0],
[0,0,0,0,0])$
(C250) ap2[1,1]:cg2*a411+cg3*a511$
(C251) ap2[1,2]:(cg1*d1q2+cg2*d4q2+cg3*d5q2)*q1$
(C252) ap2[1,3]:(cg1*d1q3+cg2*d4q3+cg3*d5q3)*q1$
```

```
(C253) ap2[1,4]:(cg1*d1q4+cg2*d4q4+cg3*d5q4)*q1$
(C254) ap2[1,5]:(cg2*d4q5+cg3*d5q5)*q1$
(C255) rcaxt:rc*axt$
(C256) ev4ax:ev4*axt$
(C257) ev5ax:ev5*axt$
(C258) coe1:q2+rcaxt$
(C259) coe:q2-rcaxt$
(C260) a121:q2*d1q1$
(C261) a421:ev4ax*drcq1+coe1*d4q1$
(C262) a521:-ev5ax*drcq1+coe*d5q1$
(C263) ap2[2,1]:cg1*a121+cg2*a421+cg3*a521$
(C264) a122:q2*d1q2+ev1$
(C265) a422:ev4+ev4ax*drcq2+coe1*d4q2$
(C266) a522:ev5-ev5ax*drcq2+coe*d5q2$
(C267) ap2[2,2]:cg1*a122+cg2*a422+cg3*a522$
(C268) a123:q2*d1q3$
(C269) a423:ev4ax*drcq3+coe1*d4q3$
(C270) a523:-ev5ax*drcq3+coe*d5q3$
(C271) ap2[2,3]:cg1*a123+cg2*a423+cg3*a523$
(C272) a124:q2*d1q4$
(C273) a424:ev4ax*drcq4+coe1*d4q4$
(C274) a524:-ev5ax*drcq4+coe*d5q4$
(C275) ap2[2,4]:cg1*a124+cg2*a424+cg3*a524$
(C276) a125:q2*d1q5$
(C277) a425:ev4ax*drcq5+coe1*d4q5$
(C278) a525:-ev5ax*drcq5+coe*d5q5$
(C279) ap2[2,5]:cg1*a125+cg2*a425+cg3*a525$
(C280) rcayt:rc*ayt$
(C281) ev4ay:ev4*ayt$
(C282) ev5ay:ev5*ayt$
(C283) coe1:q3+rcayt$
(C284) coe:q3-rcayt$
(C285) a131:q3*d1q1$
(C286) a431:ev4ay*drcq1+coe1*d4q1$
(C287) a531:-ev5ay*drcq1+coe*d5q1$
(C288) ap2[3,1]:cg1*a131+cg2*a431+cg3*a531$
(C289) a132:q3*d1q2$
(C290) a432:ev4ay*drcq2+coe1*d4q2$
(C291) a532:-ev5ay*drcq2+coe*d5q2$
(C292) ap2[3,2]:cg1*a132+cg2*a432+cg3*a532$
(C293) a133:q3*d1q3+ev1$
(C294) a433:ev4+ev4ay*drcq3+coe1*d4q3$
(C295) a533:ev5-ev5ay*drcq3+coe*d5q3$
(C296) ap2[3,3]:cg1*a133+cg2*a433+cg3*a533$
(C297) a134:q3*d1q4$
(C298) a434:ev4ay*drcq4+coe1*d4q4$
(C299) a534:-ev5ay*drcq4+coe*d5q4$
(C300) ap2[3,4]:cg1*a134+cg2*a434+cg3*a534$
(C301) a135:q3*d1q5$
(C302) a435:ev4ay*drcq5+coe1*d4q5$
(C303) a535:-ev5ay*drcq5+coe*d5q5$
```

```
(C304) ap2[3,5]:cg1*a135+cg2*a435+cg3*a535$
(C305) rcazt:rc*azt$
(C306) ev4az:ev4*azt$
(C307) ev5az:ev5*azt$
(C308) coe1:q4+rcazt$
(C309) coe:q4-rcazt$
(C310) a141:q4*d1q1$
(C311) a441:ev4az*drcq1+coe1*d4q1$
(C312) a541:-ev5az*drcq1+coe*d5q1$
(C313) ap2[4,1]:cg1*a141+cg2*a441+cg3*a541$
(C314) a142:q4*d1q2$
(C315) a442:ev4az*drcq2+coe1*d4q2$
(C316) a542:-ev5az*drcq2+coe*d5q2$
(C317) ap2[4,2]:cg1*a142+cg2*a442+cg3*a542$
(C318) a143:q4*d1q3$
(C319) a443:ev4az*drcq3+coe1*d4q3$
(C320) a543:-ev5az*drcq3+coe*d5q3$
(C321) ap2[4,3]:cg1*a143+cg2*a443+cg3*a543$
(C322) a144:q4*d1q4+ev1$
(C323) a444:ev4+ev4az*drcq4+coe1*d4q4$
(C324) a544:ev5-ev5az*drcq4+coe*d5q4$
(C325) ap2[4,4]:cg1*a144+cg2*a444+cg3*a544$
(C326) a145:q4*d1q5$
(C327) a445:ev4az*drcq5+coe1*d4q5$
(C328) a545:-ev5az*drcq5+coe*d5q5$
(C329) ap2[4,5]:cg1*a145+cg2*a445+cg3*a545$
(C330) rctt:rc*tt$
(C331) coe:0.5*(q2**2+q3**2+q4**2)*q6$
(C332) rt:rc*dttq1+tt*drcq1$
(C333) a151:2*coe*d1q1$
(C334) a451:ev4*(depq1+rt)+(pp+rctt)*d4q1$
(C335) a551:ev5*(depq1-rt)+(pp-rctt)*d5q1$
(C336) ap2[5,1]:cg1*a151+cg2*a451+cg3*a551$
(C337) rt:rc*dttq2+tt*drcq2$
(C338) a152:coe*d1q2-d1q1*q2$
(C339) a452:ev4*(depq2+rt)+(pp+rctt)*d4q2$
(C340) a552:ev5*(depq2-rt)+(pp-rctt)*d5q2$
(C341) ap2[5,2]:cg1*a152+cg2*a452+cg3*a552$
(C342) rt:rc*dttq3+tt*drcq3$
(C343) a153:coe*d1q3-d1q1*q3$
(C344) a453:ev4*(depq3+rt)+(pp+rctt)*d4q3$
(C345) a553:ev5*(depq3-rt)+(pp-rctt)*d5q3$
(C346) ap2[5,3]:cg1*a153+cg2*a453+cg3*a553$
(C347) rt:rc*dttq4+tt*drcq4$
(C348) a154:coe*d1q4-d1q1*q4$
(C349) a454:ev4*(depq4+rt)+(pp+rctt)*d4q4$
(C350) a554:ev5*(depq4-rt)+(pp-rctt)*d5q4$
(C351) ap2[5,4]:cg1*a154+cg2*a454+cg3*a554$
(C352) rt:tt*drcq5$
(C353) a155:coe*d1q5$
(C354) a455:ev4*(depq5+rt)+(pp+rctt)*d4q5$
```

```
(C355) a555:ev5*(depq5-rt)+(pp-rctt)*d5q5$
(C356) ap2[5,5]:cg1*a155+cg2*a455+cg3*a555$
(C357) diff:ap1.m-m.ap2$
(C358) diff:ratexpand(diff);
                                         [ 0  0  0  0  0 ]
                                         [               ]
                                         [ 0  0  0  0  0 ]
                                         [               ]
(D358)                                   [ 0  0  0  0  0 ]
                                         [               ]
                                         [ 0  0  0  0  0 ]
                                         [               ]
                                         [ 0  0  0  0  0 ]
(C359) closefile(Apsub)$
```

```
(C3) ap1:matrix([0,0,0,0,0],[0,0,0,0,0],[0,0,0,0,0],[0,0,0,0,0],[0
,0,0,0,0])$
(C4) ap2:matrix([0,0,0,0,0],[0,0,0,0,0],[0,0,0,0,0],[0,0,0,0,0],[0
,0,0,0,0])$
(C5) m:matrix([1,0,0,0,0],[0,1,0,0,0],[0,0,1,0,0],[0,0,0,-1,0],[0,
0,0,0,1])$
(C6) diff:matrix([0,0,0,0,0],[0,0,0,0,0],[0,0,0,0,0],[0,0,0,0,0],[
0,0,0,0,0])$
(C7) sign:1$
(C8) cgg1:(gam-1)/gam$
(C9) cgg2:1/(2*gam)$
(C10) xiy:0.0$
(C11) xiz:0.0$
(C12) sada:sqrt(xix**2+xiy**2+xiz**2)$
(C13) axt:xix/sada$
(C14) ayt:xiy/sada$
(C15) azt:xiz/sada$
(C16) rqrq:q2**2+q3**2+q4**2$
(C17) q6:1/q1$
(C18) pr:(gam-1)*(q5-0.5*rqrq*q6)$
(C19) prgam:pr*gam$
(C20) pp:q5+pr$
(C21) c:sqrt(prgam*q6)$
(C22) tt:(q2*axt+q3*ayt+q4*azt)*q6$
(C23) rc:q1*c$
(C24) csad:c*sada$
(C25) e1:tt*sada$
(C26) e4:e1+csad$
(C27) e5:e1-csad$
(C28) ev1:0.5*(e1+sign*abs(e1))$
(C29) ev4:0.5*(e4+sign*abs(e4))$
(C30) ev5:0.0$
(C31) cg1:cgg1$
(C32) cg2:cgg2$
(C33) cg3:0.0$
(C34) d1q1:-ev1*q6$
(C35) d1q2:xix*q6$
(C36) d1q3:xiy*q6$
(C37) d1q4:xiz*q6$
(C38) d1q5:0.0$
(C39) coe:gam*(gam-1)/(2*rc)$
(C40) gm1q6:(gam-1)*q6$
(C41) drcq1:coe*q5$
(C42) drcq2:-coe*q2$
(C43) drcq3:-coe*q3$
(C44) drcq4:-coe*q4$
(C45) drcq5:coe*q1$
(C46) dcq1:(drcq1-c)*q6$
(C47) dcq2:drcq2*q6$
(C48) dcq3:drcq3*q6$
(C49) dcq4:drcq4*q6$
```

```
(C50) dcq5:drcq5*q6$
(C51) depq1:0.5*gm1q6*rqrq*q6$
(C52) depq2:-q2*gm1q6$
(C53) depq3:-q3*gm1q6$
(C54) depq4:-q4*gm1q6$
(C55) depq5:gam$
(C56) dttq1:-tt*q6$
(C57) dttq2:axt*q6$
(C58) dttq3:ayt*q6$
(C59) dttq4:azt*q6$
(C60) dttq5:0.0$
(C61) d4q1:sada*(dttq1+dcq1)$
(C62) d4q2:sada*(dttq2+dcq2)$
(C63) d4q3:sada*(dttq3+dcq3)$
(C64) d4q4:sada*(dttq4+dcq4)$
(C65) d4q5:sada*dcq5$
(C66) d5q1:sada*(dttq1-dcq1)$
(C67) d5q2:sada*(dttq2-dcq2)$
(C68) d5q3:sada*(dttq3-dcq3)$
(C69) d5q4:sada*(dttq4-dcq4)$
(C70) d5q5:-d4q5$
(C71) a411:ev4+q1*d4q1$
(C72) a511:ev5+q1*d5q1$
(C73) ap1[1,1]:cg2*a411+cg3*a511$
(C74) ap1[1,2]:(cg1*d1q2+cg2*d4q2+cg3*d5q2)*q1$
(C75) ap1[1,3]:(cg1*d1q3+cg2*d4q3+cg3*d5q3)*q1$
(C76) ap1[1,4]:(cg1*d1q4+cg2*d4q4+cg3*d5q4)*q1$
(C77) ap1[1,5]:(cg2*d4q5+cg3*d5q5)*q1$
(C78) rcaxt:rc*axt$
(C79) ev4ax:ev4*axt$
(C80) ev5ax:ev5*axt$
(C81) coe1:q2+rcaxt$
(C82) coe:q2-rcaxt$
(C83) a121:q2*d1q1$
(C84) a421:ev4ax*drcq1+coe1*d4q1$
(C85) a521:-ev5ax*drcq1+coe*d5q1$
(C86) ap1[2,1]:cg1*a121+cg2*a421+cg3*a521$
(C87) a122:q2*d1q2+ev1$
(C88) a422:ev4+ev4ax*drcq2+coe1*d4q2$
(C89) a522:ev5-ev5ax*drcq2+coe*d5q2$
(C90) ap1[2,2]:cg1*a122+cg2*a422+cg3*a522$
(C91) a123:q2*d1q3$
(C92) a423:ev4ax*drcq3+coe1*d4q3$
(C93) a523:-ev5ax*drcq3+coe*d5q3$
(C94) ap1[2,3]:cg1*a123+cg2*a423+cg3*a523$
(C95) a124:q2*d1q4$
(C96) a424:ev4ax*drcq4+coe1*d4q4$
(C97) a524:-ev5ax*drcq4+coe*d5q4$
(C98) ap1[2,4]:cg1*a124+cg2*a424+cg3*a524$
(C99) a125:q2*d1q5$
(C100) a425:ev4ax*drcq5+coe1*d4q5$
```

```
(C101) a525:-ev5ax*drcq5+coe*d5q5$
(C102) ap1[2,5]:cg1*a125+cg2*a425+cg3*a525$
(C103) rcayt:rc*ayt$
(C104) ev4ay:ev4*ayt$
(C105) ev5ay:ev5*ayt$
(C106) coe1:q3+rcayt$
(C107) coe:q3-rcayt$
(C108) a131:q3*d1q1$
(C109) a431:ev4ay*drcq1+coe1*d4q1$
(C110) a531:-ev5ay*drcq1+coe*d5q1$
(C111) ap1[3,1]:cg1*a131+cg2*a431+cg3*a531$
(C112) a132:q3*d1q2$
(C113) a432:ev4ay*drcq2+coe1*d4q2$
(C114) a532:-ev5ay*drcq2+coe*d5q2$
(C115) ap1[3,2]:cg1*a132+cg2*a432+cg3*a532$
(C116) a133:q3*d1q3+ev1$
(C117) a433:ev4+ev4ay*drcq3+coe1*d4q3$
(C118) a533:ev5-ev5ay*drcq3+coe*d5q3$
(C119) ap1[3,3]:cg1*a133+cg2*a433+cg3*a533$
(C120) a134:q3*d1q4$
(C121) a434:ev4ay*drcq4+coe1*d4q4$
(C122) a534:-ev5ay*drcq4+coe*d5q4$
(C123) ap1[3,4]:cg1*a134+cg2*a434+cg3*a534$
(C124) a135:q3*d1q5$
(C125) a435:ev4ay*drcq5+coe1*d4q5$
(C126) a535:-ev5ay*drcq5+coe*d5q5$
(C127) ap1[3,5]:cg1*a135+cg2*a435+cg3*a535$
(C128) rcazt:rc*azt$
(C129) ev4az:ev4*azt$
(C130) ev5az:ev5*azt$
(C131) coe1:q4+rcazt$
(C132) coe:q4-rcazt$
(C133) a141:q4*d1q1$
(C134) a441:ev4az*drcq1+coe1*d4q1$
(C135) a541:-ev5az*drcq1+coe*d5q1$
(C136) ap1[4,1]:cg1*a141+cg2*a441+cg3*a541$
(C137) a142:q4*d1q2$
(C138) a442:ev4az*drcq2+coe1*d4q2$
(C139) a542:-ev5az*drcq2+coe*d5q2$
(C140) ap1[4,2]:cg1*a142+cg2*a442+cg3*a542$
(C141) a143:q4*d1q3$
(C142) a443:ev4az*drcq3+coe1*d4q3$
(C143) a543:-ev5az*drcq3+coe*d5q3$
(C144) ap1[4,3]:cg1*a143+cg2*a443+cg3*a543$
(C145) a144:q4*d1q4+ev1$
(C146) a444:ev4+ev4az*drcq4+coe1*d4q4$
(C147) a544:ev5-ev5az*drcq4+coe*d5q4$
(C148) ap1[4,4]:cg1*a144+cg2*a444+cg3*a544$
(C149) a145:q4*d1q5$
(C150) a445:ev4az*drcq5+coe1*d4q5$
(C151) a545:-ev5az*drcq5+coe*d5q5$
```

```
(C152) ap1[4,5]:cg1*a145+cg2*a445+cg3*a545$
(C153) rctt:rc*tt$
(C154) coe:0.5*(q2**2+q3**2+q4**2)*q6$
(C155) rt:rc*dttq1+tt*drcq1$
(C156) a151:2*coe*d1q1$
(C157) a451:ev4*(depq1+rt)+(pp+rctt)*d4q1$
(C158) a551:ev5*(depq1-rt)+(pp-rctt)*d5q1$
(C159) ap1[5,1]:cg1*a151+cg2*a451+cg3*a551$
(C160) rt:rc*dttq2+tt*drcq2$
(C161) a152:coe*d1q2-d1q1*q2$
(C162) a452:ev4*(depq2+rt)+(pp+rctt)*d4q2$
(C163) a552:ev5*(depq2-rt)+(pp-rctt)*d5q2$
(C164) ap1[5,2]:cg1*a152+cg2*a452+cg3*a552$
(C165) rt:rc*dttq3+tt*drcq3$
(C166) a153:coe*d1q3-d1q1*q3$
(C167) a453:ev4*(depq3+rt)+(pp+rctt)*d4q3$
(C168) a553:ev5*(depq3-rt)+(pp-rctt)*d5q3$
(C169) ap1[5,3]:cg1*a153+cg2*a453+cg3*a553$
(C170) rt:rc*dttq4+tt*drcq4$
(C171) a154:coe*d1q4-d1q1*q4$
(C172) a454:ev4*(depq4+rt)+(pp+rctt)*d4q4$
(C173) a554:ev5*(depq4-rt)+(pp-rctt)*d5q4$
(C174) ap1[5,4]:cg1*a154+cg2*a454+cg3*a554$
(C175) rt:tt*drcq5$
(C176) a155:coe*d1q5$
(C177) a455:ev4*(depq5+rt)+(pp+rctt)*d4q5$
(C178) a555:ev5*(depq5-rt)+(pp-rctt)*d5q5$
(C179) ap1[5,5]:cg1*a155+cg2*a455+cg3*a555$
(C180) q1:q1$
(C181) q2:q2$
(C182) q3:q3$
(C183) q4:-q4$
(C184) q5:q5$
(C185) sign:1$
(C186) cgg1:(gam-1)/gam$
(C187) cgg2:1/(2*gam)$
(C188) sada:sqrt(xix**2+xiy**2+xiz**2)$
(C189) axt:xix/sada$
(C190) ayt:xiy/sada$
(C191) azt:xiz/sada$
(C192) rqrq:q2**2+q3**2+q4**2$
(C193) q6:1/q1$
(C194) pr:(gam-1)*(q5-0.5*rqrq*q6)$
(C195) prgam:pr*gam$
(C196) pp:q5+pr$
(C197) c:sqrt(prgam*q6)$
(C198) tt:(q2*axt+q3*ayt+q4*azt)*q6$
(C199) rc:q1*c$
(C200) csad:c*sada$
(C201) e1:tt*sada$
(C202) e4:e1+csad$
```

```
(C203) e5:e1-csad$
(C204) ev1:0.5*(e1+sign*abs(e1))$
(C205) ev4:0.5*(e4+sign*abs(e4))$
(C206) ev5:0.0$
(C207) cg1:cgg1$
(C208) cg2:cgg2$
(C209) cg3:0.0$
(C210) d1q1:-ev1*q6$
(C211) d1q2:xix*q6$
(C212) d1q3:xiy*q6$
(C213) d1q4:xiz*q6$
(C214) d1q5:0.0$
(C215) coe:gam*(gam-1)/(2*rc)$
(C216) gm1q6:(gam-1)*q6$
(C217) drcq1:coe*q5$
(C218) drcq2:-coe*q2$
(C219) drcq3:-coe*q3$
(C220) drcq4:-coe*q4$
(C221) drcq5:coe*q1$
(C222) dcq1:(drcq1-c)*q6$
(C223) dcq2:drcq2*q6$
(C224) dcq3:drcq3*q6$
(C225) dcq4:drcq4*q6$
(C226) dcq5:drcq5*q6$
(C227) depq1:0.5*gm1q6*rqrq*q6$
(C228) depq2:-q2*gm1q6$
(C229) depq3:-q3*gm1q6$
(C230) depq4:-q4*gm1q6$
(C231) depq5:gam$
(C232) dttq1:-tt*q6$
(C233) dttq2:axt*q6$
(C234) dttq3:ayt*q6$
(C235) dttq4:azt*q6$
(C236) dttq5:0.0$
(C237) d4q1:sada*(dttq1+dcq1)$
(C238) d4q2:sada*(dttq2+dcq2)$
(C239) d4q3:sada*(dttq3+dcq3)$
(C240) d4q4:sada*(dttq4+dcq4)$
(C241) d4q5:sada*dcq5$
(C242) d5q1:sada*(dttq1-dcq1)$
(C243) d5q2:sada*(dttq2-dcq2)$
(C244) d5q3:sada*(dttq3-dcq3)$
(C245) d5q4:sada*(dttq4-dcq4)$
(C246) d5q5:-d4q5$
(C247) a411:ev4+q1*d4q1$
(C248) a511:ev5+q1*d5q1$
(C249) ap2:matrix([0,0,0,0,0],[0,0,0,0,0],[0,0,0,0,0],[0,0,0,0,0],
[0,0,0,0,0])$
(C250) ap2[1,1]:cg2*a411+cg3*a511$
(C251) ap2[1,2]:(cg1*d1q2+cg2*d4q2+cg3*d5q2)*q1$
(C252) ap2[1,3]:(cg1*d1q3+cg2*d4q3+cg3*d5q3)*q1$
```

```
(C253) ap2[1,4]:(cg1*d1q4+cg2*d4q4+cg3*d5q4)*q1$
(C254) ap2[1,5]:(cg2*d4q5+cg3*d5q5)*q1$
(C255) rcaxt:rc*axt$
(C256) ev4ax:ev4*axt$
(C257) ev5ax:ev5*axt$
(C258) coe1:q2+rcaxt$
(C259) coe:q2-rcaxt$
(C260) a121:q2*d1q1$
(C261) a421:ev4ax*drcq1+coe1*d4q1$
(C262) a521:-ev5ax*drcq1+coe*d5q1$
(C263) ap2[2,1]:cg1*a121+cg2*a421+cg3*a521$
(C264) a122:q2*d1q2+ev1$
(C265) a422:ev4+ev4ax*drcq2+coe1*d4q2$
(C266) a522:ev5-ev5ax*drcq2+coe*d5q2$
(C267) ap2[2,2]:cg1*a122+cg2*a422+cg3*a522$
(C268) a123:q2*d1q3$
(C269) a423:ev4ax*drcq3+coe1*d4q3$
(C270) a523:-ev5ax*drcq3+coe*d5q3$
(C271) ap2[2,3]:cg1*a123+cg2*a423+cg3*a523$
(C272) a124:q2*d1q4$
(C273) a424:ev4ax*drcq4+coe1*d4q4$
(C274) a524:-ev5ax*drcq4+coe*d5q4$
(C275) ap2[2,4]:cg1*a124+cg2*a424+cg3*a524$
(C276) a125:q2*d1q5$
(C277) a425:ev4ax*drcq5+coe1*d4q5$
(C278) a525:-ev5ax*drcq5+coe*d5q5$
(C279) ap2[2,5]:cg1*a125+cg2*a425+cg3*a525$
(C280) rcayt:rc*ayt$
(C281) ev4ay:ev4*ayt$
(C282) ev5ay:ev5*ayt$
(C283) coe1:q3+rcayt$
(C284) coe:q3-rcayt$
(C285) a131:q3*d1q1$
(C286) a431:ev4ay*drcq1+coe1*d4q1$
(C287) a531:-ev5ay*drcq1+coe*d5q1$
(C288) ap2[3,1]:cg1*a131+cg2*a431+cg3*a531$
(C289) a132:q3*d1q2$
(C290) a432:ev4ay*drcq2+coe1*d4q2$
(C291) a532:-ev5ay*drcq2+coe*d5q2$
(C292) ap2[3,2]:cg1*a132+cg2*a432+cg3*a532$
(C293) a133:q3*d1q3+ev1$
(C294) a433:ev4+ev4ay*drcq3+coe1*d4q3$
(C295) a533:ev5-ev5ay*drcq3+coe*d5q3$
(C296) ap2[3,3]:cg1*a133+cg2*a433+cg3*a533$
(C297) a134:q3*d1q4$
(C298) a434:ev4ay*drcq4+coe1*d4q4$
(C299) a534:-ev5ay*drcq4+coe*d5q4$
(C300) ap2[3,4]:cg1*a134+cg2*a434+cg3*a534$
(C301) a135:q3*d1q5$
(C302) a435:ev4ay*drcq5+coe1*d4q5$
(C303) a535:-ev5ay*drcq5+coe*d5q5$
```

```
(C304) ap2[3,5]:cg1*a135+cg2*a435+cg3*a535$
(C305) rcazt:rc*azt$
(C306) ev4az:ev4*azt$
(C307) ev5az:ev5*azt$
(C308) coe1:q4+rcazt$
(C309) coe:q4-rcazt$
(C310) a141:q4*d1q1$
(C311) a441:ev4az*drcq1+coe1*d4q1$
(C312) a541:-ev5az*drcq1+coe*d5q1$
(C313) ap2[4,1]:cg1*a141+cg2*a441+cg3*a541$
(C314) a142:q4*d1q2$
(C315) a442:ev4az*drcq2+coe1*d4q2$
(C316) a542:-ev5az*drcq2+coe*d5q2$
(C317) ap2[4,2]:cg1*a142+cg2*a442+cg3*a542$
(C318) a143:q4*d1q3$
(C319) a443:ev4az*drcq3+coe1*d4q3$
(C320) a543:-ev5az*drcq3+coe*d5q3$
(C321) ap2[4,3]:cg1*a143+cg2*a443+cg3*a543$
(C322) a144:q4*d1q4+ev1$
(C323) a444:ev4+ev4az*drcq4+coe1*d4q4$
(C324) a544:ev5-ev5az*drcq4+coe*d5q4$
(C325) ap2[4,4]:cg1*a144+cg2*a444+cg3*a544$
(C326) a145:q4*d1q5$
(C327) a445:ev4az*drcq5+coe1*d4q5$
(C328) a545:-ev5az*drcq5+coe*d5q5$
(C329) ap2[4,5]:cg1*a145+cg2*a445+cg3*a545$
(C330) rctt:rc*tt$
(C331) coe:0.5*(q2**2+q3**2+q4**2)*q6$
(C332) rt:rc*dttq1+tt*drcq1$
(C333) a151:2*coe*d1q1$
(C334) a451:ev4*(depq1+rt)+(pp+rctt)*d4q1$
(C335) a551:ev5*(depq1-rt)+(pp-rctt)*d5q1$
(C336) ap2[5,1]:cg1*a151+cg2*a451+cg3*a551$
(C337) rt:rc*dttq2+tt*drcq2$
(C338) a152:coe*d1q2-d1q1*q2$
(C339) a452:ev4*(depq2+rt)+(pp+rctt)*d4q2$
(C340) a552:ev5*(depq2-rt)+(pp-rctt)*d5q2$
(C341) ap2[5,2]:cg1*a152+cg2*a452+cg3*a552$
(C342) rt:rc*dttq3+tt*drcq3$
(C343) a153:coe*d1q3-d1q1*q3$
(C344) a453:ev4*(depq3+rt)+(pp+rctt)*d4q3$
(C345) a553:ev5*(depq3-rt)+(pp-rctt)*d5q3$
(C346) ap2[5,3]:cg1*a153+cg2*a453+cg3*a553$
(C347) rt:rc*dttq4+tt*drcq4$
(C348) a154:coe*d1q4-d1q1*q4$
(C349) a454:ev4*(depq4+rt)+(pp+rctt)*d4q4$
(C350) a554:ev5*(depq4-rt)+(pp-rctt)*d5q4$
(C351) ap2[5,4]:cg1*a154+cg2*a454+cg3*a554$
(C352) rt:tt*drcq5$
(C353) a155:coe*d1q5$
(C354) a455:ev4*(depq5+rt)+(pp+rctt)*d4q5$
```

```
(C355) a555:ev5*(depq5-rt)+(pp-rctt)*d5q5$
(C356) ap2[5,5]:cg1*a155+cg2*a455+cg3*a555$
(C357) diff:ap1.m-m.ap2$
(C358) diff:ratexpand(diff);
                                          [ 0   0   0   0   0 ]
                                          [                   ]
                                          [ 0   0   0   0   0 ]
                                          [                   ]
(D358)                                    [ 0   0   0   0   0 ]
                                          [                   ]
                                          [ 0   0   0   0   0 ]
                                          [                   ]
                                          [ 0   0   0   0   0 ]
(C359) closefile(Apsub)$
```

```
(C3) am1:matrix([0,0,0,0,0],[0,0,0,0,0],[0,0,0,0,0],[0,0,0,0,0],[0
,0,0,0,0])$
(C4) am2:matrix([0,0,0,0,0],[0,0,0,0,0],[0,0,0,0,0],[0,0,0,0,0],[0
,0,0,0,0])$
(C5) m:matrix([1,0,0,0,0],[0,1,0,0,0],[0,0,1,0,0],[0,0,0,-1,0],[0,
0,0,0,1])$
(C6) sign:-1$
(C7) cgg1:(gam-1)/gam$
(C8) cgg2:1/(2*gam)$
(C9) xiy:0.0$
(C10) xiz:0.0$
(C11) sada:sqrt(xix**2+xiy**2+xiz**2)$
(C12) axt:xix/sada$
(C13) ayt:xiy/sada$
(C14) azt:xiz/sada$
(C15) rqrq:q2**2+q3**2+q4**2$
(C16) q6:1/q1$
(C17) pr:(gam-1)*(q5-0.5*rqrq*q6)$
(C18) prgam:pr*gam$
(C19) pp:q5+pr$
(C20) c:sqrt(prgam*q6)$
(C21) tt:(q2*axt+q3*ayt+q4*azt)*q6$
(C22) rc:q1*c$
(C23) csad:c*sada$
(C24) e1:tt*sada$
(C25) e4:e1+csad$
(C26) e5:e1-csad$
(C27) ev1:0.0$
(C28) ev4:0.0$
(C29) ev5:0.0$
(C30) cg1:0.0$
(C31) cg2:0.0$
(C32) cg3:0.0$
(C33) d1q1:-ev1*q6$
(C34) d1q2:xix*q6$
(C35) d1q3:xiy*q6$
(C36) d1q4:xiz*q6$
(C37) d1q5:0.0$
(C38) coe:gam*(gam-1)/(2*rc)$
(C39) gm1q6:(gam-1)*q6$
(C40) drcq1:coe*q5$
(C41) drcq2:-coe*q2$
(C42) drcq3:-coe*q3$
(C43) drcq4:-coe*q4$
(C44) drcq5:coe*q1$
(C45) dcq1:(drcq1-c)*q6$
(C46) dcq2:drcq2*q6$
(C47) dcq3:drcq3*q6$
(C48) dcq4:drcq4*q6$
(C49) dcq5:drcq5*q6$
(C50) depq1:0.5*gm1q6*rqrq*q6$
```

```
(C51) depq2:-q2*gm1q6$
(C52) depq3:-q3*gm1q6$
(C53) depq4:-q4*gm1q6$
(C54) depq5:gam$
(C55) dttq1:-tt*q6$
(C56) dttq2:axt*q6$
(C57) dttq3:ayt*q6$
(C58) dttq4:azt*q6$
(C59) dttq5:0.0$
(C60) d4q1:sada*(dttq1+dcq1)$
(C61) d4q2:sada*(dttq2+dcq2)$
(C62) d4q3:sada*(dttq3+dcq3)$
(C63) d4q4:sada*(dttq4+dcq4)$
(C64) d4q5:sada*dcq5$
(C65) d5q1:sada*(dttq1-dcq1)$
(C66) d5q2:sada*(dttq2-dcq2)$
(C67) d5q3:sada*(dttq3-dcq3)$
(C68) d5q4:sada*(dttq4-dcq4)$
(C69) d5q5:-d4q5$
(C70) a411:ev4+q1*d4q1$
(C71) a511:ev5+q1*d5q1$
(C72) am1[1,1]:cg2*a411+cg3*a511$
(C73) am1[1,2]:(cg1*d1q2+cg2*d4q2+cg3*d5q2)*q1$
(C74) am1[1,3]:(cg1*d1q3+cg2*d4q3+cg3*d5q3)*q1$
(C75) am1[1,4]:(cg1*d1q4+cg2*d4q4+cg3*d5q4)*q1$
(C76) am1[1,5]:(cg2*d4q5+cg3*d5q5)*q1$
(C77) rcaxt:rc*axt$
(C78) ev4ax:ev4*axt$
(C79) ev5ax:ev5*axt$
(C80) coe1:q2+rcaxt$
(C81) coe:q2-rcaxt$
(C82) a121:q2*d1q1$
(C83) a421:ev4ax*drcq1+coe1*d4q1$
(C84) a521:-ev5ax*drcq1+coe*d5q1$
(C85) am1[2,1]:cg1*a121+cg2*a421+cg3*a521$
(C86) a122:q2*d1q2+ev1$
(C87) a422:ev4+ev4ax*drcq2+coe1*d4q2$
(C88) a522:ev5-ev5ax*drcq2+coe*d5q2$
(C89) am1[2,2]:cg1*a122+cg2*a422+cg3*a522$
(C90) a123:q2*d1q3$
(C91) a423:ev4ax*drcq3+coe1*d4q3$
(C92) a523:-ev5ax*drcq3+coe*d5q3$
(C93) am1[2,3]:cg1*a123+cg2*a423+cg3*a523$
(C94) a124:q2*d1q4$
(C95) a424:ev4ax*drcq4+coe1*d4q4$
(C96) a524:-ev5ax*drcq4+coe*d5q4$
(C97) am1[2,4]:cg1*a124+cg2*a424+cg3*a524$
(C98) a125:q2*d1q5$
(C99) a425:ev4ax*drcq5+coe1*d4q5$
(C100) a525:-ev5ax*drcq5+coe*d5q5$
(C101) am1[2,5]:cg1*a125+cg2*a425+cg3*a525$
```

```
(C102) rcayt:rc*ayt$
(C103) ev4ay:ev4*ayt$
(C104) ev5ay:ev5*ayt$
(C105) coe1:q3+rcayt$
(C106) coe:q3-rcayt$
(C107) a131:q3*d1q1$
(C108) a431:ev4ay*drcq1+coe1*d4q1$
(C109) a531:-ev5ay*drcq1+coe*d5q1$
(C110) am1[3,1]:cg1*a131+cg2*a431+cg3*a531$
(C111) a132:q3*d1q2$
(C112) a432:ev4ay*drcq2+coe1*d4q2$
(C113) a532:-ev5ay*drcq2+coe*d5q2$
(C114) am1[3,2]:cg1*a132+cg2*a432+cg3*a532$
(C115) a133:q3*d1q3+ev1$
(C116) a433:ev4+ev4ay*drcq3+coe1*d4q3$
(C117) a533:ev5-ev5ay*drcq3+coe*d5q3$
(C118) am1[3,3]:cg1*a133+cg2*a433+cg3*a533$
(C119) a134:q3*d1q4$
(C120) a434:ev4ay*drcq4+coe1*d4q4$
(C121) a534:-ev5ay*drcq4+coe*d5q4$
(C122) am1[3,4]:cg1*a134+cg2*a434+cg3*a534$
(C123) a135:q3*d1q5$
(C124) a435:ev4ay*drcq5+coe1*d4q5$
(C125) a535:-ev5ay*drcq5+coe*d5q5$
(C126) am1[3,5]:cg1*a135+cg2*a435+cg3*a535$
(C127) rcazt:rc*azt$
(C128) ev4az:ev4*azt$
(C129) ev5az:ev5*azt$
(C130) coe1:q4+rcazt$
(C131) coe:q4-rcazt$
(C132) a141:q4*d1q1$
(C133) a441:ev4az*drcq1+coe1*d4q1$
(C134) a541:-ev5az*drcq1+coe*d5q1$
(C135) am1[4,1]:cg1*a141+cg2*a441+cg3*a541$
(C136) a142:q4*d1q2$
(C137) a442:ev4az*drcq2+coe1*d4q2$
(C138) a542:-ev5az*drcq2+coe*d5q2$
(C139) am1[4,2]:cg1*a142+cg2*a442+cg3*a542$
(C140) a143:q4*d1q3$
(C141) a443:ev4az*drcq3+coe1*d4q3$
(C142) a543:-ev5az*drcq3+coe*d5q3$
(C143) am1[4,3]:cg1*a143+cg2*a443+cg3*a543$
(C144) a144:q4*d1q4+ev1$
(C145) a444:ev4+ev4az*drcq4+coe1*d4q4$
(C146) a544:ev5-ev5az*drcq4+coe*d5q4$
(C147) am1[4,4]:cg1*a144+cg2*a444+cg3*a544$
(C148) a145:q4*d1q5$
(C149) a445:ev4az*drcq5+coe1*d4q5$
(C150) a545:-ev5az*drcq5+coe*d5q5$
(C151) am1[4,5]:cg1*a145+cg2*a445+cg3*a545$
(C152) rctt:rc*tt$
```

```
(C153) coe:0.5*(q2**2+q3**2+q4**2)*q6$
(C154) rt:rc*dttq1+tt*drcq1$
(C155) a151:2*coe*d1q1$
(C156) a451:ev4*(depq1+rt)+(pp+rctt)*d4q1$
(C157) a551:ev5*(depq1-rt)+(pp-rctt)*d5q1$
(C158) am1[5,1]:cg1*a151+cg2*a451+cg3*a551$
(C159) rt:rc*dttq2+tt*drcq2$
(C160) a152:coe*d1q2-d1q1*q2$
(C161) a452:ev4*(depq2+rt)+(pp+rctt)*d4q2$
(C162) a552:ev5*(depq2-rt)+(pp-rctt)*d5q2$
(C163) am1[5,2]:cg1*a152+cg2*a452+cg3*a552$
(C164) rt:rc*dttq3+tt*drcq3$
(C165) a153:coe*d1q3-d1q1*q3$
(C166) a453:ev4*(depq3+rt)+(pp+rctt)*d4q3$
(C167) a553:ev5*(depq3-rt)+(pp-rctt)*d5q3$
(C168) am1[5,3]:cg1*a153+cg2*a453+cg3*a553$
(C169) rt:rc*dttq4+tt*drcq4$
(C170) a154:coe*d1q4-d1q1*q4$
(C171) a454:ev4*(depq4+rt)+(pp+rctt)*d4q4$
(C172) a554:ev5*(depq4-rt)+(pp-rctt)*d5q4$
(C173) am1[5,4]:cg1*a154+cg2*a454+cg3*a554$
(C174) rt:tt*drcq5$
(C175) a155:coe*d1q5$
(C176) a455:ev4*(depq5+rt)+(pp+rctt)*d4q5$
(C177) a555:ev5*(depq5-rt)+(pp-rctt)*d5q5$
(C178) am1[5,5]:cg1*a155+cg2*a455+cg3*a555$
(C179) q1:q1$
(C180) q2:q2$
(C181) q3:q3$
(C182) q4:-q4$
(C183) q5:q5$
(C184) sign:1$
(C185) cgg1:(gam-1)/gam$
(C186) cgg2:1/(2*gam)$
(C187) sada:sqrt(xix**2+xiy**2+xiz**2)$
(C188) axt:xix/sada$
(C189) ayt:xiy/sada$
(C190) azt:xiz/sada$
(C191) rqrq:q2**2+q3**2+q4**2$
(C192) q6:1/q1$
(C193) pr:(gam-1)*(q5-0.5*rqrq*q6)$
(C194) prgam:pr*gam$
(C195) pp:q5+pr$
(C196) c:sqrt(prgam*q6)$
(C197) tt:(q2*axt+q3*ayt+q4*azt)*q6$
(C198) rc:q1*c$
(C199) csad:c*sada$
(C200) e1:tt*sada$
(C201) e4:e1+csad$
(C202) e5:e1-csad$
(C203) ev1:0.0$
```

```
(C204) ev4:0.0$
(C205) ev5:0.0$
(C206) cg1:0.0$
(C207) cg2:0.0$
(C208) cg3:0.0$
(C209) d1q1:-ev1*q6$
(C210) d1q2:xix*q6$
(C211) d1q3:xiy*q6$
(C212) d1q4:xiz*q6$
(C213) d1q5:0.0$
(C214) coe:gam*(gam-1)/(2*rc)$
(C215) gm1q6:(gam-1)*q6$
(C216) drcq1:coe*q5$
(C217) drcq2:-coe*q2$
(C218) drcq3:-coe*q3$
(C219) drcq4:-coe*q4$
(C220) drcq5:coe*q1$
(C221) dcq1:(drcq1-c)*q6$
(C222) dcq2:drcq2*q6$
(C223) dcq3:drcq3*q6$
(C224) dcq4:drcq4*q6$
(C225) dcq5:drcq5*q6$
(C226) depq1:0.5*gm1q6*rqrq*q6$
(C227) depq2:-q2*gm1q6$
(C228) depq3:-q3*gm1q6$
(C229) depq4:-q4*gm1q6$
(C230) depq5:gam$
(C231) dttq1:-tt*q6$
(C232) dttq2:axt*q6$
(C233) dttq3:ayt*q6$
(C234) dttq4:azt*q6$
(C235) dttq5:0.0$
(C236) d4q1:sada*(dttq1+dcq1)$
(C237) d4q2:sada*(dttq2+dcq2)$
(C238) d4q3:sada*(dttq3+dcq3)$
(C239) d4q4:sada*(dttq4+dcq4)$
(C240) d4q5:sada*dcq5$
(C241) d5q1:sada*(dttq1-dcq1)$
(C242) d5q2:sada*(dttq2-dcq2)$
(C243) d5q3:sada*(dttq3-dcq3)$
(C244) d5q4:sada*(dttq4-dcq4)$
(C245) d5q5:-d4q5$
(C246) a411:ev4+q1*d4q1$
(C247) a511:ev5+q1*d5q1$
(C248) am2:matrix([0,0,0,0,0],[0,0,0,0,0],[0,0,0,0,0],[0,0,0,0,0],
[0,0,0,0,0])$
(C249) am2[1,1]:cg2*a411+cg3*a511$
(C250) am2[1,2]:(cg1*d1q2+cg2*d4q2+cg3*d5q2)*q1$
(C251) am2[1,3]:(cg1*d1q3+cg2*d4q3+cg3*d5q3)*q1$
(C252) am2[1,4]:(cg1*d1q4+cg2*d4q4+cg3*d5q4)*q1$
(C253) am2[1,5]:(cg2*d4q5+cg3*d5q5)*q1$
```

```
(C254) rcaxt:rc*axt$
(C255) ev4ax:ev4*axt$
(C256) ev5ax:ev5*axt$
(C257) coe1:q2+rcaxt$
(C258) coe:q2-rcaxt$
(C259) a121:q2*d1q1$
(C260) a421:ev4ax*drcq1+coe1*d4q1$
(C261) a521:-ev5ax*drcq1+coe*d5q1$
(C262) am2[2,1]:cg1*a121+cg2*a421+cg3*a521$
(C263) a122:q2*d1q2+ev1$
(C264) a422:ev4+ev4ax*drcq2+coe1*d4q2$
(C265) a522:ev5-ev5ax*drcq2+coe*d5q2$
(C266) am2[2,2]:cg1*a122+cg2*a422+cg3*a522$
(C267) a123:q2*d1q3$
(C268) a423:ev4ax*drcq3+coe1*d4q3$
(C269) a523:-ev5ax*drcq3+coe*d5q3$
(C270) am2[2,3]:cg1*a123+cg2*a423+cg3*a523$
(C271) a124:q2*d1q4$
(C272) a424:ev4ax*drcq4+coe1*d4q4$
(C273) a524:-ev5ax*drcq4+coe*d5q4$
(C274) am2[2,4]:cg1*a124+cg2*a424+cg3*a524$
(C275) a125:q2*d1q5$
(C276) a425:ev4ax*drcq5+coe1*d4q5$
(C277) a525:-ev5ax*drcq5+coe*d5q5$
(C278) am2[2,5]:cg1*a125+cg2*a425+cg3*a525$
(C279) rcayt:rc*ayt$
(C280) ev4ay:ev4*ayt$
(C281) ev5ay:ev5*ayt$
(C282) coe1:q3+rcayt$
(C283) coe:q3-rcayt$
(C284) a131:q3*d1q1$
(C285) a431:ev4ay*drcq1+coe1*d4q1$
(C286) a531:-ev5ay*drcq1+coe*d5q1$
(C287) am2[3,1]:cg1*a131+cg2*a431+cg3*a531$
(C288) a132:q3*d1q2$
(C289) a432:ev4ay*drcq2+coe1*d4q2$
(C290) a532:-ev5ay*drcq2+coe*d5q2$
(C291) am2[3,2]:cg1*a132+cg2*a432+cg3*a532$
(C292) a133:q3*d1q3+ev1$
(C293) a433:ev4+ev4ay*drcq3+coe1*d4q3$
(C294) a533:ev5-ev5ay*drcq3+coe*d5q3$
(C295) am2[3,3]:cg1*a133+cg2*a433+cg3*a533$
(C296) a134:q3*d1q4$
(C297) a434:ev4ay*drcq4+coe1*d4q4$
(C298) a534:-ev5ay*drcq4+coe*d5q4$
(C299) am2[3,4]:cg1*a134+cg2*a434+cg3*a534$
(C300) a135:q3*d1q5$
(C301) a435:ev4ay*drcq5+coe1*d4q5$
(C302) a535:-ev5ay*drcq5+coe*d5q5$
(C303) am2[3,5]:cg1*a135+cg2*a435+cg3*a535$
(C304) rcazt:rc*azt$
```

```
(C305) ev4az:ev4*azt$
(C306) ev5az:ev5*azt$
(C307) coe1:q4+rcazt$
(C308) coe:q4-rcazt$
(C309) a141:q4*d1q1$
(C310) a441:ev4az*drcq1+coe1*d4q1$
(C311) a541:-ev5az*drcq1+coe*d5q1$
(C312) am2[4,1]:cg1*a141+cg2*a441+cg3*a541$
(C313) a142:q4*d1q2$
(C314) a442:ev4az*drcq2+coe1*d4q2$
(C315) a542:-ev5az*drcq2+coe*d5q2$
(C316) am2[4,2]:cg1*a142+cg2*a442+cg3*a542$
(C317) a143:q4*d1q3$
(C318) a443:ev4az*drcq3+coe1*d4q3$
(C319) a543:-ev5az*drcq3+coe*d5q3$
(C320) am2[4,3]:cg1*a143+cg2*a443+cg3*a543$
(C321) a144:q4*d1q4+ev1$
(C322) a444:ev4+ev4az*drcq4+coe1*d4q4$
(C323) a544:ev5-ev5az*drcq4+coe*d5q4$
(C324) am2[4,4]:cg1*a144+cg2*a444+cg3*a544$
(C325) a145:q4*d1q5$
(C326) a445:ev4az*drcq5+coe1*d4q5$
(C327) a545:-ev5az*drcq5+coe*d5q5$
(C328) am2[4,5]:cg1*a145+cg2*a445+cg3*a545$
(C329) rctt:rc*tt$
(C330) coe:0.5*(q2**2+q3**2+q4**2)*q6$
(C331) rt:rc*dttq1+tt*drcq1$
(C332) a151:2*coe*d1q1$
(C333) a451:ev4*(depq1+rt)+(pp+rctt)*d4q1$
(C334) a551:ev5*(depq1-rt)+(pp-rctt)*d5q1$
(C335) am2[5,1]:cg1*a151+cg2*a451+cg3*a551$
(C336) rt:rc*dttq2+tt*drcq2$
(C337) a152:coe*d1q2-d1q1*q2$
(C338) a452:ev4*(depq2+rt)+(pp+rctt)*d4q2$
(C339) a552:ev5*(depq2-rt)+(pp-rctt)*d5q2$
(C340) am2[5,2]:cg1*a152+cg2*a452+cg3*a552$
(C341) rt:rc*dttq3+tt*drcq3$
(C342) a153:coe*d1q3-d1q1*q3$
(C343) a453:ev4*(depq3+rt)+(pp+rctt)*d4q3$
(C344) a553:ev5*(depq3-rt)+(pp-rctt)*d5q3$
(C345) am2[5,3]:cg1*a153+cg2*a453+cg3*a553$
(C346) rt:rc*dttq4+tt*drcq4$
(C347) a154:coe*d1q4-d1q1*q4$
(C348) a454:ev4*(depq4+rt)+(pp+rctt)*d4q4$
(C349) a554:ev5*(depq4-rt)+(pp-rctt)*d5q4$
(C350) am2[5,4]:cg1*a154+cg2*a454+cg3*a554$
(C351) rt:tt*drcq5$
(C352) a155:coe*d1q5$
(C353) a455:ev4*(depq5+rt)+(pp+rctt)*d4q5$
(C354) a555:ev5*(depq5-rt)+(pp-rctt)*d5q5$
(C355) am2[5,5]:cg1*a155+cg2*a455+cg3*a555$
```

```
(C356) diff:am1.m-m.am1$
(C357) diff:ratexpand(diff);
                                        [ 0   0   0   0   0 ]
                                        [                   ]
                                        [ 0   0   0   0   0 ]
                                        [                   ]
(D357)                                  [ 0   0   0   0   0 ]
                                        [                   ]
                                        [ 0   0   0   0   0 ]
                                        [                   ]
                                        [ 0   0   0   0   0 ]
(C358) closefile(Amsup)$
```

```
(C3) diff:matrix([0,0,0,0,0],[0,0,0,0,0],[0,0,0,0,0],[0,0,0,0,0],[
0,0,0,0,0])$
(C4) m:matrix([1,0,0,0,0],[0,1,0,0,0],[0,0,1,0,0],[0,0,0,-1,0],[0,
0,0,0,1])$
(C5) sign:1$
(C6) cgg1:(gam-1)/gam$
(C7) cgg2:1/(2*gam)$
(C8) xiy:0.0$
(C9) xiz:0.0$
(C10)  sada:sqrt(xix**2+xiy**2+xiz**2)$
(C11)  axt:xix/sada$
(C12)  ayt:xiy/sada$
(C13)  azt:xiz/sada$
(C14)  rqrq:q2**2+q3**2+q4**2$
(C15)  q6:1/q1$
(C16)  pr:(gam-1)*(q5-0.5*rqrq*q6)$
(C17)  prgam:pr*gam$
(C18)  pp:q5+pr$
(C19)  c:sqrt(prgam*q6)$
(C20)  tt:(q2*axt+q3*ayt+q4*azt)*q6$
(C21)  rc:q1*c$
(C22)  csad:c*sada$
(C23)  e1:tt*sada$
(C24)  e4:e1+csad$
(C25)  e5:e1-csad$
(C26)  ev1:0.0$
(C27)  ev4:0.0$
(C28)  ev5:0.5*(e5+sign*abs(e5))$
(C29)  cg1:0.0$
(C30)  cg2:0.0$
(C31)  cg3:cgg2$
(C32)  d1q1:-ev1*q6$
(C33)  d1q2:xix*q6$
(C34)  d1q3:xiy*q6$
(C35)  d1q4:xiz*q6$
(C36)  d1q5:0.0$
(C37)  coe:gam*(gam-1)/(2*rc)$
(C38)  gm1q6:(gam-1)*q6$
(C39)  drcq1:coe*q5$
(C40)  drcq2:-coe*q2$
(C41)  drcq3:-coe*q3$
(C42)  drcq4:-coe*q4$
(C43)  drcq5:coe*q1$
(C44)  dcq1:(drcq1-c)*q6$
(C45)  dcq2:drcq2*q6$
(C46)  dcq3:drcq3*q6$
(C47)  dcq4:drcq4*q6$
(C48)  dcq5:drcq5*q6$
(C49)  depq1:0.5*gm1q6*rqrq*q6$
(C50)  depq2:-q2*gm1q6$
(C51)  depq3:-q3*gm1q6$
```

```
(C52) depq4:-q4*gm1q6$
(C53) depq5:gam$
(C54) dttq1:-tt*q6$
(C55) dttq2:axt*q6$
(C56) dttq3:ayt*q6$
(C57) dttq4:azt*q6$
(C58) dttq5:0.0$
(C59) d4q1:sada*(dttq1+dcq1)$
(C60) d4q2:sada*(dttq2+dcq2)$
(C61) d4q3:sada*(dttq3+dcq3)$
(C62) d4q4:sada*(dttq4+dcq4)$
(C63) d4q5:sada*dcq5$
(C64) d5q1:sada*(dttq1-dcq1)$
(C65) d5q2:sada*(dttq2-dcq2)$
(C66) d5q3:sada*(dttq3-dcq3)$
(C67) d5q4:sada*(dttq4-dcq4)$
(C68) d5q5:-d4q5$
(C69) a411:ev4+q1*d4q1$
(C70) a511:ev5+q1*d5q1$
(C71) ap1:matrix([0,0,0,0,0],[0,0,0,0,0],[0,0,0,0,0],[0,0,0,0,0],[
0,0,0,0,0])$
(C72) ap2:matrix([0,0,0,0,0],[0,0,0,0,0],[0,0,0,0,0],[0,0,0,0,0],[
0,0,0,0,0])$
(C73) ap1[1,1]:cg2*a411+cg3*a511$
(C74) ap1[1,2]:(cg1*d1q2+cg2*d4q2+cg3*d5q2)*q1$
(C75) ap1[1,3]:(cg1*d1q3+cg2*d4q3+cg3*d5q3)*q1$
(C76) ap1[1,4]:(cg1*d1q4+cg2*d4q4+cg3*d5q4)*q1$
(C77) ap1[1,5]:(cg2*d4q5+cg3*d5q5)*q1$
(C78) rcaxt:rc*axt$
(C79) ev4ax:ev4*axt$
(C80) ev5ax:ev5*axt$
(C81) coe1:q2+rcaxt$
(C82) coe:q2-rcaxt$
(C83) a121:q2*d1q1$
(C84) a421:ev4ax*drcq1+coe1*d4q1$
(C85) a521:-ev5ax*drcq1+coe*d5q1$
(C86) ap1[2,1]:cg1*a121+cg2*a421+cg3*a521$
(C87) a122:q2*d1q2+ev1$
(C88) a422:ev4+ev4ax*drcq2+coe1*d4q2$
(C89) a522:ev5-ev5ax*drcq2+coe*d5q2$
(C90) ap1[2,2]:cg1*a122+cg2*a422+cg3*a522$
(C91) a123:q2*d1q3$
(C92) a423:ev4ax*drcq3+coe1*d4q3$
(C93) a523:-ev5ax*drcq3+coe*d5q3$
(C94) ap1[2,3]:cg1*a123+cg2*a423+cg3*a523$
(C95) a124:q2*d1q4$
(C96) a424:ev4ax*drcq4+coe1*d4q4$
(C97) a524:-ev5ax*drcq4+coe*d5q4$
(C98) ap1[2,4]:cg1*a124+cg2*a424+cg3*a524$
(C99) a125:q2*d1q5$
(C100) a425:ev4ax*drcq5+coe1*d4q5$
```

```
(C101) a525:-ev5ax*drcq5+coe*d5q5$
(C102) ap1[2,5]:cg1*a125+cg2*a425+cg3*a525$
(C103) rcayt:rc*ayt$
(C104) ev4ay:ev4*ayt$
(C105) ev5ay:ev5*ayt$
(C106) coe1:q3+rcayt$
(C107) coe:q3-rcayt$
(C108) a131:q3*d1q1$
(C109) a431:ev4ay*drcq1+coe1*d4q1$
(C110) a531:-ev5ay*drcq1+coe*d5q1$
(C111) ap1[3,1]:cg1*a131+cg2*a431+cg3*a531$
(C112) a132:q3*d1q2$
(C113) a432:ev4ay*drcq2+coe1*d4q2$
(C114) a532:-ev5ay*drcq2+coe*d5q2$
(C115) ap1[3,2]:cg1*a132+cg2*a432+cg3*a532$
(C116) a133:q3*d1q3+ev1$
(C117) a433:ev4+ev4ay*drcq3+coe1*d4q3$
(C118) a533:ev5-ev5ay*drcq3+coe*d5q3$
(C119) ap1[3,3]:cg1*a133+cg2*a433+cg3*a533$
(C120) a134:q3*d1q4$
(C121) a434:ev4ay*drcq4+coe1*d4q4$
(C122) a534:-ev5ay*drcq4+coe*d5q4$
(C123) ap1[3,4]:cg1*a134+cg2*a434+cg3*a534$
(C124) a135:q3*d1q5$
(C125) a435:ev4ay*drcq5+coe1*d4q5$
(C126) a535:-ev5ay*drcq5+coe*d5q5$
(C127) ap1[3,5]:cg1*a135+cg2*a435+cg3*a535$
(C128) rcazt:rc*azt$
(C129) ev4az:ev4*azt$
(C130) ev5az:ev5*azt$
(C131) coe1:q4+rcazt$
(C132) coe:q4-rcazt$
(C133) a141:q4*d1q1$
(C134) a441:ev4az*drcq1+coe1*d4q1$
(C135) a541:-ev5az*drcq1+coe*d5q1$
(C136) ap1[4,1]:cg1*a141+cg2*a441+cg3*a541$
(C137) a142:q4*d1q2$
(C138) a442:ev4az*drcq2+coe1*d4q2$
(C139) a542:-ev5az*drcq2+coe*d5q2$
(C140) ap1[4,2]:cg1*a142+cg2*a442+cg3*a542$
(C141) a143:q4*d1q3$
(C142) a443:ev4az*drcq3+coe1*d4q3$
(C143) a543:-ev5az*drcq3+coe*d5q3$
(C144) ap1[4,3]:cg1*a143+cg2*a443+cg3*a543$
(C145) a144:q4*d1q4+ev1$
(C146) a444:ev4+ev4az*drcq4+coe1*d4q4$
(C147) a544:ev5-ev5az*drcq4+coe*d5q4$
(C148) ap1[4,4]:cg1*a144+cg2*a444+cg3*a544$
(C149) a145:q4*d1q5$
(C150) a445:ev4az*drcq5+coe1*d4q5$
(C151) a545:-ev5az*drcq5+coe*d5q5$
```

```
(C152) ap1[4,5]:cg1*a145+cg2*a445+cg3*a545$
(C153) rctt:rc*tt$
(C154) coe:0.5*(q2**2+q3**2+q4**2)*q6$
(C155) rt:rc*dttq1+tt*drcq1$
(C156) a151:2*coe*d1q1$
(C157) a451:ev4*(depq1+rt)+(pp+rctt)*d4q1$
(C158) a551:ev5*(depq1-rt)+(pp-rctt)*d5q1$
(C159) ap1[5,1]:cg1*a151+cg2*a451+cg3*a551$
(C160) rt:rc*dttq2+tt*drcq2$
(C161) a152:coe*d1q2-d1q1*q2$
(C162) a452:ev4*(depq2+rt)+(pp+rctt)*d4q2$
(C163) a552:ev5*(depq2-rt)+(pp-rctt)*d5q2$
(C164) ap1[5,2]:cg1*a152+cg2*a452+cg3*a552$
(C165) rt:rc*dttq3+tt*drcq3$
(C166) a153:coe*d1q3-d1q1*q3$
(C167) a453:ev4*(depq3+rt)+(pp+rctt)*d4q3$
(C168) a553:ev5*(depq3-rt)+(pp-rctt)*d5q3$
(C169) ap1[5,3]:cg1*a153+cg2*a453+cg3*a553$
(C170) rt:rc*dttq4+tt*drcq4$
(C171) a154:coe*d1q4-d1q1*q4$
(C172) a454:ev4*(depq4+rt)+(pp+rctt)*d4q4$
(C173) a554:ev5*(depq4-rt)+(pp-rctt)*d5q4$
(C174) ap1[5,4]:cg1*a154+cg2*a454+cg3*a554$
(C175) rt:tt*drcq5$
(C176) a155:coe*d1q5$
(C177) a455:ev4*(depq5+rt)+(pp+rctt)*d4q5$
(C178) a555:ev5*(depq5-rt)+(pp-rctt)*d5q5$
(C179) ap1[5,5]:cg1*a155+cg2*a455+cg3*a555$
(C180) q1:q1$
(C181) q2:q2$
(C182) q3:q3$
(C183) q4:-q4$
(C184) q5:q5$
(C185) sign:1$
(C186) cgg1:(gam-1)/gam$
(C187) cgg2:1/(2*gam)$
(C188) sada:sqrt(xix**2+xiy**2+xiz**2)$
(C189) axt:xix/sada$
(C190) ayt:xiy/sada$
(C191) azt:xiz/sada$
(C192) rqrq:q2**2+q3**2+q4**2$
(C193) q6:1/q1$
(C194) pr:(gam-1)*(q5-0.5*rqrq*q6)$
(C195) prgam:pr*gam$
(C196) pp:q5+pr$
(C197) c:sqrt(prgam*q6)$
(C198) tt:(q2*axt+q3*ayt+q4*azt)*q6$
(C199) rc:q1*c$
(C200) csad:c*sada$
(C201) e1:tt*sada$
(C202) e4:e1+csad$
```

```
(C203) e5:e1-csad$
(C204) ev1:0.0$
(C205) ev4:0.0$
(C206) ev5:0.5*(e5+sign*abs(e5))$
(C207) cg1:0.0$
(C208) cg2:0.0$
(C209) cg3:cgg2$
(C210) d1q1:-ev1*q6$
(C211) d1q2:xix*q6$
(C212) d1q3:xiy*q6$
(C213) d1q4:xiz*q6$
(C214) d1q5:0.0$
(C215) coe:gam*(gam-1)/(2*rc)$
(C216) gm1q6:(gam-1)*q6$
(C217) drcq1:coe*q5$
(C218) drcq2:-coe*q2$
(C219) drcq3:-coe*q3$
(C220) drcq4:-coe*q4$
(C221) drcq5:coe*q1$
(C222) dcq1:(drcq1-c)*q6$
(C223) dcq2:drcq2*q6$
(C224) dcq3:drcq3*q6$
(C225) dcq4:drcq4*q6$
(C226) dcq5:drcq5*q6$
(C227) depq1:0.5*gm1q6*rqrq*q6$
(C228) depq2:-q2*gm1q6$
(C229) depq3:-q3*gm1q6$
(C230) depq4:-q4*gm1q6$
(C231) depq5:gam$
(C232) dttq1:-tt*q6$
(C233) dttq2:axt*q6$
(C234) dttq3:ayt*q6$
(C235) dttq4:azt*q6$
(C236) dttq5:0.0$
(C237) d4q1:sada*(dttq1+dcq1)$
(C238) d4q2:sada*(dttq2+dcq2)$
(C239) d4q3:sada*(dttq3+dcq3)$
(C240) d4q4:sada*(dttq4+dcq4)$
(C241) d4q5:sada*dcq5$
(C242) d5q1:sada*(dttq1-dcq1)$
(C243) d5q2:sada*(dttq2-dcq2)$
(C244) d5q3:sada*(dttq3-dcq3)$
(C245) d5q4:sada*(dttq4-dcq4)$
(C246) d5q5:-d4q5$
(C247) a411:ev4+q1*d4q1$
(C248) a511:ev5+q1*d5q1$
(C249) ap2[1,1]:cg2*a411+cg3*a511$
(C250) ap2[1,2]:(cg1*d1q2+cg2*d4q2+cg3*d5q2)*q1$
(C251) ap2[1,3]:(cg1*d1q3+cg2*d4q3+cg3*d5q3)*q1$
(C252) ap2[1,4]:(cg1*d1q4+cg2*d4q4+cg3*d5q4)*q1$
(C253) ap2[1,5]:(cg2*d4q5+cg3*d5q5)*q1$
```

```
(C254) rcaxt:rc*axt$
(C255) ev4ax:ev4*axt$
(C256) ev5ax:ev5*axt$
(C257) coe1:q2+rcaxt$
(C258) coe:q2-rcaxt$
(C259) a121:q2*d1q1$
(C260) a421:ev4ax*drcq1+coe1*d4q1$
(C261) a521:-ev5ax*drcq1+coe*d5q1$
(C262) ap2[2,1]:cg1*a121+cg2*a421+cg3*a521$
(C263) a122:q2*d1q2+ev1$
(C264) a422:ev4+ev4ax*drcq2+coe1*d4q2$
(C265) a522:ev5-ev5ax*drcq2+coe*d5q2$
(C266) ap2[2,2]:cg1*a122+cg2*a422+cg3*a522$
(C267) a123:q2*d1q3$
(C268) a423:ev4ax*drcq3+coe1*d4q3$
(C269) a523:-ev5ax*drcq3+coe*d5q3$
(C270) ap2[2,3]:cg1*a123+cg2*a423+cg3*a523$
(C271) a124:q2*d1q4$
(C272) a424:ev4ax*drcq4+coe1*d4q4$
(C273) a524:-ev5ax*drcq4+coe*d5q4$
(C274) ap2[2,4]:cg1*a124+cg2*a424+cg3*a524$
(C275) a125:q2*d1q5$
(C276) a425:ev4ax*drcq5+coe1*d4q5$
(C277) a525:-ev5ax*drcq5+coe*d5q5$
(C278) ap2[2,5]:cg1*a125+cg2*a425+cg3*a525$
(C279) rcayt:rc*ayt$
(C280) ev4ay:ev4*ayt$
(C281) ev5ay:ev5*ayt$
(C282) coe1:q3+rcayt$
(C283) coe:q3-rcayt$
(C284) a131:q3*d1q1$
(C285) a431:ev4ay*drcq1+coe1*d4q1$
(C286) a531:-ev5ay*drcq1+coe*d5q1$
(C287) ap2[3,1]:cg1*a131+cg2*a431+cg3*a531$
(C288) a132:q3*d1q2$
(C289) a432:ev4ay*drcq2+coe1*d4q2$
(C290) a532:-ev5ay*drcq2+coe*d5q2$
(C291) ap2[3,2]:cg1*a132+cg2*a432+cg3*a532$
(C292) a133:q3*d1q3+ev1$
(C293) a433:ev4+ev4ay*drcq3+coe1*d4q3$
(C294) a533:ev5-ev5ay*drcq3+coe*d5q3$
(C295) ap2[3,3]:cg1*a133+cg2*a433+cg3*a533$
(C296) a134:q3*d1q4$
(C297) a434:ev4ay*drcq4+coe1*d4q4$
(C298) a534:-ev5ay*drcq4+coe*d5q4$
(C299) ap2[3,4]:cg1*a134+cg2*a434+cg3*a534$
(C300) a135:q3*d1q5$
(C301) a435:ev4ay*drcq5+coe1*d4q5$
(C302) a535:-ev5ay*drcq5+coe*d5q5$
(C303) ap2[3,5]:cg1*a135+cg2*a435+cg3*a535$
(C304) rcazt:rc*azt$
```

```
(C305) ev4az:ev4*azt$
(C306) ev5az:ev5*azt$
(C307) coe1:q4+rcazt$
(C308) coe:q4-rcazt$
(C309) a141:q4*d1q1$
(C310) a441:ev4az*drcq1+coe1*d4q1$
(C311) a541:-ev5az*drcq1+coe*d5q1$
(C312) ap2[4,1]:cg1*a141+cg2*a441+cg3*a541$
(C313) a142:q4*d1q2$
(C314) a442:ev4az*drcq2+coe1*d4q2$
(C315) a542:-ev5az*drcq2+coe*d5q2$
(C316) ap2[4,2]:cg1*a142+cg2*a442+cg3*a542$
(C317) a143:q4*d1q3$
(C318) a443:ev4az*drcq3+coe1*d4q3$
(C319) a543:-ev5az*drcq3+coe*d5q3$
(C320) ap2[4,3]:cg1*a143+cg2*a443+cg3*a543$
(C321) a144:q4*d1q4+ev1$
(C322) a444:ev4+ev4az*drcq4+coe1*d4q4$
(C323) a544:ev5-ev5az*drcq4+coe*d5q4$
(C324) ap2[4,4]:cg1*a144+cg2*a444+cg3*a544$
(C325) a145:q4*d1q5$
(C326) a445:ev4az*drcq5+coe1*d4q5$
(C327) a545:-ev5az*drcq5+coe*d5q5$
(C328) ap2[4,5]:cg1*a145+cg2*a445+cg3*a545$
(C329) rctt:rc*tt$
(C330) coe:0.5*(q2**2+q3**2+q4**2)*q6$
(C331) rt:rc*dttq1+tt*drcq1$
(C332) a151:2*coe*d1q1$
(C333) a451:ev4*(depq1+rt)+(pp+rctt)*d4q1$
(C334) a551:ev5*(depq1-rt)+(pp-rctt)*d5q1$
(C335) ap2[5,1]:cg1*a151+cg2*a451+cg3*a551$
(C336) rt:rc*dttq2+tt*drcq2$
(C337) a152:coe*d1q2-d1q1*q2$
(C338) a452:ev4*(depq2+rt)+(pp+rctt)*d4q2$
(C339) a552:ev5*(depq2-rt)+(pp-rctt)*d5q2$
(C340) ap2[5,2]:cg1*a152+cg2*a452+cg3*a552$
(C341) rt:rc*dttq3+tt*drcq3$
(C342) a153:coe*d1q3-d1q1*q3$
(C343) a453:ev4*(depq3+rt)+(pp+rctt)*d4q3$
(C344) a553:ev5*(depq3-rt)+(pp-rctt)*d5q3$
(C345) ap2[5,3]:cg1*a153+cg2*a453+cg3*a553$
(C346) rt:rc*dttq4+tt*drcq4$
(C347) a154:coe*d1q4-d1q1*q4$
(C348) a454:ev4*(depq4+rt)+(pp+rctt)*d4q4$
(C349) a554:ev5*(depq4-rt)+(pp-rctt)*d5q4$
(C350) ap2[5,4]:cg1*a154+cg2*a454+cg3*a554$
(C351) rt:tt*drcq5$
(C352) a155:coe*d1q5$
(C353) a455:ev4*(depq5+rt)+(pp+rctt)*d4q5$
(C354) a555:ev5*(depq5-rt)+(pp-rctt)*d5q5$
(C355) ap2[5,5]:cg1*a155+cg2*a455+cg3*a555$
```

```
(C356) diff:ap1.m-m.ap2$
(C357) diff:ratexpand(diff);
                                   [ 0  0  0  0  0 ]
                                   [               ]
                                   [ 0  0  0  0  0 ]
                                   [               ]
(D357)                             [ 0  0  0  0  0 ]
                                   [               ]
                                   [ 0  0  0  0  0 ]
                                   [               ]
                                   [ 0  0  0  0  0 ]
(C358) closefile(Amsub)$
```

```
(C3) bp1:matrix([0,0,0,0,0],[0,0,0,0,0],[0,0,0,0,0],[0,0,0,0,0],[0
,0,0,0,0])$
(C4) bp2:matrix([0,0,0,0,0],[0,0,0,0,0],[0,0,0,0,0],[0,0,0,0,0],[0
,0,0,0,0])$
(C5) diff:matrix([0,0,0,0,0],[0,0,0,0,0],[0,0,0,0,0],[0,0,0,0,0],[
0,0,0,0,0])$
(C6) m:matrix([1,0,0,0,0],[0,1,0,0,0],[0,0,1,0,0],[0,0,0,-1,0],[0,
0,0,0,1])$
(C7) sign:1$
(C8) cgg1:(gam-1)/gam$
(C9) cgg2:1/(2*gam)$
(C10) etx:0.0$
(C11) sada:sqrt(etx**2+ety**2+etz**2)$
(C12) axt:etx/sada$
(C13) ayt:ety/sada$
(C14) azt:etz/sada$
(C15) rqrq:q2**2+q3**2+q4**2$
(C16) q6:1/q1$
(C17) pr:(gam-1)*(q5-0.5*rqrq*q6)$
(C18) prgam:pr*gam$
(C19) pp:q5+pr$
(C20) c:sqrt(prgam*q6)$
(C21) tt:(q2*axt+q3*ayt+q4*azt)*q6$
(C22) rc:q1*c$
(C23) csad:c*sada$
(C24) e1:tt*sada$
(C25) e4:e1+csad$
(C26) e5:e1-csad$
(C27) ev1:0.5*(e1+sign*abs(e1))$
(C28) ev4:0.5*(e4+sign*abs(e4))$
(C29) ev5:0.5*(e5+sign*abs(e5))$
(C30) cg1:cgg1$
(C31) cg2:cgg2$
(C32) cg3:cgg2$
(C33) d1q1:-ev1*q6$
(C34) d1q2:etx*q6$
(C35) d1q3:ety*q6$
(C36) d1q4:etz*q6$
(C37) d1q5:0.0$
(C38) coe:gam*(gam-1)/(2*rc)$
(C39) gm1q6:(gam-1)*q6$
(C40) drcq1:coe*q5$
(C41) drcq2:-coe*q2$
(C42) drcq3:-coe*q3$
(C43) drcq4:-coe*q4$
(C44) drcq5:coe*q1$
(C45) dcq1:(drcq1-c)*q6$
(C46) dcq2:drcq2*q6$
(C47) dcq3:drcq3*q6$
(C48) dcq4:drcq4*q6$
(C49) dcq5:drcq5*q6$
```

```
(C50) depq1:0.5*gm1q6*rqrq*q6$
(C51) depq2:-q2*gm1q6$
(C52) depq3:-q3*gm1q6$
(C53) depq4:-q4*gm1q6$
(C54) depq5:gam$
(C55) dttq1:-tt*q6$
(C56) dttq2:axt*q6$
(C57) dttq3:ayt*q6$
(C58) dttq4:azt*q6$
(C59) dttq5:0.0$
(C60) d4q1:sada*(dttq1+dcq1)$
(C61) d4q2:sada*(dttq2+dcq2)$
(C62) d4q3:sada*(dttq3+dcq3)$
(C63) d4q4:sada*(dttq4+dcq4)$
(C64) d4q5:sada*dcq5$
(C65) d5q1:sada*(dttq1-dcq1)$
(C66) d5q2:sada*(dttq2-dcq2)$
(C67) d5q3:sada*(dttq3-dcq3)$
(C68) d5q4:sada*(dttq4-dcq4)$
(C69) d5q5:-d4q5$
(C70) a411:ev4+q1*d4q1$
(C71) a511:ev5+q1*d5q1$
(C72) bp1[1,1]:cg2*a411+cg3*a511$
(C73) bp1[1,2]:(cg1*d1q2+cg2*d4q2+cg3*d5q2)*q1$
(C74) bp1[1,3]:(cg1*d1q3+cg2*d4q3+cg3*d5q3)*q1$
(C75) bp1[1,4]:(cg1*d1q4+cg2*d4q4+cg3*d5q4)*q1$
(C76) bp1[1,5]:(cg2*d4q5+cg3*d5q5)*q1$
(C77) rcaxt:rc*axt$
(C78) ev4ax:ev4*axt$
(C79) ev5ax:ev5*axt$
(C80) coe1:q2+rcaxt$
(C81) coe:q2-rcaxt$
(C82) a121:q2*d1q1$
(C83) a421:ev4ax*drcq1+coe1*d4q1$
(C84) a521:-ev5ax*drcq1+coe*d5q1$
(C85) bp1[2,1]:cg1*a121+cg2*a421+cg3*a521$
(C86) a122:q2*d1q2+ev1$
(C87) a422:ev4+ev4ax*drcq2+coe1*d4q2$
(C88) a522:ev5-ev5ax*drcq2+coe*d5q2$
(C89) bp1[2,2]:cg1*a122+cg2*a422+cg3*a522$
(C90) a123:q2*d1q3$
(C91) a423:ev4ax*drcq3+coe1*d4q3$
(C92) a523:-ev5ax*drcq3+coe*d5q3$
(C93) bp1[2,3]:cg1*a123+cg2*a423+cg3*a523$
(C94) a124:q2*d1q4$
(C95) a424:ev4ax*drcq4+coe1*d4q4$
(C96) a524:-ev5ax*drcq4+coe*d5q4$
(C97) bp1[2,4]:cg1*a124+cg2*a424+cg3*a524$
(C98) a125:q2*d1q5$
(C99) a425:ev4ax*drcq5+coe1*d4q5$
(C100) a525:-ev5ax*drcq5+coe*d5q5$
```

```
(C101) bp1[2,5]:cg1*a125+cg2*a425+cg3*a525$
(C102) rcayt:rc*ayt$
(C103) ev4ay:ev4*ayt$
(C104) ev5ay:ev5*ayt$
(C105) coe1:q3+rcayt$
(C106) coe:q3-rcayt$
(C107) a131:q3*d1q1$
(C108) a431:ev4ay*drcq1+coe1*d4q1$
(C109) a531:-ev5ay*drcq1+coe*d5q1$
(C110) bp1[3,1]:cg1*a131+cg2*a431+cg3*a531$
(C111) a132:q3*d1q2$
(C112) a432:ev4ay*drcq2+coe1*d4q2$
(C113) a532:-ev5ay*drcq2+coe*d5q2$
(C114) bp1[3,2]:cg1*a132+cg2*a432+cg3*a532$
(C115) a133:q3*d1q3+ev1$
(C116) a433:ev4+ev4ay*drcq3+coe1*d4q3$
(C117) a533:ev5-ev5ay*drcq3+coe*d5q3$
(C118) bp1[3,3]:cg1*a133+cg2*a433+cg3*a533$
(C119) a134:q3*d1q4$
(C120) a434:ev4ay*drcq4+coe1*d4q4$
(C121) a534:-ev5ay*drcq4+coe*d5q4$
(C122) bp1[3,4]:cg1*a134+cg2*a434+cg3*a534$
(C123) a135:q3*d1q5$
(C124) a435:ev4ay*drcq5+coe1*d4q5$
(C125) a535:-ev5ay*drcq5+coe*d5q5$
(C126) bp1[3,5]:cg1*a135+cg2*a435+cg3*a535$
(C127) rcazt:rc*azt$
(C128) ev4az:ev4*azt$
(C129) ev5az:ev5*azt$
(C130) coe1:q4+rcazt$
(C131) coe:q4-rcazt$
(C132) a141:q4*d1q1$
(C133) a441:ev4az*drcq1+coe1*d4q1$
(C134) a541:-ev5az*drcq1+coe*d5q1$
(C135) bp1[4,1]:cg1*a141+cg2*a441+cg3*a541$
(C136) a142:q4*d1q2$
(C137) a442:ev4az*drcq2+coe1*d4q2$
(C138) a542:-ev5az*drcq2+coe*d5q2$
(C139) bp1[4,2]:cg1*a142+cg2*a442+cg3*a542$
(C140) a143:q4*d1q3$
(C141) a443:ev4az*drcq3+coe1*d4q3$
(C142) a543:-ev5az*drcq3+coe*d5q3$
(C143) bp1[4,3]:cg1*a143+cg2*a443+cg3*a543$
(C144) a144:q4*d1q4+ev1$
(C145) a444:ev4+ev4az*drcq4+coe1*d4q4$
(C146) a544:ev5-ev5az*drcq4+coe*d5q4$
(C147) bp1[4,4]:cg1*a144+cg2*a444+cg3*a544$
(C148) a145:q4*d1q5$
(C149) a445:ev4az*drcq5+coe1*d4q5$
(C150) a545:-ev5az*drcq5+coe*d5q5$
(C151) bp1[4,5]:cg1*a145+cg2*a445+cg3*a545$
```

```
(C152) rctt:rc*tt$
(C153) coe:0.5*(q2**2+q3**2+q4**2)*q6$
(C154) rt:rc*dttq1+tt*drcq1$
(C155) a151:2*coe*d1q1$
(C156) a451:ev4*(depq1+rt)+(pp+rctt)*d4q1$
(C157) a551:ev5*(depq1-rt)+(pp-rctt)*d5q1$
(C158) bp1[5,1]:cg1*a151+cg2*a451+cg3*a551$
(C159) rt:rc*dttq2+tt*drcq2$
(C160) a152:coe*d1q2-d1q1*q2$
(C161) a452:ev4*(depq2+rt)+(pp+rctt)*d4q2$
(C162) a552:ev5*(depq2-rt)+(pp-rctt)*d5q2$
(C163) bp1[5,2]:cg1*a152+cg2*a452+cg3*a552$
(C164) rt:rc*dttq3+tt*drcq3$
(C165) a153:coe*d1q3-d1q1*q3$
(C166) a453:ev4*(depq3+rt)+(pp+rctt)*d4q3$
(C167) a553:ev5*(depq3-rt)+(pp-rctt)*d5q3$
(C168) bp1[5,3]:cg1*a153+cg2*a453+cg3*a553$
(C169) rt:rc*dttq4+tt*drcq4$
(C170) a154:coe*d1q4-d1q1*q4$
(C171) a454:ev4*(depq4+rt)+(pp+rctt)*d4q4$
(C172) a554:ev5*(depq4-rt)+(pp-rctt)*d5q4$
(C173) bp1[5,4]:cg1*a154+cg2*a454+cg3*a554$
(C174) rt:tt*drcq5$
(C175) a155:coe*d1q5$
(C176) a455:ev4*(depq5+rt)+(pp+rctt)*d4q5$
(C177) a555:ev5*(depq5-rt)+(pp-rctt)*d5q5$
(C178) bp1[5,5]:cg1*a155+cg2*a455+cg3*a555$
(C179) q1:q1$
(C180) q2:q2$
(C181) q3:q3$
(C182) q4:-q4$
(C183) q5:q5$
(C184) sign:1$
(C185) etz:-etz;
(C186) cgg1:(gam-1)/gam$
(C187) cgg2:1/(2*gam)$
(C188) sada:sqrt(etx**2+ety**2+etz**2)$
(C189) axt:etx/sada$
(C190) ayt:ety/sada$
(C191) azt:etz/sada$
(C192) rqrq:q2**2+q3**2+q4**2$
(C193) q6:1/q1$
(C194) pr:(gam-1)*(q5-0.5*rqrq*q6)$
(C195) prgam:pr*gam$
(C196) pp:q5+pr$
(C197) c:sqrt(prgam*q6)$
(C198) tt:(q2*axt+q3*ayt+q4*azt)*q6$
(C199) rc:q1*c$
(C200) csad:c*sada$
(C201) e1:tt*sada$
(C202) e4:e1+csad$
```

```
(C203) e5:e1-csad$
(C204) ev1:0.5*(e1+sign*abs(e1))$
(C205) ev4:0.5*(e4+sign*abs(e4))$
(C206) ev5:0.5*(e5+sign*abs(e5))$
(C207) cg1:cgg1$
(C208) cg2:cgg2$
(C209) cg3:cgg2$
(C210) d1q1:-ev1*q6$
(C211) d1q2:etx*q6$
(C212) d1q3:ety*q6$
(C213) d1q4:etz*q6$
(C214) d1q5:0.0$
(C215) coe:gam*(gam-1)/(2*rc)$
(C216) gm1q6:(gam-1)*q6$
(C217) drcq1:coe*q5$
(C218) drcq2:-coe*q2$
(C219) drcq3:-coe*q3$
(C220) drcq4:-coe*q4$
(C221) drcq5:coe*q1$
(C222) dcq1:(drcq1-c)*q6$
(C223) dcq2:drcq2*q6$
(C224) dcq3:drcq3*q6$
(C225) dcq4:drcq4*q6$
(C226) dcq5:drcq5*q6$
(C227) depq1:0.5*gm1q6*rqrq*q6$
(C228) depq2:-q2*gm1q6$
(C229) depq3:-q3*gm1q6$
(C230) depq4:-q4*gm1q6$
(C231) depq5:gam$
(C232) dttq1:-tt*q6$
(C233) dttq2:axt*q6$
(C234) dttq3:ayt*q6$
(C235) dttq4:azt*q6$
(C236) dttq5:0.0$
(C237) d4q1:sada*(dttq1+dcq1)$
(C238) d4q2:sada*(dttq2+dcq2)$
(C239) d4q3:sada*(dttq3+dcq3)$
(C240) d4q4:sada*(dttq4+dcq4)$
(C241) d4q5:sada*dcq5$
(C242) d5q1:sada*(dttq1-dcq1)$
(C243) d5q2:sada*(dttq2-dcq2)$
(C244) d5q3:sada*(dttq3-dcq3)$
(C245) d5q4:sada*(dttq4-dcq4)$
(C246) d5q5:-d4q5$
(C247) a411:ev4+q1*d4q1$
(C248) a511:ev5+q1*d5q1$
(C249) bp2:matrix([0,0,0,0,0],[0,0,0,0,0],[0,0,0,0,0],[0,0,0,0,0],
[0,0,0,0,0])$
(C250) bp2[1,1]:cg2*a411+cg3*a511$
(C251) bp2[1,2]:(cg1*d1q2+cg2*d4q2+cg3*d5q2)*q1$
(C252) bp2[1,3]:(cg1*d1q3+cg2*d4q3+cg3*d5q3)*q1$
```

```
(C253) bp2[1,4]:(cg1*d1q4+cg2*d4q4+cg3*d5q4)*q1$
(C254) bp2[1,5]:(cg2*d4q5+cg3*d5q5)*q1$
(C255) rcaxt:rc*axt$
(C256) ev4ax:ev4*axt$
(C257) ev5ax:ev5*axt$
(C258) coe1:q2+rcaxt$
(C259) coe:q2-rcaxt$
(C260) a121:q2*d1q1$
(C261) a421:ev4ax*drcq1+coe1*d4q1$
(C262) a521:-ev5ax*drcq1+coe*d5q1$
(C263) bp2[2,1]:cg1*a121+cg2*a421+cg3*a521$
(C264) a122:q2*d1q2+ev1$
(C265) a422:ev4+ev4ax*drcq2+coe1*d4q2$
(C266) a522:ev5-ev5ax*drcq2+coe*d5q2$
(C267) bp2[2,2]:cg1*a122+cg2*a422+cg3*a522$
(C268) a123:q2*d1q3$
(C269) a423:ev4ax*drcq3+coe1*d4q3$
(C270) a523:-ev5ax*drcq3+coe*d5q3$
(C271) bp2[2,3]:cg1*a123+cg2*a423+cg3*a523$
(C272) a124:q2*d1q4$
(C273) a424:ev4ax*drcq4+coe1*d4q4$
(C274) a524:-ev5ax*drcq4+coe*d5q4$
(C275) bp2[2,4]:cg1*a124+cg2*a424+cg3*a524$
(C276) a125:q2*d1q5$
(C277) a425:ev4ax*drcq5+coe1*d4q5$
(C278) a525:-ev5ax*drcq5+coe*d5q5$
(C279) bp2[2,5]:cg1*a125+cg2*a425+cg3*a525$
(C280) rcayt:rc*ayt$
(C281) ev4ay:ev4*ayt$
(C282) ev5ay:ev5*ayt$
(C283) coe1:q3+rcayt$
(C284) coe:q3-rcayt$
(C285) a131:q3*d1q1$
(C286) a431:ev4ay*drcq1+coe1*d4q1$
(C287) a531:-ev5ay*drcq1+coe*d5q1$
(C288) bp2[3,1]:cg1*a131+cg2*a431+cg3*a531$
(C289) a132:q3*d1q2$
(C290) a432:ev4ay*drcq2+coe1*d4q2$
(C291) a532:-ev5ay*drcq2+coe*d5q2$
(C292) bp2[3,2]:cg1*a132+cg2*a432+cg3*a532$
(C293) a133:q3*d1q3+ev1$
(C294) a433:ev4+ev4ay*drcq3+coe1*d4q3$
(C295) a533:ev5-ev5ay*drcq3+coe*d5q3$
(C296) bp2[3,3]:cg1*a133+cg2*a433+cg3*a533$
(C297) a134:q3*d1q4$
(C298) a434:ev4ay*drcq4+coe1*d4q4$
(C299) a534:-ev5ay*drcq4+coe*d5q4$
(C300) bp2[3,4]:cg1*a134+cg2*a434+cg3*a534$
(C301) a135:q3*d1q5$
(C302) a435:ev4ay*drcq5+coe1*d4q5$
(C303) a535:-ev5ay*drcq5+coe*d5q5$
```

```
(C304) bp2[3,5]:cg1*a135+cg2*a435+cg3*a535$
(C305) rcazt:rc*azt$
(C306) ev4az:ev4*azt$
(C307) ev5az:ev5*azt$
(C308) coe1:q4+rcazt$
(C309) coe:q4-rcazt$
(C310) a141:q4*d1q1$
(C311) a441:ev4az*drcq1+coe1*d4q1$
(C312) a541:-ev5az*drcq1+coe*d5q1$
(C313) bp2[4,1]:cg1*a141+cg2*a441+cg3*a541$
(C314) a142:q4*d1q2$
(C315) a442:ev4az*drcq2+coe1*d4q2$
(C316) a542:-ev5az*drcq2+coe*d5q2$
(C317) bp2[4,2]:cg1*a142+cg2*a442+cg3*a542$
(C318) a143:q4*d1q3$
(C319) a443:ev4az*drcq3+coe1*d4q3$
(C320) a543:-ev5az*drcq3+coe*d5q3$
(C321) bp2[4,3]:cg1*a143+cg2*a443+cg3*a543$
(C322) a144:q4*d1q4+ev1$
(C323) a444:ev4+ev4az*drcq4+coe1*d4q4$
(C324) a544:ev5-ev5az*drcq4+coe*d5q4$
(C325) bp2[4,4]:cg1*a144+cg2*a444+cg3*a544$
(C326) a145:q4*d1q5$
(C327) a445:ev4az*drcq5+coe1*d4q5$
(C328) a545:-ev5az*drcq5+coe*d5q5$
(C329) bp2[4,5]:cg1*a145+cg2*a445+cg3*a545$
(C330) rctt:rc*tt$
(C331) coe:0.5*(q2**2+q3**2+q4**2)*q6$
(C332) rt:rc*dttq1+tt*drcq1$
(C333) a151:2*coe*d1q1$
(C334) a451:ev4*(depq1+rt)+(pp+rctt)*d4q1$
(C335) a551:ev5*(depq1-rt)+(pp-rctt)*d5q1$
(C336) bp2[5,1]:cg1*a151+cg2*a451+cg3*a551$
(C337) rt:rc*dttq2+tt*drcq2$
(C338) a152:coe*d1q2-d1q1*q2$
(C339) a452:ev4*(depq2+rt)+(pp+rctt)*d4q2$
(C340) a552:ev5*(depq2-rt)+(pp-rctt)*d5q2$
(C341) bp2[5,2]:cg1*a152+cg2*a452+cg3*a552$
(C342) rt:rc*dttq3+tt*drcq3$
(C343) a153:coe*d1q3-d1q1*q3$
(C344) a453:ev4*(depq3+rt)+(pp+rctt)*d4q3$
(C345) a553:ev5*(depq3-rt)+(pp-rctt)*d5q3$
(C346) bp2[5,3]:cg1*a153+cg2*a453+cg3*a553$
(C347) rt:rc*dttq4+tt*drcq4$
(C348) a154:coe*d1q4-d1q1*q4$
(C349) a454:ev4*(depq4+rt)+(pp+rctt)*d4q4$
(C350) a554:ev5*(depq4-rt)+(pp-rctt)*d5q4$
(C351) bp2[5,4]:cg1*a154+cg2*a454+cg3*a554$
(C352) rt:tt*drcq5$
(C353) a155:coe*d1q5$
(C354) a455:ev4*(depq5+rt)+(pp+rctt)*d4q5$
```

```
(C355) a555:ev5*(depq5-rt)+(pp-rctt)*d5q5$
(C356) bp2[5,5]:cg1*a155+cg2*a455+cg3*a555$
(C357) diff:bp1.m-m.bp2$
(C358) diff:ratexpand(diff);
                                            [ 0  0  0  0  0 ]
                                            [               ]
                                            [ 0  0  0  0  0 ]
                                            [               ]
(D358)                                      [ 0  0  0  0  0 ]
                                            [               ]
                                            [ 0  0  0  0  0 ]
                                            [               ]
                                            [ 0  0  0  0  0 ]
(C359) closefile(Bpsup)$
```

```
(C3) bp1:matrix([0,0,0,0,0],[0,0,0,0,0],[0,0,0,0,0],[0,0,0,0,0],[0
,0,0,0,0])$
(C4) bp2:matrix([0,0,0,0,0],[0,0,0,0,0],[0,0,0,0,0],[0,0,0,0,0],[0
,0,0,0,0])$
(C5) diff:matrix([0,0,0,0,0],[0,0,0,0,0],[0,0,0,0,0],[0,0,0,0,0],[
0,0,0,0,0])$
(C6) m:matrix([1,0,0,0,0],[0,1,0,0,0],[0,0,1,0,0],[0,0,0,-1,0],[0,
0,0,0,1])$
(C7) sign:1$
(C8) cgg1:(gam-1)/gam$
(C9) cgg2:1/(2*gam)$
(C10) etx:0.0$
(C11) sada:sqrt(etx**2+ety**2+etz**2)$
(C12) axt:etx/sada$
(C13) ayt:ety/sada$
(C14) azt:etz/sada$
(C15) rqrq:q2**2+q3**2+q4**2$
(C16) q6:1/q1$
(C17) pr:(gam-1)*(q5-0.5*rqrq*q6)$
(C18) prgam:pr*gam$
(C19) pp:q5+pr$
(C20) c:sqrt(prgam*q6)$
(C21) tt:(q2*axt+q3*ayt+q4*azt)*q6$
(C22) rc:q1*c$
(C23) csad:c*sada$
(C24) e1:tt*sada$
(C25) e4:e1+csad$
(C26) e5:e1-csad$
(C27) ev1:0.5*(e1+sign*abs(e1))$
(C28) ev4:0.5*(e4+sign*abs(e4))$
(C29) ev5:0.0$
(C30) cg1:cgg1$
(C31) cg2:cgg2$
(C32) cg3:0.0$
(C33) d1q1:-ev1*q6$
(C34) d1q2:etx*q6$
(C35) d1q3:ety*q6$
(C36) d1q4:etz*q6$
(C37) d1q5:0.0$
(C38) coe:gam*(gam-1)/(2*rc)$
(C39) gm1q6:(gam-1)*q6$
(C40) drcq1:coe*q5$
(C41) drcq2:-coe*q2$
(C42) drcq3:-coe*q3$
(C43) drcq4:-coe*q4$
(C44) drcq5:coe*q1$
(C45) dcq1:(drcq1-c)*q6$
(C46) dcq2:drcq2*q6$
(C47) dcq3:drcq3*q6$
(C48) dcq4:drcq4*q6$
(C49) dcq5:drcq5*q6$
```

```
(C50) depq1:0.5*gm1q6*rqrq*q6$
(C51) depq2:-q2*gm1q6$
(C52) depq3:-q3*gm1q6$
(C53) depq4:-q4*gm1q6$
(C54) depq5:gam$
(C55) dttq1:-tt*q6$
(C56) dttq2:axt*q6$
(C57) dttq3:ayt*q6$
(C58) dttq4:azt*q6$
(C59) dttq5:0.0$
(C60) d4q1:sada*(dttq1+dcq1)$
(C61) d4q2:sada*(dttq2+dcq2)$
(C62) d4q3:sada*(dttq3+dcq3)$
(C63) d4q4:sada*(dttq4+dcq4)$
(C64) d4q5:sada*dcq5$
(C65) d5q1:sada*(dttq1-dcq1)$
(C66) d5q2:sada*(dttq2-dcq2)$
(C67) d5q3:sada*(dttq3-dcq3)$
(C68) d5q4:sada*(dttq4-dcq4)$
(C69) d5q5:-d4q5$
(C70) a411:ev4+q1*d4q1$
(C71) a511:ev5+q1*d5q1$
(C72) bp1[1,1]:cg2*a411+cg3*a511$
(C73) bp1[1,2]:(cg1*d1q2+cg2*d4q2+cg3*d5q2)*q1$
(C74) bp1[1,3]:(cg1*d1q3+cg2*d4q3+cg3*d5q3)*q1$
(C75) bp1[1,4]:(cg1*d1q4+cg2*d4q4+cg3*d5q4)*q1$
(C76) bp1[1,5]:(cg2*d4q5+cg3*d5q5)*q1$
(C77) rcaxt:rc*axt$
(C78) ev4ax:ev4*axt$
(C79) ev5ax:ev5*axt$
(C80) coe1:q2+rcaxt$
(C81) coe:q2-rcaxt$
(C82) a121:q2*d1q1$
(C83) a421:ev4ax*drcq1+coe1*d4q1$
(C84) a521:-ev5ax*drcq1+coe*d5q1$
(C85) bp1[2,1]:cg1*a121+cg2*a421+cg3*a521$
(C86) a122:q2*d1q2+ev1$
(C87) a422:ev4+ev4ax*drcq2+coe1*d4q2$
(C88) a522:ev5-ev5ax*drcq2+coe*d5q2$
(C89) bp1[2,2]:cg1*a122+cg2*a422+cg3*a522$
(C90) a123:q2*d1q3$
(C91) a423:ev4ax*drcq3+coe1*d4q3$
(C92) a523:-ev5ax*drcq3+coe*d5q3$
(C93) bp1[2,3]:cg1*a123+cg2*a423+cg3*a523$
(C94) a124:q2*d1q4$
(C95) a424:ev4ax*drcq4+coe1*d4q4$
(C96) a524:-ev5ax*drcq4+coe*d5q4$
(C97) bp1[2,4]:cg1*a124+cg2*a424+cg3*a524$
(C98) a125:q2*d1q5$
(C99) a425:ev4ax*drcq5+coe1*d4q5$
(C100) a525:-ev5ax*drcq5+coe*d5q5$
```

```
(C101) bp1[2,5]:cg1*a125+cg2*a425+cg3*a525$
(C102) rcayt:rc*ayt$
(C103) ev4ay:ev4*ayt$
(C104) ev5ay:ev5*ayt$
(C105) coe1:q3+rcayt$
(C106) coe:q3-rcayt$
(C107) a131:q3*d1q1$
(C108) a431:ev4ay*drcq1+coe1*d4q1$
(C109) a531:-ev5ay*drcq1+coe*d5q1$
(C110) bp1[3,1]:cg1*a131+cg2*a431+cg3*a531$
(C111) a132:q3*d1q2$
(C112) a432:ev4ay*drcq2+coe1*d4q2$
(C113) a532:-ev5ay*drcq2+coe*d5q2$
(C114) bp1[3,2]:cg1*a132+cg2*a432+cg3*a532$
(C115) a133:q3*d1q3+ev1$
(C116) a433:ev4+ev4ay*drcq3+coe1*d4q3$
(C117) a533:ev5-ev5ay*drcq3+coe*d5q3$
(C118) bp1[3,3]:cg1*a133+cg2*a433+cg3*a533$
(C119) a134:q3*d1q4$
(C120) a434:ev4ay*drcq4+coe1*d4q4$
(C121) a534:-ev5ay*drcq4+coe*d5q4$
(C122) bp1[3,4]:cg1*a134+cg2*a434+cg3*a534$
(C123) a135:q3*d1q5$
(C124) a435:ev4ay*drcq5+coe1*d4q5$
(C125) a535:-ev5ay*drcq5+coe*d5q5$
(C126) bp1[3,5]:cg1*a135+cg2*a435+cg3*a535$
(C127) rcazt:rc*azt$
(C128) ev4az:ev4*azt$
(C129) ev5az:ev5*azt$
(C130) coe1:q4+rcazt$
(C131) coe:q4-rcazt$
(C132) a141:q4*d1q1$
(C133) a441:ev4az*drcq1+coe1*d4q1$
(C134) a541:-ev5az*drcq1+coe*d5q1$
(C135) bp1[4,1]:cg1*a141+cg2*a441+cg3*a541$
(C136) a142:q4*d1q2$
(C137) a442:ev4az*drcq2+coe1*d4q2$
(C138) a542:-ev5az*drcq2+coe*d5q2$
(C139) bp1[4,2]:cg1*a142+cg2*a442+cg3*a542$
(C140) a143:q4*d1q3$
(C141) a443:ev4az*drcq3+coe1*d4q3$
(C142) a543:-ev5az*drcq3+coe*d5q3$
(C143) bp1[4,3]:cg1*a143+cg2*a443+cg3*a543$
(C144) a144:q4*d1q4+ev1$
(C145) a444:ev4+ev4az*drcq4+coe1*d4q4$
(C146) a544:ev5-ev5az*drcq4+coe*d5q4$
(C147) bp1[4,4]:cg1*a144+cg2*a444+cg3*a544$
(C148) a145:q4*d1q5$
(C149) a445:ev4az*drcq5+coe1*d4q5$
(C150) a545:-ev5az*drcq5+coe*d5q5$
(C151) bp1[4,5]:cg1*a145+cg2*a445+cg3*a545$
```

```
(C152) rctt:rc*tt$
(C153) coe:0.5*(q2**2+q3**2+q4**2)*q6$
(C154) rt:rc*dttq1+tt*drcq1$
(C155) a151:2*coe*d1q1$
(C156) a451:ev4*(depq1+rt)+(pp+rctt)*d4q1$
(C157) a551:ev5*(depq1-rt)+(pp-rctt)*d5q1$
(C158) bp1[5,1]:cg1*a151+cg2*a451+cg3*a551$
(C159) rt:rc*dttq2+tt*drcq2$
(C160) a152:coe*d1q2-d1q1*q2$
(C161) a452:ev4*(depq2+rt)+(pp+rctt)*d4q2$
(C162) a552:ev5*(depq2-rt)+(pp-rctt)*d5q2$
(C163) bp1[5,2]:cg1*a152+cg2*a452+cg3*a552$
(C164) rt:rc*dttq3+tt*drcq3$
(C165) a153:coe*d1q3-d1q1*q3$
(C166) a453:ev4*(depq3+rt)+(pp+rctt)*d4q3$
(C167) a553:ev5*(depq3-rt)+(pp-rctt)*d5q3$
(C168) bp1[5,3]:cg1*a153+cg2*a453+cg3*a553$
(C169) rt:rc*dttq4+tt*drcq4$
(C170) a154:coe*d1q4-d1q1*q4$
(C171) a454:ev4*(depq4+rt)+(pp+rctt)*d4q4$
(C172) a554:ev5*(depq4-rt)+(pp-rctt)*d5q4$
(C173) bp1[5,4]:cg1*a154+cg2*a454+cg3*a554$
(C174) rt:tt*drcq5$
(C175) a155:coe*d1q5$
(C176) a455:ev4*(depq5+rt)+(pp+rctt)*d4q5$
(C177) a555:ev5*(depq5-rt)+(pp-rctt)*d5q5$
(C178) bp1[5,5]:cg1*a155+cg2*a455+cg3*a555$
(C179) q1:q1$
(C180) q2:q2$
(C181) q3:q3$
(C182) q4:-q4$
(C183) q5:q5$
(C184) sign:1$
(C185) etz:-etz;
(C186) cgg1:(gam-1)/gam$
(C187) cgg2:1/(2*gam)$
(C188) sada:sqrt(etx**2+ety**2+etz**2)$
(C189) axt:etx/sada$
(C190) ayt:ety/sada$
(C191) azt:etz/sada$
(C192) rqrq:q2**2+q3**2+q4**2$
(C193) q6:1/q1$
(C194) pr:(gam-1)*(q5-0.5*rqrq*q6)$
(C195) prgam:pr*gam$
(C196) pp:q5+pr$
(C197) c:sqrt(prgam*q6)$
(C198) tt:(q2*axt+q3*ayt+q4*azt)*q6$
(C199) rc:q1*c$
(C200) csad:c*sada$
(C201) e1:tt*sada$
(C202) e4:e1+csad$
```

```
(C203) e5:e1-csad$
(C204) ev1:0.5*(e1+sign*abs(e1))$
(C205) ev4:0.5*(e4+sign*abs(e4))$
(C206) ev5:0.0$
(C207) cg1:cgg1$
(C208) cg2:cgg2$
(C209) cg3:0.0$
(C210) d1q1:-ev1*q6$
(C211) d1q2:etx*q6$
(C212) d1q3:ety*q6$
(C213) d1q4:etz*q6$
(C214) d1q5:0.0$
(C215) coe:gam*(gam-1)/(2*rc)$
(C216) gm1q6:(gam-1)*q6$
(C217) drcq1:coe*q5$
(C218) drcq2:-coe*q2$
(C219) drcq3:-coe*q3$
(C220) drcq4:-coe*q4$
(C221) drcq5:coe*q1$
(C222) dcq1:(drcq1-c)*q6$
(C223) dcq2:drcq2*q6$
(C224) dcq3:drcq3*q6$
(C225) dcq4:drcq4*q6$
(C226) dcq5:drcq5*q6$
(C227) depq1:0.5*gm1q6*rqrq*q6$
(C228) depq2:-q2*gm1q6$
(C229) depq3:-q3*gm1q6$
(C230) depq4:-q4*gm1q6$
(C231) depq5:gam$
(C232) dttq1:-tt*q6$
(C233) dttq2:axt*q6$
(C234) dttq3:ayt*q6$
(C235) dttq4:azt*q6$
(C236) dttq5:0.0$
(C237) d4q1:sada*(dttq1+dcq1)$
(C238) d4q2:sada*(dttq2+dcq2)$
(C239) d4q3:sada*(dttq3+dcq3)$
(C240) d4q4:sada*(dttq4+dcq4)$
(C241) d4q5:sada*dcq5$
(C242) d5q1:sada*(dttq1-dcq1)$
(C243) d5q2:sada*(dttq2-dcq2)$
(C244) d5q3:sada*(dttq3-dcq3)$
(C245) d5q4:sada*(dttq4-dcq4)$
(C246) d5q5:-d4q5$
(C247) a411:ev4+q1*d4q1$
(C248) a511:ev5+q1*d5q1$
(C249) bp2:matrix([0,0,0,0,0],[0,0,0,0,0],[0,0,0,0,0],[0,0,0,0,0],
[0,0,0,0,0])$
(C250) bp2[1,1]:cg2*a411+cg3*a511$
(C251) bp2[1,2]:(cg1*d1q2+cg2*d4q2+cg3*d5q2)*q1$
(C252) bp2[1,3]:(cg1*d1q3+cg2*d4q3+cg3*d5q3)*q1$
```

```
(C253) bp2[1,4]:(cg1*d1q4+cg2*d4q4+cg3*d5q4)*q1$
(C254) bp2[1,5]:(cg2*d4q5+cg3*d5q5)*q1$
(C255) rcaxt:rc*axt$
(C256) ev4ax:ev4*axt$
(C257) ev5ax:ev5*axt$
(C258) coe1:q2+rcaxt$
(C259) coe:q2-rcaxt$
(C260) a121:q2*d1q1$
(C261) a421:ev4ax*drcq1+coe1*d4q1$
(C262) a521:-ev5ax*drcq1+coe*d5q1$
(C263) bp2[2,1]:cg1*a121+cg2*a421+cg3*a521$
(C264) a122:q2*d1q2+ev1$
(C265) a422:ev4+ev4ax*drcq2+coe1*d4q2$
(C266) a522:ev5-ev5ax*drcq2+coe*d5q2$
(C267) bp2[2,2]:cg1*a122+cg2*a422+cg3*a522$
(C268) a123:q2*d1q3$
(C269) a423:ev4ax*drcq3+coe1*d4q3$
(C270) a523:-ev5ax*drcq3+coe*d5q3$
(C271) bp2[2,3]:cg1*a123+cg2*a423+cg3*a523$
(C272) a124:q2*d1q4$
(C273) a424:ev4ax*drcq4+coe1*d4q4$
(C274) a524:-ev5ax*drcq4+coe*d5q4$
(C275) bp2[2,4]:cg1*a124+cg2*a424+cg3*a524$
(C276) a125:q2*d1q5$
(C277) a425:ev4ax*drcq5+coe1*d4q5$
(C278) a525:-ev5ax*drcq5+coe*d5q5$
(C279) bp2[2,5]:cg1*a125+cg2*a425+cg3*a525$
(C280) rcayt:rc*ayt$
(C281) ev4ay:ev4*ayt$
(C282) ev5ay:ev5*ayt$
(C283) coe1:q3+rcayt$
(C284) coe:q3-rcayt$
(C285) a131:q3*d1q1$
(C286) a431:ev4ay*drcq1+coe1*d4q1$
(C287) a531:-ev5ay*drcq1+coe*d5q1$
(C288) bp2[3,1]:cg1*a131+cg2*a431+cg3*a531$
(C289) a132:q3*d1q2$
(C290) a432:ev4ay*drcq2+coe1*d4q2$
(C291) a532:-ev5ay*drcq2+coe*d5q2$
(C292) bp2[3,2]:cg1*a132+cg2*a432+cg3*a532$
(C293) a133:q3*d1q3+ev1$
(C294) a433:ev4+ev4ay*drcq3+coe1*d4q3$
(C295) a533:ev5-ev5ay*drcq3+coe*d5q3$
(C296) bp2[3,3]:cg1*a133+cg2*a433+cg3*a533$
(C297) a134:q3*d1q4$
(C298) a434:ev4ay*drcq4+coe1*d4q4$
(C299) a534:-ev5ay*drcq4+coe*d5q4$
(C300) bp2[3,4]:cg1*a134+cg2*a434+cg3*a534$
(C301) a135:q3*d1q5$
(C302) a435:ev4ay*drcq5+coe1*d4q5$
(C303) a535:-ev5ay*drcq5+coe*d5q5$
```

```
(C304) bp2[3,5]:cg1*a135+cg2*a435+cg3*a535$
(C305) rcazt:rc*azt$
(C306) ev4az:ev4*azt$
(C307) ev5az:ev5*azt$
(C308) coe1:q4+rcazt$
(C309) coe:q4-rcazt$
(C310) a141:q4*d1q1$
(C311) a441:ev4az*drcq1+coe1*d4q1$
(C312) a541:-ev5az*drcq1+coe*d5q1$
(C313) bp2[4,1]:cg1*a141+cg2*a441+cg3*a541$
(C314) a142:q4*d1q2$
(C315) a442:ev4az*drcq2+coe1*d4q2$
(C316) a542:-ev5az*drcq2+coe*d5q2$
(C317) bp2[4,2]:cg1*a142+cg2*a442+cg3*a542$
(C318) a143:q4*d1q3$
(C319) a443:ev4az*drcq3+coe1*d4q3$
(C320) a543:-ev5az*drcq3+coe*d5q3$
(C321) bp2[4,3]:cg1*a143+cg2*a443+cg3*a543$
(C322) a144:q4*d1q4+ev1$
(C323) a444:ev4+ev4az*drcq4+coe1*d4q4$
(C324) a544:ev5-ev5az*drcq4+coe*d5q4$
(C325) bp2[4,4]:cg1*a144+cg2*a444+cg3*a544$
(C326) a145:q4*d1q5$
(C327) a445:ev4az*drcq5+coe1*d4q5$
(C328) a545:-ev5az*drcq5+coe*d5q5$
(C329) bp2[4,5]:cg1*a145+cg2*a445+cg3*a545$
(C330) rctt:rc*tt$
(C331) coe:0.5*(q2**2+q3**2+q4**2)*q6$
(C332) rt:rc*dttq1+tt*drcq1$
(C333) a151:2*coe*d1q1$
(C334) a451:ev4*(depq1+rt)+(pp+rctt)*d4q1$
(C335) a551:ev5*(depq1-rt)+(pp-rctt)*d5q1$
(C336) bp2[5,1]:cg1*a151+cg2*a451+cg3*a551$
(C337) rt:rc*dttq2+tt*drcq2$
(C338) a152:coe*d1q2-d1q1*q2$
(C339) a452:ev4*(depq2+rt)+(pp+rctt)*d4q2$
(C340) a552:ev5*(depq2-rt)+(pp-rctt)*d5q2$
(C341) bp2[5,2]:cg1*a152+cg2*a452+cg3*a552$
(C342) rt:rc*dttq3+tt*drcq3$
(C343) a153:coe*d1q3-d1q1*q3$
(C344) a453:ev4*(depq3+rt)+(pp+rctt)*d4q3$
(C345) a553:ev5*(depq3-rt)+(pp-rctt)*d5q3$
(C346) bp2[5,3]:cg1*a153+cg2*a453+cg3*a553$
(C347) rt:rc*dttq4+tt*drcq4$
(C348) a154:coe*d1q4-d1q1*q4$
(C349) a454:ev4*(depq4+rt)+(pp+rctt)*d4q4$
(C350) a554:ev5*(depq4-rt)+(pp-rctt)*d5q4$
(C351) bp2[5,4]:cg1*a154+cg2*a454+cg3*a554$
(C352) rt:tt*drcq5$
(C353) a155:coe*d1q5$
(C354) a455:ev4*(depq5+rt)+(pp+rctt)*d4q5$
```

```
(C355) a555:ev5*(depq5-rt)+(pp-rctt)*d5q5$
(C356) bp2[5,5]:cg1*a155+cg2*a455+cg3*a555$
(C357) diff:bp1.m-m.bp2$
(C358) diff:ratexpand(diff);
                                    [ 0  0  0  0  0 ]
                                    [               ]
                                    [ 0  0  0  0  0 ]
                                    [               ]
(D358)                              [ 0  0  0  0  0 ]
                                    [               ]
                                    [ 0  0  0  0  0 ]
                                    [               ]
                                    [ 0  0  0  0  0 ]
(C359) closefile(Bpsub)$
```

```
(C3) bm1:matrix([0,0,0,0,0],[0,0,0,0,0],[0,0,0,0,0],[0,0,0,0,0],[0
,0,0,0,0])$
(C4) bm2:matrix([0,0,0,0,0],[0,0,0,0,0],[0,0,0,0,0],[0,0,0,0,0],[0
,0,0,0,0])$
(C5) m:matrix([1,0,0,0,0],[0,1,0,0,0],[0,0,1,0,0],[0,0,0,-1,0],[0,
0,0,0,1])$
(C6) diff:matrix([0,0,0,0,0],[0,0,0,0,0],[0,0,0,0,0],[0,0,0,0,0],[
0,0,0,0,0])$
(C7) sign:-1$
(C8) cgg1:(gam-1)/gam$
(C9) cgg2:1/(2*gam)$
(C10) etx:0.0$
(C11) sada:sqrt(etx**2+ety**2+etz**2)$
(C12) axt:etx/sada$
(C13) ayt:ety/sada$
(C14) azt:etz/sada$
(C15) rqrq:q2**2+q3**2+q4**2$
(C16) q6:1/q1$
(C17) pr:(gam-1)*(q5-0.5*rqrq*q6)$
(C18) prgam:pr*gam$
(C19) pp:q5+pr$
(C20) c:sqrt(prgam*q6)$
(C21) tt:(q2*axt+q3*ayt+q4*azt)*q6$
(C22) rc:q1*c$
(C23) csad:c*sada$
(C24) e1:tt*sada$
(C25) e4:e1+csad$
(C26) e5:e1-csad$
(C27) ev1:0.0$
(C28) ev4:0.0$
(C29) ev5:0.0$
(C30) cg1:0.0$
(C31) cg2:0.0$
(C32) cg3:0.0$
(C33) d1q1:-ev1*q6$
(C34) d1q2:etx*q6$
(C35) d1q3:ety*q6$
(C36) d1q4:etz*q6$
(C37) d1q5:0.0$
(C38) coe:gam*(gam-1)/(2*rc)$
(C39) gm1q6:(gam-1)*q6$
(C40) drcq1:coe*q5$
(C41) drcq2:-coe*q2$
(C42) drcq3:-coe*q3$
(C43) drcq4:-coe*q4$
(C44) drcq5:coe*q1$
(C45) dcq1:(drcq1-c)*q6$
(C46) dcq2:drcq2*q6$
(C47) dcq3:drcq3*q6$
(C48) dcq4:drcq4*q6$
(C49) dcq5:drcq5*q6$
```

```
(C50) depq1:0.5*gm1q6*rqrq*q6$
(C51) depq2:-q2*gm1q6$
(C52) depq3:-q3*gm1q6$
(C53) depq4:-q4*gm1q6$
(C54) depq5:gam$
(C55) dttq1:-tt*q6$
(C56) dttq2:axt*q6$
(C57) dttq3:ayt*q6$
(C58) dttq4:azt*q6$
(C59) dttq5:0.0$
(C60) d4q1:sada*(dttq1+dcq1)$
(C61) d4q2:sada*(dttq2+dcq2)$
(C62) d4q3:sada*(dttq3+dcq3)$
(C63) d4q4:sada*(dttq4+dcq4)$
(C64) d4q5:sada*dcq5$
(C65) d5q1:sada*(dttq1-dcq1)$
(C66) d5q2:sada*(dttq2-dcq2)$
(C67) d5q3:sada*(dttq3-dcq3)$
(C68) d5q4:sada*(dttq4-dcq4)$
(C69) d5q5:-d4q5$
(C70) a411:ev4+q1*d4q1$
(C71) a511:ev5+q1*d5q1$
(C72) bm1[1,1]:cg2*a411+cg3*a511$
(C73) bm1[1,2]:(cg1*d1q2+cg2*d4q2+cg3*d5q2)*q1$
(C74) bm1[1,3]:(cg1*d1q3+cg2*d4q3+cg3*d5q3)*q1$
(C75) bm1[1,4]:(cg1*d1q4+cg2*d4q4+cg3*d5q4)*q1$
(C76) bm1[1,5]:(cg2*d4q5+cg3*d5q5)*q1$
(C77) rcaxt:rc*axt$
(C78) ev4ax:ev4*axt$
(C79) ev5ax:ev5*axt$
(C80) coe1:q2+rcaxt$
(C81) coe:q2-rcaxt$
(C82) a121:q2*d1q1$
(C83) a421:ev4ax*drcq1+coe1*d4q1$
(C84) a521:-ev5ax*drcq1+coe*d5q1$
(C85) bm1[2,1]:cg1*a121+cg2*a421+cg3*a521$
(C86) a122:q2*d1q2+ev1$
(C87) a422:ev4+ev4ax*drcq2+coe1*d4q2$
(C88) a522:ev5-ev5ax*drcq2+coe*d5q2$
(C89) bm1[2,2]:cg1*a122+cg2*a422+cg3*a522$
(C90) a123:q2*d1q3$
(C91) a423:ev4ax*drcq3+coe1*d4q3$
(C92) a523:-ev5ax*drcq3+coe*d5q3$
(C93) bm1[2,3]:cg1*a123+cg2*a423+cg3*a523$
(C94) a124:q2*d1q4$
(C95) a424:ev4ax*drcq4+coe1*d4q4$
(C96) a524:-ev5ax*drcq4+coe*d5q4$
(C97) bm1[2,4]:cg1*a124+cg2*a424+cg3*a524$
(C98) a125:q2*d1q5$
(C99) a425:ev4ax*drcq5+coe1*d4q5$
(C100) a525:-ev5ax*drcq5+coe*d5q5$
```

```
(C101) bm1[2,5]:cg1*a125+cg2*a425+cg3*a525$
(C102) rcayt:rc*ayt$
(C103) ev4ay:ev4*ayt$
(C104) ev5ay:ev5*ayt$
(C105) coe1:q3+rcayt$
(C106) coe:q3-rcayt$
(C107) a131:q3*d1q1$
(C108) a431:ev4ay*drcq1+coe1*d4q1$
(C109) a531:-ev5ay*drcq1+coe*d5q1$
(C110) bm1[3,1]:cg1*a131+cg2*a431+cg3*a531$
(C111) a132:q3*d1q2$
(C112) a432:ev4ay*drcq2+coe1*d4q2$
(C113) a532:-ev5ay*drcq2+coe*d5q2$
(C114) bm1[3,2]:cg1*a132+cg2*a432+cg3*a532$
(C115) a133:q3*d1q3+ev1$
(C116) a433:ev4+ev4ay*drcq3+coe1*d4q3$
(C117) a533:ev5-ev5ay*drcq3+coe*d5q3$
(C118) bm1[3,3]:cg1*a133+cg2*a433+cg3*a533$
(C119) a134:q3*d1q4$
(C120) a434:ev4ay*drcq4+coe1*d4q4$
(C121) a534:-ev5ay*drcq4+coe*d5q4$
(C122) bm1[3,4]:cg1*a134+cg2*a434+cg3*a534$
(C123) a135:q3*d1q5$
(C124) a435:ev4ay*drcq5+coe1*d4q5$
(C125) a535:-ev5ay*drcq5+coe*d5q5$
(C126) bm1[3,5]:cg1*a135+cg2*a435+cg3*a535$
(C127) rcazt:rc*azt$
(C128) ev4az:ev4*azt$
(C129) ev5az:ev5*azt$
(C130) coe1:q4+rcazt$
(C131) coe:q4-rcazt$
(C132) a141:q4*d1q1$
(C133) a441:ev4az*drcq1+coe1*d4q1$
(C134) a541:-ev5az*drcq1+coe*d5q1$
(C135) bm1[4,1]:cg1*a141+cg2*a441+cg3*a541$
(C136) a142:q4*d1q2$
(C137) a442:ev4az*drcq2+coe1*d4q2$
(C138) a542:-ev5az*drcq2+coe*d5q2$
(C139) bm1[4,2]:cg1*a142+cg2*a442+cg3*a542$
(C140) a143:q4*d1q3$
(C141) a443:ev4az*drcq3+coe1*d4q3$
(C142) a543:-ev5az*drcq3+coe*d5q3$
(C143) bm1[4,3]:cg1*a143+cg2*a443+cg3*a543$
(C144) a144:q4*d1q4+ev1$
(C145) a444:ev4+ev4az*drcq4+coe1*d4q4$
(C146) a544:ev5-ev5az*drcq4+coe*d5q4$
(C147) bm1[4,4]:cg1*a144+cg2*a444+cg3*a544$
(C148) a145:q4*d1q5$
(C149) a445:ev4az*drcq5+coe1*d4q5$
(C150) a545:-ev5az*drcq5+coe*d5q5$
(C151) bm1[4,5]:cg1*a145+cg2*a445+cg3*a545$
```

```
(C152) rctt:rc*tt$
(C153) coe:0.5*(q2**2+q3**2+q4**2)*q6$
(C154) rt:rc*dttq1+tt*drcq1$
(C155) a151:2*coe*d1q1$
(C156) a451:ev4*(depq1+rt)+(pp+rctt)*d4q1$
(C157) a551:ev5*(depq1-rt)+(pp-rctt)*d5q1$
(C158) bm1[5,1]:cg1*a151+cg2*a451+cg3*a551$
(C159) rt:rc*dttq2+tt*drcq2$
(C160) a152:coe*d1q2-d1q1*q2$
(C161) a452:ev4*(depq2+rt)+(pp+rctt)*d4q2$
(C162) a552:ev5*(depq2-rt)+(pp-rctt)*d5q2$
(C163) bm1[5,2]:cg1*a152+cg2*a452+cg3*a552$
(C164) rt:rc*dttq3+tt*drcq3$
(C165) a153:coe*d1q3-d1q1*q3$
(C166) a453:ev4*(depq3+rt)+(pp+rctt)*d4q3$
(C167) a553:ev5*(depq3-rt)+(pp-rctt)*d5q3$
(C168) bm1[5,3]:cg1*a153+cg2*a453+cg3*a553$
(C169) rt:rc*dttq4+tt*drcq4$
(C170) a154:coe*d1q4-d1q1*q4$
(C171) a454:ev4*(depq4+rt)+(pp+rctt)*d4q4$
(C172) a554:ev5*(depq4-rt)+(pp-rctt)*d5q4$
(C173) bm1[5,4]:cg1*a154+cg2*a454+cg3*a554$
(C174) rt:tt*drcq5$
(C175) a155:coe*d1q5$
(C176) a455:ev4*(depq5+rt)+(pp+rctt)*d4q5$
(C177) a555:ev5*(depq5-rt)+(pp-rctt)*d5q5$
(C178) bm1[5,5]:cg1*a155+cg2*a455+cg3*a555$
(C179) q1:q1$
(C180) q2:q2$
(C181) q3:q3$
(C182) q4:-q4$
(C183) q5:q5$
(C184) sign:1$
(C185) etz:-etz;
(C186) cgg1:(gam-1)/gam$
(C187) cgg2:1/(2*gam)$
(C188) sada:sqrt(etx**2+ety**2+etz**2)$
(C189) axt:etx/sada$
(C190) ayt:ety/sada$
(C191) azt:etz/sada$
(C192) rqrq:q2**2+q3**2+q4**2$
(C193) q6:1/q1$
(C194) pr:(gam-1)*(q5-0.5*rqrq*q6)$
(C195) prgam:pr*gam$
(C196) pp:q5+pr$
(C197) c:sqrt(prgam*q6)$
(C198) tt:(q2*axt+q3*ayt+q4*azt)*q6$
(C199) rc:q1*c$
(C200) csad:c*sada$
(C201) e1:tt*sada$
(C202) e4:e1+csad$
```

```
(C203) e5:e1-csad$
(C204) ev1:0.0$
(C205) ev4:0.0$
(C206) ev5:0.0$
(C207) cg1:0.0$
(C208) cg2:0.0$
(C209) cg3:0.0$
(C210) d1q1:-ev1*q6$
(C211) d1q2:etx*q6$
(C212) d1q3:ety*q6$
(C213) d1q4:etz*q6$
(C214) d1q5:0.0$
(C215) coe:gam*(gam-1)/(2*rc)$
(C216) gm1q6:(gam-1)*q6$
(C217) drcq1:coe*q5$
(C218) drcq2:-coe*q2$
(C219) drcq3:-coe*q3$
(C220) drcq4:-coe*q4$
(C221) drcq5:coe*q1$
(C222) dcq1:(drcq1-c)*q6$
(C223) dcq2:drcq2*q6$
(C224) dcq3:drcq3*q6$
(C225) dcq4:drcq4*q6$
(C226) dcq5:drcq5*q6$
(C227) depq1:0.5*gm1q6*rqrq*q6$
(C228) depq2:-q2*gm1q6$
(C229) depq3:-q3*gm1q6$
(C230) depq4:-q4*gm1q6$
(C231) depq5:gam$
(C232) dttq1:-tt*q6$
(C233) dttq2:axt*q6$
(C234) dttq3:ayt*q6$
(C235) dttq4:azt*q6$
(C236) dttq5:0.0$
(C237) d4q1:sada*(dttq1+dcq1)$
(C238) d4q2:sada*(dttq2+dcq2)$
(C239) d4q3:sada*(dttq3+dcq3)$
(C240) d4q4:sada*(dttq4+dcq4)$
(C241) d4q5:sada*dcq5$
(C242) d5q1:sada*(dttq1-dcq1)$
(C243) d5q2:sada*(dttq2-dcq2)$
(C244) d5q3:sada*(dttq3-dcq3)$
(C245) d5q4:sada*(dttq4-dcq4)$
(C246) d5q5:-d4q5$
(C247) a411:ev4+q1*d4q1$
(C248) a511:ev5+q1*d5q1$
(C249) bm2:matrix([0,0,0,0,0],[0,0,0,0,0],[0,0,0,0,0],[0,0,0,0,0],
[0,0,0,0,0])$
(C250) bm2[1,1]:cg2*a411+cg3*a511$
(C251) bm2[1,2]:(cg1*d1q2+cg2*d4q2+cg3*d5q2)*q1$
(C252) bm2[1,3]:(cg1*d1q3+cg2*d4q3+cg3*d5q3)*q1$
```

```
(C253) bm2[1,4]:(cg1*d1q4+cg2*d4q4+cg3*d5q4)*q1$
(C254) bm2[1,5]:(cg2*d4q5+cg3*d5q5)*q1$
(C255) rcaxt:rc*axt$
(C256) ev4ax:ev4*axt$
(C257) ev5ax:ev5*axt$
(C258) coe1:q2+rcaxt$
(C259) coe:q2-rcaxt$
(C260) a121:q2*d1q1$
(C261) a421:ev4ax*drcq1+coe1*d4q1$
(C262) a521:-ev5ax*drcq1+coe*d5q1$
(C263) bm2[2,1]:cg1*a121+cg2*a421+cg3*a521$
(C264) a122:q2*d1q2+ev1$
(C265) a422:ev4+ev4ax*drcq2+coe1*d4q2$
(C266) a522:ev5-ev5ax*drcq2+coe*d5q2$
(C267) bm2[2,2]:cg1*a122+cg2*a422+cg3*a522$
(C268) a123:q2*d1q3$
(C269) a423:ev4ax*drcq3+coe1*d4q3$
(C270) a523:-ev5ax*drcq3+coe*d5q3$
(C271) bm2[2,3]:cg1*a123+cg2*a423+cg3*a523$
(C272) a124:q2*d1q4$
(C273) a424:ev4ax*drcq4+coe1*d4q4$
(C274) a524:-ev5ax*drcq4+coe*d5q4$
(C275) bm2[2,4]:cg1*a124+cg2*a424+cg3*a524$
(C276) a125:q2*d1q5$
(C277) a425:ev4ax*drcq5+coe1*d4q5$
(C278) a525:-ev5ax*drcq5+coe*d5q5$
(C279) bm2[2,5]:cg1*a125+cg2*a425+cg3*a525$
(C280) rcayt:rc*ayt$
(C281) ev4ay:ev4*ayt$
(C282) ev5ay:ev5*ayt$
(C283) coe1:q3+rcayt$
(C284) coe:q3-rcayt$
(C285) a131:q3*d1q1$
(C286) a431:ev4ay*drcq1+coe1*d4q1$
(C287) a531:-ev5ay*drcq1+coe*d5q1$
(C288) bm2[3,1]:cg1*a131+cg2*a431+cg3*a531$
(C289) a132:q3*d1q2$
(C290) a432:ev4ay*drcq2+coe1*d4q2$
(C291) a532:-ev5ay*drcq2+coe*d5q2$
(C292) bm2[3,2]:cg1*a132+cg2*a432+cg3*a532$
(C293) a133:q3*d1q3+ev1$
(C294) a433:ev4+ev4ay*drcq3+coe1*d4q3$
(C295) a533:ev5-ev5ay*drcq3+coe*d5q3$
(C296) bm2[3,3]:cg1*a133+cg2*a433+cg3*a533$
(C297) a134:q3*d1q4$
(C298) a434:ev4ay*drcq4+coe1*d4q4$
(C299) a534:-ev5ay*drcq4+coe*d5q4$
(C300) bm2[3,4]:cg1*a134+cg2*a434+cg3*a534$
(C301) a135:q3*d1q5$
(C302) a435:ev4ay*drcq5+coe1*d4q5$
(C303) a535:-ev5ay*drcq5+coe*d5q5$
```

```
(C304) bm2[3,5]:cg1*a135+cg2*a435+cg3*a535$
(C305) rcazt:rc*azt$
(C306) ev4az:ev4*azt$
(C307) ev5az:ev5*azt$
(C308) coel:q4+rcazt$
(C309) coe:q4-rcazt$
(C310) a141:q4*d1q1$
(C311) a441:ev4az*drcq1+coel*d4q1$
(C312) a541:-ev5az*drcq1+coe*d5q1$
(C313) bm2[4,1]:cg1*a141+cg2*a441+cg3*a541$
(C314) a142:q4*d1q2$
(C315) a442:ev4az*drcq2+coel*d4q2$
(C316) a542:-ev5az*drcq2+coe*d5q2$
(C317) bm2[4,2]:cg1*a142+cg2*a442+cg3*a542$
(C318) a143:q4*d1q3$
(C319) a443:ev4az*drcq3+coel*d4q3$
(C320) a543:-ev5az*drcq3+coe*d5q3$
(C321) bm2[4,3]:cg1*a143+cg2*a443+cg3*a543$
(C322) a144:q4*d1q4+ev1$
(C323) a444:ev4+ev4az*drcq4+coel*d4q4$
(C324) a544:ev5-ev5az*drcq4+coe*d5q4$
(C325) bm2[4,4]:cg1*a144+cg2*a444+cg3*a544$
(C326) a145:q4*d1q5$
(C327) a445:ev4az*drcq5+coel*d4q5$
(C328) a545:-ev5az*drcq5+coe*d5q5$
(C329) bm2[4,5]:cg1*a145+cg2*a445+cg3*a545$
(C330) rctt:rc*tt$
(C331) coe:0.5*(q2**2+q3**2+q4**2)*q6$
(C332) rt:rc*dttq1+tt*drcq1$
(C333) a151:2*coe*d1q1$
(C334) a451:ev4*(depq1+rt)+(pp+rctt)*d4q1$
(C335) a551:ev5*(depq1-rt)+(pp-rctt)*d5q1$
(C336) bm2[5,1]:cg1*a151+cg2*a451+cg3*a551$
(C337) rt:rc*dttq2+tt*drcq2$
(C338) a152:coe*d1q2-d1q1*q2$
(C339) a452:ev4*(depq2+rt)+(pp+rctt)*d4q2$
(C340) a552:ev5*(depq2-rt)+(pp-rctt)*d5q2$
(C341) bm2[5,2]:cg1*a152+cg2*a452+cg3*a552$
(C342) rt:rc*dttq3+tt*drcq3$
(C343) a153:coe*d1q3-d1q1*q3$
(C344) a453:ev4*(depq3+rt)+(pp+rctt)*d4q3$
(C345) a553:ev5*(depq3-rt)+(pp-rctt)*d5q3$
(C346) bm2[5,3]:cg1*a153+cg2*a453+cg3*a553$
(C347) rt:rc*dttq4+tt*drcq4$
(C348) a154:coe*d1q4-d1q1*q4$
(C349) a454:ev4*(depq4+rt)+(pp+rctt)*d4q4$
(C350) a554:ev5*(depq4-rt)+(pp-rctt)*d5q4$
(C351) bm2[5,4]:cg1*a154+cg2*a454+cg3*a554$
(C352) rt:tt*drcq5$
(C353) a155:coe*d1q5$
(C354) a455:ev4*(depq5+rt)+(pp+rctt)*d4q5$
```

```
(C355) a555:ev5*(depq5-rt)+(pp-rctt)*d5q5$
(C356) bm2[5,5]:cg1*a155+cg2*a455+cg3*a555$
(C357) diff:bm1.m-m.bm2$
(C358) diff:ratexpand(diff);
                                        [ 0  0  0  0  0 ]
                                        [               ]
                                        [ 0  0  0  0  0 ]
                                        [               ]
(D358)                                  [ 0  0  0  0  0 ]
                                        [               ]
                                        [ 0  0  0  0  0 ]
                                        [               ]
                                        [ 0  0  0  0  0 ]
(C359) closefile(Bmsup)$
```

```
(C3) bm1:matrix([0,0,0,0,0],[0,0,0,0,0],[0,0,0,0,0],[0,0,0,0,0],[0
,0,0,0,0])$
(C4) bm2:matrix([0,0,0,0,0],[0,0,0,0,0],[0,0,0,0,0],[0,0,0,0,0],[0
,0,0,0,0])$
(C5) m:matrix([1,0,0,0,0],[0,1,0,0,0],[0,0,1,0,0],[0,0,0,-1,0],[0,
0,0,0,1])$
(C6) diff:matrix([0,0,0,0,0],[0,0,0,0,0],[0,0,0,0,0],[0,0,0,0,0],[
0,0,0,0,0])$
(C7) sign:-1$
(C8) cgg1:(gam-1)/gam$
(C9) cgg2:1/(2*gam)$
(C10) etx:0.0$
(C11) sada:sqrt(etx**2+ety**2+etz**2)$
(C12) axt:etx/sada$
(C13) ayt:ety/sada$
(C14) azt:etz/sada$
(C15) rqrq:q2**2+q3**2+q4**2$
(C16) q6:1/q1$
(C17) pr:(gam-1)*(q5-0.5*rqrq*q6)$
(C18) prgam:pr*gam$
(C19) pp:q5+pr$
(C20) c:sqrt(prgam*q6)$
(C21) tt:(q2*axt+q3*ayt+q4*azt)*q6$
(C22) rc:q1*c$
(C23) csad:c*sada$
(C24) e1:tt*sada$
(C25) e4:e1+csad$
(C26) e5:e1-csad$
(C27) ev1:0.0$
(C28) ev4:0.0$
(C29) ev5:0.5*(e5+sign*abs(e5))$
(C30) cg1:0.0$
(C31) cg2:0.0$
(C32) cg3:cgg2$
(C33) d1q1:-ev1*q6$
(C34) d1q2:etx*q6$
(C35) d1q3:ety*q6$
(C36) d1q4:etz*q6$
(C37) d1q5:0.0$
(C38) coe:gam*(gam-1)/(2*rc)$
(C39) gm1q6:(gam-1)*q6$
(C40) drcq1:coe*q5$
(C41) drcq2:-coe*q2$
(C42) drcq3:-coe*q3$
(C43) drcq4:-coe*q4$
(C44) drcq5:coe*q1$
(C45) dcq1:(drcq1-c)*q6$
(C46) dcq2:drcq2*q6$
(C47) dcq3:drcq3*q6$
(C48) dcq4:drcq4*q6$
(C49) dcq5:drcq5*q6$
```

```
(C50) depq1:0.5*gm1q6*rqrq*q6$
(C51) depq2:-q2*gm1q6$
(C52) depq3:-q3*gm1q6$
(C53) depq4:-q4*gm1q6$
(C54) depq5:gam$
(C55) dttq1:-tt*q6$
(C56) dttq2:axt*q6$
(C57) dttq3:ayt*q6$
(C58) dttq4:azt*q6$
(C59) dttq5:0.0$
(C60) d4q1:sada*(dttq1+dcq1)$
(C61) d4q2:sada*(dttq2+dcq2)$
(C62) d4q3:sada*(dttq3+dcq3)$
(C63) d4q4:sada*(dttq4+dcq4)$
(C64) d4q5:sada*dcq5$
(C65) d5q1:sada*(dttq1-dcq1)$
(C66) d5q2:sada*(dttq2-dcq2)$
(C67) d5q3:sada*(dttq3-dcq3)$
(C68) d5q4:sada*(dttq4-dcq4)$
(C69) d5q5:-d4q5$
(C70) a411:ev4+q1*d4q1$
(C71) a511:ev5+q1*d5q1$
(C72) bm1[1,1]:cg2*a411+cg3*a511$
(C73) bm1[1,2]:(cg1*d1q2+cg2*d4q2+cg3*d5q2)*q1$
(C74) bm1[1,3]:(cg1*d1q3+cg2*d4q3+cg3*d5q3)*q1$
(C75) bm1[1,4]:(cg1*d1q4+cg2*d4q4+cg3*d5q4)*q1$
(C76) bm1[1,5]:(cg2*d4q5+cg3*d5q5)*q1$
(C77) rcaxt:rc*axt$
(C78) ev4ax:ev4*axt$
(C79) ev5ax:ev5*axt$
(C80) coe1:q2+rcaxt$
(C81) coe:q2-rcaxt$
(C82) a121:q2*d1q1$
(C83) a421:ev4ax*drcq1+coe1*d4q1$
(C84) a521:-ev5ax*drcq1+coe*d5q1$
(C85) bm1[2,1]:cg1*a121+cg2*a421+cg3*a521$
(C86) a122:q2*d1q2+ev1$
(C87) a422:ev4+ev4ax*drcq2+coe1*d4q2$
(C88) a522:ev5-ev5ax*drcq2+coe*d5q2$
(C89) bm1[2,2]:cg1*a122+cg2*a422+cg3*a522$
(C90) a123:q2*d1q3$
(C91) a423:ev4ax*drcq3+coe1*d4q3$
(C92) a523:-ev5ax*drcq3+coe*d5q3$
(C93) bm1[2,3]:cg1*a123+cg2*a423+cg3*a523$
(C94) a124:q2*d1q4$
(C95) a424:ev4ax*drcq4+coe1*d4q4$
(C96) a524:-ev5ax*drcq4+coe*d5q4$
(C97) bm1[2,4]:cg1*a124+cg2*a424+cg3*a524$
(C98) a125:q2*d1q5$
(C99) a425:ev4ax*drcq5+coe1*d4q5$
(C100) a525:-ev5ax*drcq5+coe*d5q5$
```

```
(C101) bm1[2,5]:cg1*a125+cg2*a425+cg3*a525$
(C102) rcayt:rc*ayt$
(C103) ev4ay:ev4*ayt$
(C104) ev5ay:ev5*ayt$
(C105) coe1:q3+rcayt$
(C106) coe:q3-rcayt$
(C107) a131:q3*d1q1$
(C108) a431:ev4ay*drcq1+coe1*d4q1$
(C109) a531:-ev5ay*drcq1+coe*d5q1$
(C110) bm1[3,1]:cg1*a131+cg2*a431+cg3*a531$
(C111) a132:q3*d1q2$
(C112) a432:ev4ay*drcq2+coe1*d4q2$
(C113) a532:-ev5ay*drcq2+coe*d5q2$
(C114) bm1[3,2]:cg1*a132+cg2*a432+cg3*a532$
(C115) a133:q3*d1q3+ev1$
(C116) a433:ev4+ev4ay*drcq3+coe1*d4q3$
(C117) a533:ev5-ev5ay*drcq3+coe*d5q3$
(C118) bm1[3,3]:cg1*a133+cg2*a433+cg3*a533$
(C119) a134:q3*d1q4$
(C120) a434:ev4ay*drcq4+coe1*d4q4$
(C121) a534:-ev5ay*drcq4+coe*d5q4$
(C122) bm1[3,4]:cg1*a134+cg2*a434+cg3*a534$
(C123) a135:q3*d1q5$
(C124) a435:ev4ay*drcq5+coe1*d4q5$
(C125) a535:-ev5ay*drcq5+coe*d5q5$
(C126) bm1[3,5]:cg1*a135+cg2*a435+cg3*a535$
(C127) rcazt:rc*azt$
(C128) ev4az:ev4*azt$
(C129) ev5az:ev5*azt$
(C130) coe1:q4+rcazt$
(C131) coe:q4-rcazt$
(C132) a141:q4*d1q1$
(C133) a441:ev4az*drcq1+coe1*d4q1$
(C134) a541:-ev5az*drcq1+coe*d5q1$
(C135) bm1[4,1]:cg1*a141+cg2*a441+cg3*a541$
(C136) a142:q4*d1q2$
(C137) a442:ev4az*drcq2+coe1*d4q2$
(C138) a542:-ev5az*drcq2+coe*d5q2$
(C139) bm1[4,2]:cg1*a142+cg2*a442+cg3*a542$
(C140) a143:q4*d1q3$
(C141) a443:ev4az*drcq3+coe1*d4q3$
(C142) a543:-ev5az*drcq3+coe*d5q3$
(C143) bm1[4,3]:cg1*a143+cg2*a443+cg3*a543$
(C144) a144:q4*d1q4+ev1$
(C145) a444:ev4+ev4az*drcq4+coe1*d4q4$
(C146) a544:ev5-ev5az*drcq4+coe*d5q4$
(C147) bm1[4,4]:cg1*a144+cg2*a444+cg3*a544$
(C148) a145:q4*d1q5$
(C149) a445:ev4az*drcq5+coe1*d4q5$
(C150) a545:-ev5az*drcq5+coe*d5q5$
(C151) bm1[4,5]:cg1*a145+cg2*a445+cg3*a545$
```

```
(C152) rctt:rc*tt$
(C153) coe:0.5*(q2**2+q3**2+q4**2)*q6$
(C154) rt:rc*dttq1+tt*drcq1$
(C155) a151:2*coe*d1q1$
(C156) a451:ev4*(depq1+rt)+(pp+rctt)*d4q1$
(C157) a551:ev5*(depq1-rt)+(pp-rctt)*d5q1$
(C158) bm1[5,1]:cg1*a151+cg2*a451+cg3*a551$
(C159) rt:rc*dttq2+tt*drcq2$
(C160) a152:coe*d1q2-d1q1*q2$
(C161) a452:ev4*(depq2+rt)+(pp+rctt)*d4q2$
(C162) a552:ev5*(depq2-rt)+(pp-rctt)*d5q2$
(C163) bm1[5,2]:cg1*a152+cg2*a452+cg3*a552$
(C164) rt:rc*dttq3+tt*drcq3$
(C165) a153:coe*d1q3-d1q1*q3$
(C166) a453:ev4*(depq3+rt)+(pp+rctt)*d4q3$
(C167) a553:ev5*(depq3-rt)+(pp-rctt)*d5q3$
(C168) bm1[5,3]:cg1*a153+cg2*a453+cg3*a553$
(C169) rt:rc*dttq4+tt*drcq4$
(C170) a154:coe*d1q4-d1q1*q4$
(C171) a454:ev4*(depq4+rt)+(pp+rctt)*d4q4$
(C172) a554:ev5*(depq4-rt)+(pp-rctt)*d5q4$
(C173) bm1[5,4]:cg1*a154+cg2*a454+cg3*a554$
(C174) rt:tt*drcq5$
(C175) a155:coe*d1q5$
(C176) a455:ev4*(depq5+rt)+(pp+rctt)*d4q5$
(C177) a555:ev5*(depq5-rt)+(pp-rctt)*d5q5$
(C178) bm1[5,5]:cg1*a155+cg2*a455+cg3*a555$
(C179) q1:q1$
(C180) q2:q2$
(C181) q3:q3$
(C182) q4:-q4$
(C183) q5:q5$
(C184) etz:-etz;
(C185) cgg1:(gam-1)/gam$
(C186) cgg2:1/(2*gam)$
(C187) sada:sqrt(etx**2+ety**2+etz**2)$
(C188) axt:etx/sada$
(C189) ayt:ety/sada$
(C190) azt:etz/sada$
(C191) rqrq:q2**2+q3**2+q4**2$
(C192) q6:1/q1$
(C193) pr:(gam-1)*(q5-0.5*rqrq*q6)$
(C194) prgam:pr*gam$
(C195) pp:q5+pr$
(C196) c:sqrt(prgam*q6)$
(C197) tt:(q2*axt+q3*ayt+q4*azt)*q6$
(C198) rc:q1*c$
(C199) csad:c*sada$
(C200) e1:tt*sada$
(C201) e4:e1+csad$
(C202) e5:e1-csad$
```

```
(C203) ev1:0.0$
(C204) ev4:0.0$
(C205) ev5:0.5*(e5+sign*abs(e5))$
(C206) cg1:0.0$
(C207) cg2:0.0$
(C208) cg3:cgg2$
(C209) d1q1:-ev1*q6$
(C210) d1q2:etx*q6$
(C211) d1q3:ety*q6$
(C212) d1q4:etz*q6$
(C213) d1q5:0.0$
(C214) coe:gam*(gam-1)/(2*rc)$
(C215) gm1q6:(gam-1)*q6$
(C216) drcq1:coe*q5$
(C217) drcq2:-coe*q2$
(C218) drcq3:-coe*q3$
(C219) drcq4:-coe*q4$
(C220) drcq5:coe*q1$
(C221) dcq1:(drcq1-c)*q6$
(C222) dcq2:drcq2*q6$
(C223) dcq3:drcq3*q6$
(C224) dcq4:drcq4*q6$
(C225) dcq5:drcq5*q6$
(C226) depq1:0.5*gm1q6*rqrq*q6$
(C227) depq2:-q2*gm1q6$
(C228) depq3:-q3*gm1q6$
(C229) depq4:-q4*gm1q6$
(C230) depq5:gam$
(C231) dttq1:-tt*q6$
(C232) dttq2:axt*q6$
(C233) dttq3:ayt*q6$
(C234) dttq4:azt*q6$
(C235) dttq5:0.0$
(C236) d4q1:sada*(dttq1+dcq1)$
(C237) d4q2:sada*(dttq2+dcq2)$
(C238) d4q3:sada*(dttq3+dcq3)$
(C239) d4q4:sada*(dttq4+dcq4)$
(C240) d4q5:sada*dcq5$
(C241) d5q1:sada*(dttq1-dcq1)$
(C242) d5q2:sada*(dttq2-dcq2)$
(C243) d5q3:sada*(dttq3-dcq3)$
(C244) d5q4:sada*(dttq4-dcq4)$
(C245) d5q5:-d4q5$
(C246) a411:ev4+q1*d4q1$
(C247) a511:ev5+q1*d5q1$
(C248) bm2:matrix([0,0,0,0,0],[0,0,0,0,0],[0,0,0,0,0],[0,0,0,0,0],
[0,0,0,0,0])$
(C249) bm2[1,1]:cg2*a411+cg3*a511$
(C250) bm2[1,2]:(cg1*d1q2+cg2*d4q2+cg3*d5q2)*q1$
(C251) bm2[1,3]:(cg1*d1q3+cg2*d4q3+cg3*d5q3)*q1$
(C252) bm2[1,4]:(cg1*d1q4+cg2*d4q4+cg3*d5q4)*q1$
```

```
(C253) bm2[1,5]:(cg2*d4q5+cg3*d5q5)*q1$
(C254) rcaxt:rc*axt$
(C255) ev4ax:ev4*axt$
(C256) ev5ax:ev5*axt$
(C257) coel:q2+rcaxt$
(C258) coe:q2-rcaxt$
(C259) a121:q2*d1q1$
(C260) a421:ev4ax*drcq1+coel*d4q1$
(C261) a521:-ev5ax*drcq1+coe*d5q1$
(C262) bm2[2,1]:cg1*a121+cg2*a421+cg3*a521$
(C263) a122:q2*d1q2+ev1$
(C264) a422:ev4+ev4ax*drcq2+coel*d4q2$
(C265) a522:ev5-ev5ax*drcq2+coe*d5q2$
(C266) bm2[2,2]:cg1*a122+cg2*a422+cg3*a522$
(C267) a123:q2*d1q3$
(C268) a423:ev4ax*drcq3+coel*d4q3$
(C269) a523:-ev5ax*drcq3+coe*d5q3$
(C270) bm2[2,3]:cg1*a123+cg2*a423+cg3*a523$
(C271) a124:q2*d1q4$
(C272) a424:ev4ax*drcq4+coel*d4q4$
(C273) a524:-ev5ax*drcq4+coe*d5q4$
(C274) bm2[2,4]:cg1*a124+cg2*a424+cg3*a524$
(C275) a125:q2*d1q5$
(C276) a425:ev4ax*drcq5+coel*d4q5$
(C277) a525:-ev5ax*drcq5+coe*d5q5$
(C278) bm2[2,5]:cg1*a125+cg2*a425+cg3*a525$
(C279) rcayt:rc*ayt$
(C280) ev4ay:ev4*ayt$
(C281) ev5ay:ev5*ayt$
(C282) coel:q3+rcayt$
(C283) coe:q3-rcayt$
(C284) a131:q3*d1q1$
(C285) a431:ev4ay*drcq1+coel*d4q1$
(C286) a531:-ev5ay*drcq1+coe*d5q1$
(C287) bm2[3,1]:cg1*a131+cg2*a431+cg3*a531$
(C288) a132:q3*d1q2$
(C289) a432:ev4ay*drcq2+coel*d4q2$
(C290) a532:-ev5ay*drcq2+coe*d5q2$
(C291) bm2[3,2]:cg1*a132+cg2*a432+cg3*a532$
(C292) a133:q3*d1q3+ev1$
(C293) a433:ev4+ev4ay*drcq3+coel*d4q3$
(C294) a533:ev5-ev5ay*drcq3+coe*d5q3$
(C295) bm2[3,3]:cg1*a133+cg2*a433+cg3*a533$
(C296) a134:q3*d1q4$
(C297) a434:ev4ay*drcq4+coel*d4q4$
(C298) a534:-ev5ay*drcq4+coe*d5q4$
(C299) bm2[3,4]:cg1*a134+cg2*a434+cg3*a534$
(C300) a135:q3*d1q5$
(C301) a435:ev4ay*drcq5+coel*d4q5$
(C302) a535:-ev5ay*drcq5+coe*d5q5$
(C303) bm2[3,5]:cg1*a135+cg2*a435+cg3*a535$
```

```
(C304) rcazt:rc*azt$
(C305) ev4az:ev4*azt$
(C306) ev5az:ev5*azt$
(C307) coe1:q4+rcazt$
(C308) coe:q4-rcazt$
(C309) a141:q4*d1q1$
(C310) a441:ev4az*drcq1+coe1*d4q1$
(C311) a541:-ev5az*drcq1+coe*d5q1$
(C312) bm2[4,1]:cg1*a141+cg2*a441+cg3*a541$
(C313) a142:q4*d1q2$
(C314) a442:ev4az*drcq2+coe1*d4q2$
(C315) a542:-ev5az*drcq2+coe*d5q2$
(C316) bm2[4,2]:cg1*a142+cg2*a442+cg3*a542$
(C317) a143:q4*d1q3$
(C318) a443:ev4az*drcq3+coe1*d4q3$
(C319) a543:-ev5az*drcq3+coe*d5q3$
(C320) bm2[4,3]:cg1*a143+cg2*a443+cg3*a543$
(C321) a144:q4*d1q4+ev1$
(C322) a444:ev4+ev4az*drcq4+coe1*d4q4$
(C323) a544:ev5-ev5az*drcq4+coe*d5q4$
(C324) bm2[4,4]:cg1*a144+cg2*a444+cg3*a544$
(C325) a145:q4*d1q5$
(C326) a445:ev4az*drcq5+coe1*d4q5$
(C327) a545:-ev5az*drcq5+coe*d5q5$
(C328) bm2[4,5]:cg1*a145+cg2*a445+cg3*a545$
(C329) rctt:rc*tt$
(C330) coe:0.5*(q2**2+q3**2+q4**2)*q6$
(C331) rt:rc*dttq1+tt*drcq1$
(C332) a151:2*coe*d1q1$
(C333) a451:ev4*(depq1+rt)+(pp+rctt)*d4q1$
(C334) a551:ev5*(depq1-rt)+(pp-rctt)*d5q1$
(C335) bm2[5,1]:cg1*a151+cg2*a451+cg3*a551$
(C336) rt:rc*dttq2+tt*drcq2$
(C337) a152:coe*d1q2-d1q1*q2$
(C338) a452:ev4*(depq2+rt)+(pp+rctt)*d4q2$
(C339) a552:ev5*(depq2-rt)+(pp-rctt)*d5q2$
(C340) bm2[5,2]:cg1*a152+cg2*a452+cg3*a552$
(C341) rt:rc*dttq3+tt*drcq3$
(C342) a153:coe*d1q3-d1q1*q3$
(C343) a453:ev4*(depq3+rt)+(pp+rctt)*d4q3$
(C344) a553:ev5*(depq3-rt)+(pp-rctt)*d5q3$
(C345) bm2[5,3]:cg1*a153+cg2*a453+cg3*a553$
(C346) rt:rc*dttq4+tt*drcq4$
(C347) a154:coe*d1q4-d1q1*q4$
(C348) a454:ev4*(depq4+rt)+(pp+rctt)*d4q4$
(C349) a554:ev5*(depq4-rt)+(pp-rctt)*d5q4$
(C350) bm2[5,4]:cg1*a154+cg2*a454+cg3*a554$
(C351) rt:tt*drcq5$
(C352) a155:coe*d1q5$
(C353) a455:ev4*(depq5+rt)+(pp+rctt)*d4q5$
(C354) a555:ev5*(depq5-rt)+(pp-rctt)*d5q5$
```

```
(C355) bm2[5,5]:cg1*a155+cg2*a455+cg3*a555$
(C356) diff:bm1.m-m.bm2$
(C357) diff:ratexpand(diff);
                                       [ 0  0  0  0  0 ]
                                       [               ]
                                       [ 0  0  0  0  0 ]
                                       [               ]
(D357)                                 [ 0  0  0  0  0 ]
                                       [               ]
                                       [ 0  0  0  0  0 ]
                                       [               ]
                                       [ 0  0  0  0  0 ]
(C358) closefile(Bmsub)$
```

```
(C3) cp:matrix([0,0,0,0,0],[0,0,0,0,0],[0,0,0,0,0],[0,0,0,0,0],[0,
0,0,0,0])$
(C4) cm:matrix([0,0,0,0,0],[0,0,0,0,0],[0,0,0,0,0],[0,0,0,0,0],[0,
0,0,0,0])$
(C5) diff:matrix([0,0,0,0,0],[0,0,0,0,0],[0,0,0,0,0],[0,0,0,0,0],[
0,0,0,0,0])$
(C6) m:matrix([1,0,0,0,0],[0,1,0,0,0],[0,0,1,0,0],[0,0,0,-1,0],[0,
0,0,0,1])$
(C7) sign:1$
(C8) cgg1:(gam-1)/gam$
(C9) cgg2:1/(2*gam)$
(C10) sada:sqrt(ztx**2+zty**2+ztz**2)$
(C11) axt:ztx/sada$
(C12) ayt:zty/sada$
(C13) azt:ztz/sada$
(C14) rqrq:q2**2+q3**2+q4**2$
(C15) q6:1/q1$
(C16) pr:(gam-1)*(q5-0.5*rqrq*q6)$
(C17) prgam:pr*gam$
(C18) pp:q5+pr$
(C19) c:sqrt(prgam*q6)$
(C20) tt:(q2*axt+q3*ayt+q4*azt)*q6$
(C21) rc:q1*c$
(C22) csad:c*sada$
(C23) e1:tt*sada$
(C24) e4:e1+csad$
(C25) e5:e1-csad$
(C26) ev1:e1$
(C27) ev4:e4$
(C28) ev5:e1$
(C29) cg1:cgg1$
(C30) cg2:cgg2$
(C31) cg3:cgg2$
(C32) d1q1:-ev1*q6$
(C33) d1q2:ztx*q6$
(C34) d1q3:zty*q6$
(C35) d1q4:ztz*q6$
(C36) d1q5:0.0$
(C37) coe:gam*(gam-1)/(2*rc)$
(C38) gm1q6:(gam-1)*q6$
(C39) drcq1:coe*q5$
(C40) drcq2:-coe*q2$
(C41) drcq3:-coe*q3$
(C42) drcq4:-coe*q4$
(C43) drcq5:coe*q1$
(C44) dcq1:(drcq1-c)*q6$
(C45) dcq2:drcq2*q6$
(C46) dcq3:drcq3*q6$
(C47) dcq4:drcq4*q6$
(C48) dcq5:drcq5*q6$
(C49) depq1:0.5*gm1q6*rqrq*q6$
```

```
(C50) depq2:-q2*gm1q6$
(C51) depq3:-q3*gm1q6$
(C52) depq4:-q4*gm1q6$
(C53) depq5:gam$
(C54) dttq1:-tt*q6$
(C55) dttq2:axt*q6$
(C56) dttq3:ayt*q6$
(C57) dttq4:azt*q6$
(C58) dttq5:0.0$
(C59) d4q1:sada*(dttq1+dcq1)$
(C60) d4q2:sada*(dttq2+dcq2)$
(C61) d4q3:sada*(dttq3+dcq3)$
(C62) d4q4:sada*(dttq4+dcq4)$
(C63) d4q5:sada*dcq5$
(C64) d5q1:sada*(dttq1-dcq1)$
(C65) d5q2:sada*(dttq2-dcq2)$
(C66) d5q3:sada*(dttq3-dcq3)$
(C67) d5q4:sada*(dttq4-dcq4)$
(C68) d5q5:-d4q5$
(C69) a411:ev4+q1*d4q1$
(C70) a511:ev5+q1*d5q1$
(C71) cp[1,1]:cg2*a411+cg3*a511$
(C72) cp[1,2]:(cg1*d1q2+cg2*d4q2+cg3*d5q2)*q1$
(C73) cp[1,3]:(cg1*d1q3+cg2*d4q3+cg3*d5q3)*q1$
(C74) cp[1,4]:(cg1*d1q4+cg2*d4q4+cg3*d5q4)*q1$
(C75) cp[1,5]:(cg2*d4q5+cg3*d5q5)*q1$
(C76) rcaxt:rc*axt$
(C77) ev4ax:ev4*axt$
(C78) ev5ax:ev5*axt$
(C79) coe1:q2+rcaxt$
(C80) coe:q2-rcaxt$
(C81) a121:q2*d1q1$
(C82) a421:ev4ax*drcq1+coe1*d4q1$
(C83) a521:-ev5ax*drcq1+coe*d5q1$
(C84) cp[2,1]:cg1*a121+cg2*a421+cg3*a521$
(C85) a122:q2*d1q2+ev1$
(C86) a422:ev4+ev4ax*drcq2+coe1*d4q2$
(C87) a522:ev5-ev5ax*drcq2+coe*d5q2$
(C88) cp[2,2]:cg1*a122+cg2*a422+cg3*a522$
(C89) a123:q2*d1q3$
(C90) a423:ev4ax*drcq3+coe1*d4q3$
(C91) a523:-ev5ax*drcq3+coe*d5q3$
(C92) cp[2,3]:cg1*a123+cg2*a423+cg3*a523$
(C93) a124:q2*d1q4$
(C94) a424:ev4ax*drcq4+coe1*d4q4$
(C95) a524:-ev5ax*drcq4+coe*d5q4$
(C96) cp[2,4]:cg1*a124+cg2*a424+cg3*a524$
(C97) a125:q2*d1q5$
(C98) a425:ev4ax*drcq5+coe1*d4q5$
(C99) a525:-ev5ax*drcq5+coe*d5q5$
(C100) cp[2,5]:cg1*a125+cg2*a425+cg3*a525$
```

```
(C101) rcayt:rc*ayt$
(C102) ev4ay:ev4*ayt$
(C103) ev5ay:ev5*ayt$
(C104) coe1:q3+rcayt$
(C105) coe:q3-rcayt$
(C106) a131:q3*d1q1$
(C107) a431:ev4ay*drcq1+coe1*d4q1$
(C108) a531:-ev5ay*drcq1+coe*d5q1$
(C109) cp[3,1]:cg1*a131+cg2*a431+cg3*a531$
(C110) a132:q3*d1q2$
(C111) a432:ev4ay*drcq2+coe1*d4q2$
(C112) a532:-ev5ay*drcq2+coe*d5q2$
(C113) cp[3,2]:cg1*a132+cg2*a432+cg3*a532$
(C114) a133:q3*d1q3+ev1$
(C115) a433:ev4+ev4ay*drcq3+coe1*d4q3$
(C116) a533:ev5-ev5ay*drcq3+coe*d5q3$
(C117) cp[3,3]:cg1*a133+cg2*a433+cg3*a533$
(C118) a134:q3*d1q4$
(C119) a434:ev4ay*drcq4+coe1*d4q4$
(C120) a534:-ev5ay*drcq4+coe*d5q4$
(C121) cp[3,4]:cg1*a134+cg2*a434+cg3*a534$
(C122) a135:q3*d1q5$
(C123) a435:ev4ay*drcq5+coe1*d4q5$
(C124) a535:-ev5ay*drcq5+coe*d5q5$
(C125) cp[3,5]:cg1*a135+cg2*a435+cg3*a535$
(C126) rcazt:rc*azt$
(C127) ev4az:ev4*azt$
(C128) ev5az:ev5*azt$
(C129) coe1:q4+rcazt$
(C130) coe:q4-rcazt$
(C131) a141:q4*d1q1$
(C132) a441:ev4az*drcq1+coe1*d4q1$
(C133) a541:-ev5az*drcq1+coe*d5q1$
(C134) cp[4,1]:cg1*a141+cg2*a441+cg3*a541$
(C135) a142:q4*d1q2$
(C136) a442:ev4az*drcq2+coe1*d4q2$
(C137) a542:-ev5az*drcq2+coe*d5q2$
(C138) cp[4,2]:cg1*a142+cg2*a442+cg3*a542$
(C139) a143:q4*d1q3$
(C140) a443:ev4az*drcq3+coe1*d4q3$
(C141) a543:-ev5az*drcq3+coe*d5q3$
(C142) cp[4,3]:cg1*a143+cg2*a443+cg3*a543$
(C143) a144:q4*d1q4+ev1$
(C144) a444:ev4+ev4az*drcq4+coe1*d4q4$
(C145) a544:ev5-ev5az*drcq4+coe*d5q4$
(C146) cp[4,4]:cg1*a144+cg2*a444+cg3*a544$
(C147) a145:q4*d1q5$
(C148) a445:ev4az*drcq5+coe1*d4q5$
(C149) a545:-ev5az*drcq5+coe*d5q5$
(C150) cp[4,5]:cg1*a145+cg2*a445+cg3*a545$
(C151) rctt:rc*tt$
```

```
(C152) coe:0.5*(q2**2+q3**2+q4**2)*q6$
(C153) rt:rc*dttq1+tt*drcq1$
(C154) a151:2*coe*d1q1$
(C155) a451:ev4*(depq1+rt)+(pp+rctt)*d4q1$
(C156) a551:ev5*(depq1-rt)+(pp-rctt)*d5q1$
(C157) cp[5,1]:cg1*a151+cg2*a451+cg3*a551$
(C158) rt:rc*dttq2+tt*drcq2$
(C159) a152:coe*d1q2-d1q1*q2$
(C160) a452:ev4*(depq2+rt)+(pp+rctt)*d4q2$
(C161) a552:ev5*(depq2-rt)+(pp-rctt)*d5q2$
(C162) cp[5,2]:cg1*a152+cg2*a452+cg3*a552$
(C163) rt:rc*dttq3+tt*drcq3$
(C164) a153:coe*d1q3-d1q1*q3$
(C165) a453:ev4*(depq3+rt)+(pp+rctt)*d4q3$
(C166) a553:ev5*(depq3-rt)+(pp-rctt)*d5q3$
(C167) cp[5,3]:cg1*a153+cg2*a453+cg3*a553$
(C168) rt:rc*dttq4+tt*drcq4$
(C169) a154:coe*d1q4-d1q1*q4$
(C170) a454:ev4*(depq4+rt)+(pp+rctt)*d4q4$
(C171) a554:ev5*(depq4-rt)+(pp-rctt)*d5q4$
(C172) cp[5,4]:cg1*a154+cg2*a454+cg3*a554$
(C173) rt:tt*drcq5$
(C174) a155:coe*d1q5$
(C175) a455:ev4*(depq5+rt)+(pp+rctt)*d4q5$
(C176) a555:ev5*(depq5-rt)+(pp-rctt)*d5q5$
(C177) cp[5,5]:cg1*a155+cg2*a455+cg3*a555$
(C178) q1:q1$
(C179) q2:q2$
(C180) q3:q3$
(C181) q4:-q4$
(C182) q5:q5$
(C183) ztx:-ztx$
(C184) zty:-zty$
(C185) sign:-1$
(C186) cgg1:(gam-1)/gam$
(C187) cgg2:1/(2*gam)$
(C188) sada:sqrt(ztx**2+zty**2+ztz**2)$
(C189) axt:ztx/sada$
(C190) ayt:zty/sada$
(C191) azt:ztz/sada$
(C192) rqrq:q2**2+q3**2+q4**2$
(C193) q6:1/q1$
(C194) pr:(gam-1)*(q5-0.5*rqrq*q6)$
(C195) prgam:pr*gam$
(C196) pp:q5+pr$
(C197) c:sqrt(prgam*q6)$
(C198) tt:(q2*axt+q3*ayt+q4*azt)*q6$
(C199) rc:q1*c$
(C200) csad:c*sada$
(C201) e1:tt*sada$
(C202) e4:e1+csad$
```

```
(C203) e5:e1-csad$
(C204) ev1:e1$
(C205) ev4:e1$
(C206) ev5:e5$
(C209) cg1:cgg1$
(C208) cg2:cgg2$
(C209) cg3:cgg2$
(C210) d1q1:-ev1*q6$
(C211) d1q2:ztx*q6$
(C212) d1q3:zty*q6$
(C213) d1q4:ztz*q6$
(C214) d1q5:0.0$
(C215) coe:gam*(gam-1)/(2*rc)$
(C216) gm1q6:(gam-1)*q6$
(C217) drcq1:coe*q5$
(C218) drcq2:-coe*q2$
(C219) drcq3:-coe*q3$
(C220) drcq4:-coe*q4$
(C221) drcq5:coe*q1$
(C222) dcq1:(drcq1-c)*q6$
(C223) dcq2:drcq2*q6$
(C224) dcq3:drcq3*q6$
(C225) dcq4:drcq4*q6$
(C226) dcq5:drcq5*q6$
(C227) depq1:0.5*gm1q6*rqrq*q6$
(C228) depq2:-q2*gm1q6$
(C229) depq3:-q3*gm1q6$
(C230) depq4:-q4*gm1q6$
(C231) depq5:gam$
(C232) dttq1:-tt*q6$
(C233) dttq2:axt*q6$
(C234) dttq3:ayt*q6$
(C235) dttq4:azt*q6$
(C236) dttq5:0.0$
(C237) d4q1:sada*(dttq1+dcq1)$
(C238) d4q2:sada*(dttq2+dcq2)$
(C239) d4q3:sada*(dttq3+dcq3)$
(C240) d4q4:sada*(dttq4+dcq4)$
(C241) d4q5:sada*dcq5$
(C242) d5q1:sada*(dttq1-dcq1)$
(C243) d5q2:sada*(dttq2-dcq2)$
(C244) d5q3:sada*(dttq3-dcq3)$
(C245) d5q4:sada*(dttq4-dcq4)$
(C246) d5q5:-d4q5$
(C247) a411:ev4+q1*d4q1$
(C248) a511:ev5+q1*d5q1$
(C249) cm[1,1]:cg2*a411+cg3*a511$
(C250) cm[1,2]:(cg1*d1q2+cg2*d4q2+cg3*d5q2)*q1$
(C251) cm[1,3]:(cg1*d1q3+cg2*d4q3+cg3*d5q3)*q1$
(C252) cm[1,4]:(cg1*d1q4+cg2*d4q4+cg3*d5q4)*q1$
(C253) cm[1,5]:(cg2*d4q5+cg3*d5q5)*q1$
```

```
(C254) rcaxt:rc*axt$
(C255) ev4ax:ev4*axt$
(C256) ev5ax:ev5*axt$
(C257) coe1:q2+rcaxt$
(C258) coe:q2-rcaxt$
(C259) a121:q2*d1q1$
(C260) a421:ev4ax*drcq1+coe1*d4q1$
(C261) a521:-ev5ax*drcq1+coe*d5q1$
(C262) cm[2,1]:cg1*a121+cg2*a421+cg3*a521$
(C263) a122:q2*d1q2+ev1$
(C264) a422:ev4+ev4ax*drcq2+coe1*d4q2$
(C265) a522:ev5-ev5ax*drcq2+coe*d5q2$
(C266) cm[2,2]:cg1*a122+cg2*a422+cg3*a522$
(C267) a123:q2*d1q3$
(C268) a423:ev4ax*drcq3+coe1*d4q3$
(C269) a523:-ev5ax*drcq3+coe*d5q3$
(C270) cm[2,3]:cg1*a123+cg2*a423+cg3*a523$
(C271) a124:q2*d1q4$
(C272) a424:ev4ax*drcq4+coe1*d4q4$
(C273) a524:-ev5ax*drcq4+coe*d5q4$
(C274) cm[2,4]:cg1*a124+cg2*a424+cg3*a524$
(C275) a125:q2*d1q5$
(C276) a425:ev4ax*drcq5+coe1*d4q5$
(C277) a525:-ev5ax*drcq5+coe*d5q5$
(C278) cm[2,5]:cg1*a125+cg2*a425+cg3*a525$
(C279) rcayt:rc*ayt$
(C280) ev4ay:ev4*ayt$
(C281) ev5ay:ev5*ayt$
(C282) coe1:q3+rcayt$
(C283) coe:q3-rcayt$
(C284) a131:q3*d1q1$
(C285) a431:ev4ay*drcq1+coe1*d4q1$
(C286) a531:-ev5ay*drcq1+coe*d5q1$
(C287) cm[3,1]:cg1*a131+cg2*a431+cg3*a531$
(C288) a132:q3*d1q2$
(C289) a432:ev4ay*drcq2+coe1*d4q2$
(C290) a532:-ev5ay*drcq2+coe*d5q2$
(C291) cm[3,2]:cg1*a132+cg2*a432+cg3*a532$
(C292) a133:q3*d1q3+ev1$
(C293) a433:ev4+ev4ay*drcq3+coe1*d4q3$
(C294) a533:ev5-ev5ay*drcq3+coe*d5q3$
(C295) cm[3,3]:cg1*a133+cg2*a433+cg3*a533$
(C296) a134:q3*d1q4$
(C297) a434:ev4ay*drcq4+coe1*d4q4$
(C298) a534:-ev5ay*drcq4+coe*d5q4$
(C299) cm[3,4]:cg1*a134+cg2*a434+cg3*a534$
(C300) a135:q3*d1q5$
(C301) a435:ev4ay*drcq5+coe1*d4q5$
(C302) a535:-ev5ay*drcq5+coe*d5q5$
(C303) cm[3,5]:cg1*a135+cg2*a435+cg3*a535$
(C304) rcazt:rc*azt$
```

```
(C305) ev4az:ev4*azt$
(C306) ev5az:ev5*azt$
(C307) coe1:q4+rcazt$
(C308) coe:q4-rcazt$
(C309) a141:q4*d1q1$
(C310) a441:ev4az*drcq1+coe1*d4q1$
(C311) a541:-ev5az*drcq1+coe*d5q1$
(C312) cm[4,1]:cg1*a141+cg2*a441+cg3*a541$
(C313) a142:q4*d1q2$
(C314) a442:ev4az*drcq2+coe1*d4q2$
(C315) a542:-ev5az*drcq2+coe*d5q2$
(C316) cm[4,2]:cg1*a142+cg2*a442+cg3*a542$
(C317) a143:q4*d1q3$
(C318) a443:ev4az*drcq3+coe1*d4q3$
(C319) a543:-ev5az*drcq3+coe*d5q3$
(C320) cm[4,3]:cg1*a143+cg2*a443+cg3*a543$
(C321) a144:q4*d1q4+ev1$
(C322) a444:ev4+ev4az*drcq4+coe1*d4q4$
(C323) a544:ev5-ev5az*drcq4+coe*d5q4$
(C324) cm[4,4]:cg1*a144+cg2*a444+cg3*a544$
(C325) a145:q4*d1q5$
(C326) a445:ev4az*drcq5+coe1*d4q5$
(C327) a545:-ev5az*drcq5+coe*d5q5$
(C328) cm[4,5]:cg1*a145+cg2*a445+cg3*a545$
(C329) rctt:rc*tt$
(C330) coe:0.5*(q2**2+q3**2+q4**2)*q6$
(C331) rt:rc*dttq1+tt*drcq1$
(C332) a151:2*coe*d1q1$
(C333) a451:ev4*(depq1+rt)+(pp+rctt)*d4q1$
(C334) a551:ev5*(depq1-rt)+(pp-rctt)*d5q1$
(C335) cm[5,1]:cg1*a151+cg2*a451+cg3*a551$
(C336) rt:rc*dttq2+tt*drcq2$
(C337) a152:coe*d1q2-d1q1*q2$
(C338) a452:ev4*(depq2+rt)+(pp+rctt)*d4q2$
(C339) a552:ev5*(depq2-rt)+(pp-rctt)*d5q2$
(C340) cm[5,2]:cg1*a152+cg2*a452+cg3*a552$
(C341) rt:rc*dttq3+tt*drcq3$
(C342) a153:coe*d1q3-d1q1*q3$
(C343) a453:ev4*(depq3+rt)+(pp+rctt)*d4q3$
(C344) a553:ev5*(depq3-rt)+(pp-rctt)*d5q3$
(C346) rt:rc*dttq4+tt*drcq4$
(C347) a154:coe*d1q4-d1q1*q4$
(C348) a454:ev4*(depq4+rt)+(pp+rctt)*d4q4$
(C349) a554:ev5*(depq4-rt)+(pp-rctt)*d5q4$
(C350) cm[5,4]:cg1*a154+cg2*a454+cg3*a554$
(C351) rt:tt*drcq5$
(C352) a155:coe*d1q5$
(C353) a455:ev4*(depq5+rt)+(pp+rctt)*d4q5$
(C354) a555:ev5*(depq5-rt)+(pp-rctt)*d5q5$
(C355) cm[5,5]:cg1*a155+cg2*a455+cg3*a555$
(C356) diff:cp.m+m.cm$
```

```
(C357) diff:ratexpand(diff);
                                        [ 0  0  0  0  0 ]
                                        [               ]
                                        [ 0  0  0  0  0 ]
                                        [               ]
(D357)                                  [ 0  0  0  0  0 ]
                                        [               ]
                                        [ 0  0  0  0  0 ]
                                        [               ]
                                        [ 0  0  0  0  0 ]

(C358) closefile(Ccsup1)$
```

```
(C3) cp:matrix([0,0,0,0,0],[0,0,0,0,0],[0,0,0,0,0],[0,0,0,0,0],[0,
0,0,0,0])$
(C4) cm:matrix([0,0,0,0,0],[0,0,0,0,0],[0,0,0,0,0],[0,0,0,0,0],[0,
0,0,0,0])$
(C5) diff:matrix([0,0,0,0,0],[0,0,0,0,0],[0,0,0,0,0],[0,0,0,0,0],[
0,0,0,0,0])$
(C6) m:matrix([1,0,0,0,0],[0,1,0,0,0],[0,0,1,0,0],[0,0,0,-1,0],[0,
0,0,0,1])$
(C7) sign:1$
(C8) cgg1:(gam-1)/gam$
(C9) cgg2:1/(2*gam)$
(C10) sada:sqrt(ztx**2+zty**2+ztz**2)$
(C11) axt:ztx/sada$
(C12) ayt:zty/sada$
(C13) azt:ztz/sada$
(C14) rqrq:q2**2+q3**2+q4**2$
(C15) q6:1/q1$
(C16) pr:(gam-1)*(q5-0.5*rqrq*q6)$
(C17) prgam:pr*gam$
(C18) pp:q5+pr$
(C19) c:sqrt(prgam*q6)$
(C20) tt:(q2*axt+q3*ayt+q4*azt)*q6$
(C21) rc:q1*c$
(C22) csad:c*sada$
(C23) e1:tt*sada$
(C24) e4:e1+csad$
(C25) e5:e1-csad$
(C26) ev1:e1$
(C27) ev4:e4$
(C28) ev5:0.0$
(C29) cg1:cgg1$
(C30) cg2:cgg2$
(C31) cg3:0.0$
(C32) d1q1:-ev1*q6$
(C33) d1q2:ztx*q6$
(C34) d1q3:zty*q6$
(C35) d1q4:ztz*q6$
(C36) d1q5:0.0$
(C37) coe:gam*(gam-1)/(2*rc)$
(C38) gm1q6:(gam-1)*q6$
(C39) drcq1:coe*q5$
(C40) drcq2:-coe*q2$
(C41) drcq3:-coe*q3$
(C42) drcq4:-coe*q4$
(C43) drcq5:coe*q1$
(C44) dcq1:(drcq1-c)*q6$
(C45) dcq2:drcq2*q6$
(C46) dcq3:drcq3*q6$
(C47) dcq4:drcq4*q6$
(C48) dcq5:drcq5*q6$
(C49) depq1:0.5*gm1q6*rqrq*q6$
```

```
(C50) depq2:-q2*gm1q6$
(C51) depq3:-q3*gm1q6$
(C52) depq4:-q4*gm1q6$
(C53) depq5:gam$
(C54) dttq1:-tt*q6$
(C55) dttq2:axt*q6$
(C56) dttq3:ayt*q6$
(C57) dttq4:azt*q6$
(C58) dttq5:0.0$
(C59) d4q1:sada*(dttq1+dcq1)$
(C60) d4q2:sada*(dttq2+dcq2)$
(C61) d4q3:sada*(dttq3+dcq3)$
(C62) d4q4:sada*(dttq4+dcq4)$
(C63) d4q5:sada*dcq5$
(C64) d5q1:sada*(dttq1-dcq1)$
(C65) d5q2:sada*(dttq2-dcq2)$
(C66) d5q3:sada*(dttq3-dcq3)$
(C67) d5q4:sada*(dttq4-dcq4)$
(C68) d5q5:-d4q5$
(C69) a411:ev4+q1*d4q1$
(C70) a511:ev5+q1*d5q1$
(C71) cp[1,1]:cg2*a411+cg3*a511$
(C72) cp[1,2]:(cg1*d1q2+cg2*d4q2+cg3*d5q2)*q1$
(C73) cp[1,3]:(cg1*d1q3+cg2*d4q3+cg3*d5q3)*q1$
(C74) cp[1,4]:(cg1*d1q4+cg2*d4q4+cg3*d5q4)*q1$
(C75) cp[1,5]:(cg2*d4q5+cg3*d5q5)*q1$
(C76) rcaxt:rc*axt$
(C77) ev4ax:ev4*axt$
(C78) ev5ax:ev5*axt$
(C79) coe1:q2+rcaxt$
(C80) coe:q2-rcaxt$
(C81) a121:q2*d1q1$
(C82) a421:ev4ax*drcq1+coe1*d4q1$
(C83) a521:-ev5ax*drcq1+coe*d5q1$
(C84) cp[2,1]:cg1*a121+cg2*a421+cg3*a521$
(C85) a122:q2*d1q2+ev1$
(C86) a422:ev4+ev4ax*drcq2+coe1*d4q2$
(C87) a522:ev5-ev5ax*drcq2+coe*d5q2$
(C88) cp[2,2]:cg1*a122+cg2*a422+cg3*a522$
(C89) a123:q2*d1q3$
(C90) a423:ev4ax*drcq3+coe1*d4q3$
(C91) a523:-ev5ax*drcq3+coe*d5q3$
(C92) cp[2,3]:cg1*a123+cg2*a423+cg3*a523$
(C93) a124:q2*d1q4$
(C94) a424:ev4ax*drcq4+coe1*d4q4$
(C95) a524:-ev5ax*drcq4+coe*d5q4$
(C96) cp[2,4]:cg1*a124+cg2*a424+cg3*a524$
(C97) a125:q2*d1q5$
(C98) a425:ev4ax*drcq5+coe1*d4q5$
(C99) a525:-ev5ax*drcq5+coe*d5q5$
(C100) cp[2,5]:cg1*a125+cg2*a425+cg3*a525$
```

```
(C101) rcayt:rc*ayt$
(C102) ev4ay:ev4*ayt$
(C103) ev5ay:ev5*ayt$
(C104) coe1:q3+rcayt$
(C105) coe:q3-rcayt$
(C106) a131:q3*d1q1$
(C107) a431:ev4ay*drcq1+coe1*d4q1$
(C108) a531:-ev5ay*drcq1+coe*d5q1$
(C109) cp[3,1]:cg1*a131+cg2*a431+cg3*a531$
(C110) a132:q3*d1q2$
(C111) a432:ev4ay*drcq2+coe1*d4q2$
(C112) a532:-ev5ay*drcq2+coe*d5q2$
(C113) cp[3,2]:cg1*a132+cg2*a432+cg3*a532$
(C114) a133:q3*d1q3+ev1$
(C115) a433:ev4+ev4ay*drcq3+coe1*d4q3$
(C116) a533:ev5-ev5ay*drcq3+coe*d5q3$
(C117) cp[3,3]:cg1*a133+cg2*a433+cg3*a533$
(C118) a134:q3*d1q4$
(C119) a434:ev4ay*drcq4+coe1*d4q4$
(C120) a534:-ev5ay*drcq4+coe*d5q4$
(C121) cp[3,4]:cg1*a134+cg2*a434+cg3*a534$
(C122) a135:q3*d1q5$
(C123) a435:ev4ay*drcq5+coe1*d4q5$
(C124) a535:-ev5ay*drcq5+coe*d5q5$
(C125) cp[3,5]:cg1*a135+cg2*a435+cg3*a535$
(C126) rcazt:rc*azt$
(C127) ev4az:ev4*azt$
(C128) ev5az:ev5*azt$
(C129) coe1:q4+rcazt$
(C130) coe:q4-rcazt$
(C131) a141:q4*d1q1$
(C132) a441:ev4az*drcq1+coe1*d4q1$
(C133) a541:-ev5az*drcq1+coe*d5q1$
(C134) cp[4,1]:cg1*a141+cg2*a441+cg3*a541$
(C135) a142:q4*d1q2$
(C136) a442:ev4az*drcq2+coe1*d4q2$
(C137) a542:-ev5az*drcq2+coe*d5q2$
(C138) cp[4,2]:cg1*a142+cg2*a442+cg3*a542$
(C139) a143:q4*d1q3$
(C140) a443:ev4az*drcq3+coe1*d4q3$
(C141) a543:-ev5az*drcq3+coe*d5q3$
(C142) cp[4,3]:cg1*a143+cg2*a443+cg3*a543$
(C143) a144:q4*d1q4+ev1$
(C144) a444:ev4+ev4az*drcq4+coe1*d4q4$
(C145) a544:ev5-ev5az*drcq4+coe*d5q4$
(C146) cp[4,4]:cg1*a144+cg2*a444+cg3*a544$
(C147) a145:q4*d1q5$
(C148) a445:ev4az*drcq5+coe1*d4q5$
(C149) a545:-ev5az*drcq5+coe*d5q5$
(C150) cp[4,5]:cg1*a145+cg2*a445+cg3*a545$
(C151) rctt:rc*tt$
```

```
(C152) coe:0.5*(q2**2+q3**2+q4**2)*q6$
(C153) rt:rc*dttq1+tt*drcq1$
(C154) a151:2*coe*d1q1$
(C155) a451:ev4*(depq1+rt)+(pp+rctt)*d4q1$
(C156) a551:ev5*(depq1-rt)+(pp-rctt)*d5q1$
(C157) cp[5,1]:cg1*a151+cg2*a451+cg3*a551$
(C158) rt:rc*dttq2+tt*drcq2$
(C159) a152:coe*d1q2-d1q1*q2$
(C160) a452:ev4*(depq2+rt)+(pp+rctt)*d4q2$
(C161) a552:ev5*(depq2-rt)+(pp-rctt)*d5q2$
(C162) cp[5,2]:cg1*a152+cg2*a452+cg3*a552$
(C163) rt:rc*dttq3+tt*drcq3$
(C164) a153:coe*d1q3-d1q1*q3$
(C165) a453:ev4*(depq3+rt)+(pp+rctt)*d4q3$
(C166) a553:ev5*(depq3-rt)+(pp-rctt)*d5q3$
(C167) cp[5,3]:cg1*a153+cg2*a453+cg3*a553$
(C168) rt:rc*dttq4+tt*drcq4$
(C169) a154:coe*d1q4-d1q1*q4$
(C170) a454:ev4*(depq4+rt)+(pp+rctt)*d4q4$
(C171) a554:ev5*(depq4-rt)+(pp-rctt)*d5q4$
(C172) cp[5,4]:cg1*a154+cg2*a454+cg3*a554$
(C173) rt:tt*drcq5$
(C174) a155:coe*d1q5$
(C175) a455:ev4*(depq5+rt)+(pp+rctt)*d4q5$
(C176) a555:ev5*(depq5-rt)+(pp-rctt)*d5q5$
(C177) cp[5,5]:cg1*a155+cg2*a455+cg3*a555$
(C178) q1:q1$
(C179) q2:q2$
(C180) q3:q3$
(C181) q4:-q4$
(C182) q5:q5$
(C183) ztx:-ztx$
(C184) zty:-zty$
(C185) sign:-1$
(C186) cgg1:(gam-1)/gam$
(C187) cgg2:1/(2*gam)$
(C188) sada:sqrt(ztx**2+zty**2+ztz**2)$
(C189) axt:ztx/sada$
(C190) ayt:zty/sada$
(C191) azt:ztz/sada$
(C192) rqrq:q2**2+q3**2+q4**2$
(C193) q6:1/q1$
(C194) pr:(gam-1)*(q5-0.5*rqrq*q6)$
(C195) prgam:pr*gam$
(C196) pp:q5+pr$
(C197) c:sqrt(prgam*q6)$
(C198) tt:(q2*axt+q3*ayt+q4*azt)*q6$
(C199) rc:q1*c$
(C200) csad:c*sada$
(C201) e1:tt*sada$
(C202) e4:e1+csad$
```

```
(C203) e5:e1-csad$
(C204) ev1:e1$
(C205) ev4:0.0$
(C206) ev5:e5$
(C207) cg1:cgg1$
(C208) cg2:0.0$
(C209) cg3:cgg2$
(C210) d1q1:-ev1*q6$
(C211) d1q2:ztx*q6$
(C212) d1q3:zty*q6$
(C213) d1q4:ztz*q6$
(C214) d1q5:0.0$
(C215) coe:gam*(gam-1)/(2*rc)$
(C216) gm1q6:(gam-1)*q6$
(C217) drcq1:coe*q5$
(C218) drcq2:-coe*q2$
(C219) drcq3:-coe*q3$
(C220) drcq4:-coe*q4$
(C221) drcq5:coe*q1$
(C222) dcq1:(drcq1-c)*q6$
(C223) dcq2:drcq2*q6$
(C224) dcq3:drcq3*q6$
(C225) dcq4:drcq4*q6$
(C226) dcq5:drcq5*q6$
(C227) depq1:0.5*gm1q6*rqrq*q6$
(C228) depq2:-q2*gm1q6$
(C229) depq3:-q3*gm1q6$
(C230) depq4:-q4*gm1q6$
(C231) depq5:gam$
(C232) dttq1:-tt*q6$
(C233) dttq2:axt*q6$
(C234) dttq3:ayt*q6$
(C235) dttq4:azt*q6$
(C236) dttq5:0.0$
(C237) d4q1:sada*(dttq1+dcq1)$
(C238) d4q2:sada*(dttq2+dcq2)$
(C239) d4q3:sada*(dttq3+dcq3)$
(C240) d4q4:sada*(dttq4+dcq4)$
(C241) d4q5:sada*dcq5$
(C242) d5q1:sada*(dttq1-dcq1)$
(C243) d5q2:sada*(dttq2-dcq2)$
(C244) d5q3:sada*(dttq3-dcq3)$
(C245) d5q4:sada*(dttq4-dcq4)$
(C246) d5q5:-d4q5$
(C247) a411:ev4+q1*d4q1$
(C248) a511:ev5+q1*d5q1$
(C249) cm[1,1]:cg2*a411+cg3*a511$
(C250) cm[1,2]:(cg1*d1q2+cg2*d4q2+cg3*d5q2)*q1$
(C251) cm[1,3]:(cg1*d1q3+cg2*d4q3+cg3*d5q3)*q1$
(C252) cm[1,4]:(cg1*d1q4+cg2*d4q4+cg3*d5q4)*q1$
(C253) cm[1,5]:(cg2*d4q5+cg3*d5q5)*q1$
```

```
(C254) rcaxt:rc*axt$
(C255) ev4ax:ev4*axt$
(C256) ev5ax:ev5*axt$
(C257) coel:q2+rcaxt$
(C258) coe:q2-rcaxt$
(C259) a121:q2*d1q1$
(C260) a421:ev4ax*drcq1+coel*d4q1$
(C261) a521:-ev5ax*drcq1+coe*d5q1$
(C262) cm[2,1]:cg1*a121+cg2*a421+cg3*a521$
(C263) a122:q2*d1q2+ev1$
(C264) a422:ev4+ev4ax*drcq2+coel*d4q2$
(C265) a522:ev5-ev5ax*drcq2+coe*d5q2$
(C266) cm[2,2]:cg1*a122+cg2*a422+cg3*a522$
(C267) a123:q2*d1q3$
(C268) a423:ev4ax*drcq3+coel*d4q3$
(C269) a523:-ev5ax*drcq3+coe*d5q3$
(C270) cm[2,3]:cg1*a123+cg2*a423+cg3*a523$
(C271) a124:q2*d1q4$
(C272) a424:ev4ax*drcq4+coel*d4q4$
(C273) a524:-ev5ax*drcq4+coe*d5q4$
(C274) cm[2,4]:cg1*a124+cg2*a424+cg3*a524$
(C275) a125:q2*d1q5$
(C276) a425:ev4ax*drcq5+coel*d4q5$
(C277) a525:-ev5ax*drcq5+coe*d5q5$
(C278) cm[2,5]:cg1*a125+cg2*a425+cg3*a525$
(C279) rcayt:rc*ayt$
(C280) ev4ay:ev4*ayt$
(C281) ev5ay:ev5*ayt$
(C282) coel:q3+rcayt$
(C283) coe:q3-rcayt$
(C284) a131:q3*d1q1$
(C285) a431:ev4ay*drcq1+coel*d4q1$
(C286) a531:-ev5ay*drcq1+coe*d5q1$
(C287) cm[3,1]:cg1*a131+cg2*a431+cg3*a531$
(C288) a132:q3*d1q2$
(C289) a432:ev4ay*drcq2+coel*d4q2$
(C290) a532:-ev5ay*drcq2+coe*d5q2$
(C291) cm[3,2]:cg1*a132+cg2*a432+cg3*a532$
(C292) a133:q3*d1q3+ev1$
(C293) a433:ev4+ev4ay*drcq3+coel*d4q3$
(C294) a533:ev5-ev5ay*drcq3+coe*d5q3$
(C295) cm[3,3]:cg1*a133+cg2*a433+cg3*a533$
(C296) a134:q3*d1q4$
(C297) a434:ev4ay*drcq4+coel*d4q4$
(C298) a534:-ev5ay*drcq4+coe*d5q4$
(C299) cm[3,4]:cg1*a134+cg2*a434+cg3*a534$
(C300) a135:q3*d1q5$
(C301) a435:ev4ay*drcq5+coel*d4q5$
(C302) a535:-ev5ay*drcq5+coe*d5q5$
(C303) cm[3,5]:cg1*a135+cg2*a435+cg3*a535$
(C304) rcazt:rc*azt$
```

```
(C305) ev4az:ev4*azt$
(C306) ev5az:ev5*azt$
(C307) coel:q4+rcazt$
(C308) coe:q4-rcazt$
(C309) a141:q4*d1q1$
(C310) a441:ev4az*drcq1+coe1*d4q1$
(C311) a541:-ev5az*drcq1+coe*d5q1$
(C312) cm[4,1]:cg1*a141+cg2*a441+cg3*a541$
(C313) a142:q4*d1q2$
(C314) a442:ev4az*drcq2+coe1*d4q2$
(C315) a542:-ev5az*drcq2+coe*d5q2$
(C316) cm[4,2]:cg1*a142+cg2*a442+cg3*a542$
(C317) a143:q4*d1q3$
(C318) a443:ev4az*drcq3+coe1*d4q3$
(C319) a543:-ev5az*drcq3+coe*d5q3$
(C320) cm[4,3]:cg1*a143+cg2*a443+cg3*a543$
(C321) a144:q4*d1q4+ev1$
(C322) a444:ev4+ev4az*drcq4+coe1*d4q4$
(C323) a544:ev5-ev5az*drcq4+coe*d5q4$
(C324) cm[4,4]:cg1*a144+cg2*a444+cg3*a544$
(C325) a145:q4*d1q5$
(C326) a445:ev4az*drcq5+coe1*d4q5$
(C327) a545:-ev5az*drcq5+coe*d5q5$
(C328) cm[4,5]:cg1*a145+cg2*a445+cg3*a545$
(C329) rctt:rc*tt$
(C330) coe:0.5*(q2**2+q3**2+q4**2)*q6$
(C331) rt:rc*dttq1+tt*drcq1$
(C332) a151:2*coe*d1q1$
(C333) a451:ev4*(depq1+rt)+(pp+rctt)*d4q1$
(C334) a551:ev5*(depq1-rt)+(pp-rctt)*d5q1$
(C335) cm[5,1]:cg1*a151+cg2*a451+cg3*a551$
(C336) rt:rc*dttq2+tt*drcq2$
(C337) a152:coe*d1q2-d1q1*q2$
(C338) a452:ev4*(depq2+rt)+(pp+rctt)*d4q2$
(C339) a552:ev5*(depq2-rt)+(pp-rctt)*d5q2$
(C340) cm[5,2]:cg1*a152+cg2*a452+cg3*a552$
(C341) rt:rc*dttq3+tt*drcq3$
(C342) a153:coe*d1q3-d1q1*q3$
(C343) a453:ev4*(depq3+rt)+(pp+rctt)*d4q3$
(C344) a553:ev5*(depq3-rt)+(pp-rctt)*d5q3$
(C345) cm[5,3]:cg1*a153+cg2*a453+cg3*a553$
(C346) rt:rc*dttq4+tt*drcq4$
(C347) a154:coe*d1q4-d1q1*q4$
(C348) a454:ev4*(depq4+rt)+(pp+rctt)*d4q4$
(C349) a554:ev5*(depq4-rt)+(pp-rctt)*d5q4$
(C350) cm[5,4]:cg1*a154+cg2*a454+cg3*a554$
(C351) rt:tt*drcq5$
(C352) a155:coe*d1q5$
(C353) a455:ev4*(depq5+rt)+(pp+rctt)*d4q5$
(C354) a555:ev5*(depq5-rt)+(pp-rctt)*d5q5$
(C355) cm[5,5]:cg1*a155+cg2*a455+cg3*a555$
```

```
(C356) diff:cp.m+m.cm$
(C357) diff:ratexpand(diff);
                                       [ 0   0   0   0   0 ]
                                       [                   ]
                                       [ 0   0   0   0   0 ]
                                       [                   ]
(D357)                                 [ 0   0   0   0   0 ]
                                       [                   ]
                                       [ 0   0   0   0   0 ]
                                       [                   ]
                                       [ 0   0   0   0   0 ]
(C358) closefile(Ccsub1)$
```