Masters Thesis

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PICLE: A 2-D CODE FOR LASER-BEAM/[#]
-[#]GAS-JET INTERACTION STUDIES

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PICLE: A 2-D Code for Laser Beam - Gas-Jet
Interaction Studies

ABSTRACT

A heat transport hydrodynamic PIC code was adapted for application to the KMSF gas-jet experiments. The input material density profile was changed from the original solid slab geometry to a cylindrically symmetric profile modeling the gas-jet plume. The target material was changed from the original $Z = 1$ to arbitrary Z . Energy deposition was modified to include inverse bremsstrahlung and resonance absorption. Preliminary results indicate electron thermal conduction dominates over mass flow for times up to about the laser pulse length. Electron thermal conduction is seen to vary between classical and flux-limited values spatially and temporally according to plasma conditions. Applications of this code, entitled PICLE (Particle-In-Cell Laser Experiment code), to absorption and flux-limit parameter studies are described. A source listing and sample input deck are included.

PICLE: A 2-D Code for Laser Beam - Gas-Jet Interaction Studies

M. J. Dunning*

I. INTRODUCTION

A two-dimensional macroscopic PIC (particle-in-cell) code written for laser beam-solid hydrogen target interaction studies^[1] was adapted for laser-target studies using an input material density profile approximating the profile of the KMSF gas jet.^[2] The PIC method, originally developed at LANL,^[3] is a cross between Lagrangean and Eulerian solution schemes, and can be characterized as a Lagrangean scheme with rezoning after each time step. The code assumes the target to be fully ionized from the beginning of the impinging laser beam and, for simplicity, an ideal gas law is used for the equation-of-state. The geometry is two-dimensional with cylindrical symmetry (see Fig. 1). Thus, the density profile and the laser beam are assumed to have no azimuthal dependence. In this geometry the governing equations (i.e., the conservation laws of hydrodynamics for a single fluid component) are:^[1]

$$\frac{\partial \rho}{\partial t} + \frac{\partial}{\partial x} \rho V_x + \frac{1}{r} \frac{\partial}{\partial r} r \rho V_r = 0 \quad (1)$$

$$\rho \frac{dV_x}{dt} = - \frac{\partial}{\partial x} (p + Q_x) \quad (2)$$

$$\rho \frac{dV_r}{dt} = - \frac{\partial}{\partial r} (p + Q_r) \quad (3)$$

$$\begin{aligned} \rho \frac{d\epsilon}{dt} = & W_{ABS} - (p + Q_x) \frac{\partial V_x}{\partial x} \\ & - (p + Q_r) \frac{1}{r} \frac{\partial}{\partial r} (r V_r) - \nabla \vec{q} \end{aligned} \quad (4)$$

where

$Q_x, Q_r \equiv$ artificial viscosity components

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$$Q_x = \alpha \rho \frac{\partial V_x}{\partial x} \quad (5)$$

$$Q_r = \alpha \rho \frac{\partial V_r}{\partial r} \quad (6)$$

where

$\alpha \equiv$ appropriate constant

$\epsilon \equiv$ internal energy per unit mass

$$\epsilon = \begin{cases} \frac{3}{2} \frac{k}{m_i} T & \text{if } T_i = 0 \\ 3 \frac{k}{m_i} T & \text{if } T_i = T_e \end{cases}$$

$\vec{q} \equiv$ flux-limited heat flow

$$\vec{q} = - \frac{2}{7} \frac{K_0 \nabla T^{7/2}}{\left[1 + \frac{2}{7} \frac{K_0}{f g} T |\nabla T| \right]} \quad (7)$$

$$g = n_e k^{3/2} m_e^{-1/2}$$

$$K_0 = \frac{20(2/\pi)^{3/2} k^{7/2}}{m_e^{1/2} e^4 Z \ln \Lambda} \frac{Z}{(Z+1)^2}$$

$f \equiv$ flux-limit parameter

The target material of the original code was assumed to be hydrogen (deuterium), $Z = 1$. Note that $\vec{q}$, the flux-limited heat flow, is set equal to the harmonic mean of the classical (Spitzer) value and the flux-limited value (f times the free streaming limit). The harmonic mean heat flow is discussed further below.

Several changes and additions were made to the original code to include more physical phenomena in PICLE. Modifications to the original code include

- 1) alteration of target density profile;
- 2) allowance of non-hydrogen targets;
- 3) time step determination consistent with thermal transport;

- 4) a switch to circumvent mass transport;
- 5) modeling of inverse bremsstrahlung absorption.

The initial target material density profile was changed from a solid hydrogen to a gas-jet profile of any material, simulating the KMSF gas jet. Early runs indicated that heat conduction can dominate over mass transfer for times approaching five times the laser pulse (laser pulse ≈ 30 picoseconds), which led to the implementation of a hydro on-off switch which bypasses mass transport calculations in an effort to reduce computing time. The ion temperature can be chosen to be cold ($T_i \ll T_e$) or equal to the electron temperature ($T_i = T_e$). The temporal laser pulse now appears as a square pulse of chosen length rather than the original "continuously on" laser, allowing for studies concerning cooling and energy transport as well as heating. The laser energy deposition method was changed from total energy deposition at the critical density layer to a deposition package including both non-linear inverse bremsstrahlung absorption^[4] and resonance absorption modeling at critical.

Interesting preliminary results have been obtained running this revised code. Electron heat conduction is found to vary in calculations between classical and flux-limited values with space and time in the gas-jet density profile according to local temperatures, densities, and density gradients. Heat conduction is flux-limited in heated regions at early times. As the heat conducts out over a larger region, the conduction becomes classical in the dense hot regions but remains flux-limited at the heat front where the temperature gradient is steep. Thermal conduction is also flux-limited in low density regions ($q_{fl} = f n_e \theta_e c_e$) due to the low densities. Later in time the temperature gradient decreases throughout the density profile and heat is conducted classically everywhere. These observations imply that electron thermal conduction may no longer be considered solely classical or solely flux-limited. Thermal conduction is discussed further in the paper.

There are many possible applications for PICLE. An example is the parametric study of the importance of the flux-limit parameter value on a number of experimental observables in the gas-jet experiments. Using the code to calculate x-ray production and simulate x-ray pinhole plots^[5] should allow a means of estimating f . These code determined computer plots could also be used in an attempt to explain the observed high temperature "lobes" on experimental pinhole photographs. This code delivers time and spatially resolved temperatures and densities; thus, potentially any temperature and density dependent phenomena could be investigated.

A source listing of PICLE and a sample input deck are found in Appendix A.

II. MODIFICATIONS OF THE CODE

1. Density Profile

Several modifications have been made to the original PIC code to create PICLE. The initial material density profile for the target was changed from a solid hydrogen slab to a profile simulating the KMSF gas jet.^[2] The density profile now generated by PICLE is superimposed on a holographic interferogram of the gas jet in Figure 2. This is not exactly correct, but could be made more accurate using the holographic data reduction procedure. The axial density distribution was known to vary as:^[2]

$$\rho_N \simeq \rho_0 e^{-Z/Z_0} \quad \text{for } 0 < Z < Z_1 \quad (\text{near field}) \quad (8)$$

$$\rho_F \simeq \rho_1 \left(\frac{Z_1}{Z}\right)^2 \quad \text{for } Z > Z_1 \quad (\text{far field}) \quad (9)$$

where

$Z_0 \equiv$ scale length

$$= D/1.7$$

$D \equiv$ diameter of jet orifice (cm)

$\rho_0 \equiv$ density at orifice

$$\rho_1 = \rho_0 e^{-Z_1/Z}$$

Setting the two gradients equal at $Z = Z_1$ yields^[2]

$$\frac{Z_1}{Z_0} = 2.0$$

The "angular" dependence in the far field was known to scale as

$$\cos^3 \left(\frac{\pi}{2} \frac{\phi}{\phi_{\max}} \right),$$

taking $\gamma = 5/3$ -- an ideal gas.^[5] The angle $\phi_{\max}$ is half the cone angle formed by converging iso-density lines on holographic interferograms, and the limits on ϕ are $0 \leq \phi \leq \phi_{\max}$. Note that this is not the azimuthal angle.

In the near field, the best fit to holographic interferograms was obtained by averaging ρ_N and ρ_F . Thus,

$$\rho_{\text{near}} = \frac{1}{2} (\rho_N + \rho_F) \quad 0 < Z < Z_1 \quad (10)$$

The angular dependence in this region was determined to be

$$\cos^{-3} \left(\frac{\pi}{2} \frac{\phi}{\phi_{\text{exp}}} \right)$$

where $\phi_{\text{exp}} = 2.36$ radians and $0 \leq \phi \leq \phi_{\text{exp}}$. Multiplicative scaling constants on the order of unity were also used in the near field to obtain the profile shown in Fig. 2.

The density gradient in the region where iso-density lines converge is steep and causes numerical problems. To avoid these difficulties, the gradient is not allowed to decrease more than ten-fold per mesh spacing. In regions where the decrease is greater than ten-fold, it is set at ten-fold.

2. Non-Hydrogen Targets

Originally written to do studies of deuterium targets ($Z = 1$), PICLE allows targets of any Z -material. This required changes in the specific heat per unit mass and electronic heat conduction.^[6] Accounting for Z , the specific heat is

$$C_V = \frac{3}{2} (Z + CTION) \frac{k}{m_i} \quad (11)$$

where

$$CTION = \begin{cases} 1 & \text{if } T_e = T_i \\ 0 & \text{if } T_i = 0 \end{cases}$$

The thermal conductivity is also Z-dependent, and can be expressed as^[7]

$$K_o = \frac{20(2/\pi)^{3/2} (kT_e)^{5/2} k}{m_e^{1/2} e^4 Z \ln \Lambda} \epsilon \delta_T \quad (12)$$

where the correction factors ϵ and δ_T have been plotted and found to scale as^[7]

$$\epsilon \delta_T \simeq \frac{0.36}{(1 + \frac{1}{Z})^2} \quad (13)$$

Thus, the Z-dependence of the thermal conductivity is

$$K_o \propto \frac{1}{Z (1 + \frac{1}{Z})^2}$$

or

$$K_o \propto \frac{Z}{(Z + 1)^2}$$

This Z-dependence for thermal conductivity is included in the code for both heat conduction and time-step control purposes.

3. Time-Step Controller

Corrections were made to the time-step determination routine. PICLE uses a variable time-step (dt) which is determined each cycle as the minimum of three values:

- 1) dt(MAX);
- 2) dt(HYDRO);
- 3) dt(HEAT).

- 1) dt (MAX): a user specified maximum timestep,
- 2) dt (HYDRO):

$$dt(HYDRO) \equiv \frac{dx}{v_x(max)} \text{ or } \frac{dr}{v_r(max)}$$

where

$v_{x,r}(max) \equiv$ maximum x,r component velocity

$dx, dr \equiv$ mesh spacing in x,r direction,

Thus, the fastest particle is not allowed to transverse more than one calculational cell per timestep.

- 3) dt (HEAT): the determination of this value is similar to dt (HYDRO), but here we do not allow the heat wave to transverse more than one cell per timestep, hence

$$C_v \rho \frac{\partial \theta_e}{\partial t} = \nabla \phi \quad (14)$$

where

$\phi \equiv$ heat flux

Rearranging yields

$$dt(HEAT) = \frac{C_v \rho \theta_e \Delta r}{\phi} \quad (15)$$

The heat flux ϕ is calculated as the harmonic mean of the classical (Spitzer) and flux-limited values,

$$\phi = \frac{1}{\frac{1}{\phi_c} + \frac{1}{\phi_{FL}}} = \frac{\phi_c \phi_{FL}}{\phi_c + \phi_{FL}} \quad (16)$$

where

$$\phi_c = -K(\theta_e) \nabla \theta_e$$

$$\phi_{FL} = f n_e \theta_e c_e$$

$f \equiv$ flux-limiter

$$c_e = \left(\frac{\theta_e}{m_e} \right)^{1/2}$$

The harmonic mean of the heat flux guarantees the applied heat flux is the lesser of the classical and flux-limited values. In the original code the harmonic mean was applied for thermal conduction purposes, but the timestep determination used the classical heat flux ϕ_c rather than the harmonic mean. This has been corrected in PICLE and Δt (HEAT) is now calculated using the harmonic mean flux (Eq. 16).

4. Hydro "ON/OFF Switch"

Preliminary results have indicated that on the timescales of interest ($\sim 2-3$ times the laser pulse), mass motion is unimportant compared to electron thermal conduction for a large portion of the calculation. This observation has led to the implementation of a hydro "on/off switch", which circumvents the particle transport portion of the code if it is estimated to be negligible. Particle transport is considered negligible if:

$$\left(\frac{v}{\Delta} \right)_{\max} \Delta t \leq \text{HYDOFF} \quad (17)$$

where

$$\left(\frac{v}{\Delta} \right)_{\max} \text{ is the larger of } \frac{v_r(\max)}{\Delta r}, \frac{v_x(\max)}{\Delta x}$$

$v_{x,r}(\max) \equiv$ maximum velocity in the x, r direction

$dx, dr \equiv$ mesh spacing in the x, r direction

HYDOFF $\equiv$ user input fraction

Particle transport is bypassed if the product of the maximum velocity and the current timestep is less than some fraction (HYDOFF) of the mesh spacing. These bypass conditions are examined each timestep, allowing mass transport to turn on and off as $v_{\max}$ and dt change with time. Preliminary results indicate that PICLE runs approximately 25% faster when the negligible mass transport is bypassed (HYDOFF = 0.02). This savings is dependent upon the length of the run, since particle motion becomes more significant at later times. The 25% savings is probably slightly above average for most timescales of interest.

5. Inverse Bremsstrahlung Absorption

Originally, laser energy was deposited only at the critical surface. Currently, energy is deposited by modeling resonance absorption at critical, and modeling inverse bremsstrahlung absorption (IBA) for the penetrating and reflecting laser light. Ray tracing is not included.

The IBA process for the gas jet is shown schematically in Figure 3. We assume that the speed of light is infinite to begin the problem. This allows the assumption that light has penetrated in and reflected out before the first timestep is taken. Thus, there is light in each zone encountered by the laser, varying in intensity from the initial target surface to critical and back out to the surface. To determine the energy deposition per zone, we calculate the intensity and the absorption efficiency at each zone.

Knowing the initial intensity and calculating the absorption efficiency for the first zone encountered by the laser allows the determination of energy deposition in this zone. The absorption efficiency is given by^[4]

$$\epsilon = \left(1 - \exp \left(-2 \int_0^L K_{IB} dx \right) \right) \quad (18)$$

where

$$K_{IB} = k_c \left(\frac{n}{n_c} \right)^2 \frac{1}{(1 - n/n_c)^{1/2}} \cdot g_{NL} \quad (19)$$

and

$g_{NL} \equiv$ non-linear factor

$$g_{NL} = \frac{1}{\left(1 + \left(\frac{v_o}{v_t}\right)^6\right)^{1/2}} \quad (20)$$

$$\left(\frac{v_o}{v_t}\right)^2 \approx \frac{1}{3} \frac{\lambda^2 I_{15}}{\theta_e}$$

$$k_c = 3.3 \ln \Lambda Z \theta_e^{-3/2} \lambda^{-2} \quad (21)$$

θ_e in keV

λ in μm

$\ln \Lambda$ assumed constant

I_{15} is laser intensity in $10^{15} \frac{W}{cm^2}$

The absorption efficiency (18) is given as a total absorption efficiency accounting for penetration and reflection (hence the factor 2) from the target surface to critical and back (hence the limits $0 \rightarrow L$). We are interested in the absorption per cell, thus (18) becomes

$$\epsilon_{i,i+1} = \left(1 - \exp\left(-\int_{x_i}^{x_{i+1}} K_{IB} dx\right)\right) \quad (22)$$

$$0 \leq i \leq 2N-1$$

$$i \neq N$$

(N is at critical)

The efficiency is used to calculate the energy deposition and the intensity reduction corresponding to a particular cell, after which the procedure is repeated for the next cell.

When $i = N$ we examine the critical layer. At the critical layer a constant fraction of the available laser energy is deposited, modeling resonance absorption. IBA is not applied to this cell due to the instability in the denominator of (19) as $n \rightarrow n_c$. The remaining energy is reflected back undergoing IBA as it retraces its penetrating path. The intensity of the light reflected from critical is

$$I_{N+1} = (1.0 - \text{CRITEF}) I_N$$

where

$$I_{N+1} \equiv \text{reflected intensity}$$

$$I_N \equiv \text{incident intensity}$$

$$\text{CRITEF} \equiv \text{absorption efficiency at critical}$$

This intensity (I_{N+1}) then undergoes IBA by (22) from critical back to the target surface. The emergent laser beam intensity (I_{2N}) is used to calculate the reflected power.

III. PRELIMINARY RESULTS

1. Electron Thermal Conduction

Preliminary studies have concentrated on electron thermal conduction. Figure 4.(a-f) illustrates the progress of electron thermal conduction for a 30 psec. laser pulse at an intensity of $3.7 \times 10^{15} \text{ W/cm}^2$ and flux limiter $f = 0.32$. (The value $f = 0.32$ is obtained from Ref. 8). The symbolic "X" plotted indicates zones where conduction is flux limited, that is

$$\frac{\phi_c}{\phi_{FL}} > 1.0$$

where

$$\phi_c = -K(\theta_e) \nabla \theta_e$$

$$\phi_{FL} = f n_e \theta_e c_e$$

$$c_e = \left(\frac{\theta_e}{m_e} \right)^{1/2}$$

For times within the laser pulse (Fig. 4.a - 4.c) temperatures in the heated region are high and the temperature gradient (∇T) at the heat front is large hence thermal conduction is flux limited. As the gas begins to cool (Fig. 4.d), ∇T decreases and conduction becomes classical in high density regions. The majority of the heat front is still flux limited due to ∇T . As the gas continues to cool (Fig. 4.e), ∇T decreases allowing the classically conducting region to spread from high to low densities. At still later times (Fig. 4.f) only the very low density regions remain flux limited. The important realization is that classical and flux limited thermal conduction are operative at different times and regions according to local densities, temperatures, and temperature gradients.

Figure 5 illustrates the same case at a later time ($t > 6t_{\text{laser}}$), when the entire gas profile has cooled to below 500 eV. Notice the area of flux limitation appearing at $x \approx 0.02 \text{ cm}$, $r \approx 0.03 \text{ cm}$ where the density is low. In this region the density gradient is very large. For numerical reasons the density here was "feathered" to decay by no greater than a factor of 10.0 per

mesh spacing. The heat is shown "pouring" down the density gradient in this region. (In the actual experiment, this "pouring" is more pronounced than illustrated due to the buffered density gradient.) This is a possible explanation of the "lobes" illustrated to either side of the orifice on the pinhole photograph of the gas jet in Fig. 6. The laser pulse used to obtain Fig. 6 was 90 psec -- three times longer than that to obtain Fig. 5. A 90 psec pulse "pours" more heat down the density gradient into the lobe region creating more intense x-rays. Using a different value of the flux limit parameter f to generate Fig. 5 would also effect the temperature in these lobes. More modeling studies are required to accurately understand the origin of these features.

Fig. 4 (a-f) and Fig. 5 also illustrate that thermal conduction is faster toward low densities than toward high densities. This is due to the amount of matter which must be heated. It takes longer to heat a large amount of matter (high density) than it does to heat a lesser amount of matter (low density) at the same heat flux level.

Fig. 7 illustrates the effects of varying the flux-limiter, f . The only difference in the cases run for Fig. 4 and Fig. 7 is the value of f ; in Fig. 4, $f_4 = 0.32$; Fig. 7, $f_7 = 0.032$. Reducing f leads to:

- 1) higher temperatures (maximum temperatures obtained with f_7 is larger than with f_4 by a factor of ~ 3);
- 2) flux limited heat conduction for longer times;
- 3) larger temperature gradients;
- 4) significant mass transport at earlier times.

These become evident upon close examination of Figs. 4 and 7.

2. Hydrodynamics

Preliminary results indicate that the mass transport is negligible compared with electron thermal conduction on the short timescales of interest. For a laser pulse of 30 psec at $3.7 \times 10^{15} \text{ W/cm}^2$, maximum particle motion per timestep remained less than 2.0% of the cell spacing for 120 psec after the laser pulse had turned off. These results were obtained from nitrogen ($Z = 7$) with a flux limiter value of $f = 0.32$. Electron thermal conduction dominates mass transport and dictates the timestep because high temperature/low density combinations encountered early in the computation allow "fast" thermal transport. The resultant thermally determined timestep (see II-3) and maximum

particle velocity produce a negligible displacement per timestep. This observation led to the creation of the hydro on/off switch discussed in II-4.

3. Inverse Bremsstrahlung Absorption

Inverse bremsstrahlung absorption (IBA) is applied as the primary absorbing mechanism for laser energy into the gas. The process of the laser "burning" into the density profile is illustrated in Fig. 8. For these figures the incident laser intensity is $3.7 \times 10^{15} \text{ W/cm}^2$, flux limit parameter is $f = 0.32$, $Z = 7$, and there is no energy deposited at critical via resonance absorption (pure reflection). The iso-density lines plotted are, from left to right, 10.0, 2.0, 1.0, and 0.5 in units of critical. These plots were made before the inclusion of the non-linear effects, and hence illustrate linear IBA only.

From Equations (19)-(21) it is seen that absorption efficiency is proportional to n_e^2 and $\theta_e^{-3/2}$ implying IBA is strongest at high densities and low temperatures. Hence as the temperature increases due to IBA, the efficiency of IBA decreases and the profile becomes more transparent. This reduction in calculated absorption efficiency has been observed directly by examining its time dependent value and indirectly by observing the increase in the reflected energy fraction.

IV. FUTURE APPLICATIONS

In the above, the operation and modification of the original code leading to the PICLE have been outlined. This is always the first step in code work; however, application of the code is the bottom line. A few applications of PICLE are discussed below.

1. X-Ray Emission

Calculation of the x-ray production in the heated gas can be easily accomplished. The free-free continuum radiation source rate is given as^[9]

$$S_{ff} = .25 \left(\frac{n_e}{n_c} \right)^2 \frac{Z}{\theta^{1/2}} \bar{G}(\epsilon, \theta) \quad (23)$$

in units of

$$\frac{J}{\text{cm}^3 \text{ keV psec steradian}}$$

$\bar{G}(\epsilon, \theta) \equiv$ Gaunt factor after summing over the velocity distribution

$$\bar{G}(\text{Born Approximation}) = \frac{\sqrt{3}}{\pi} K_0 \left(\frac{\epsilon}{2\theta} \right) e^{-\frac{\epsilon}{2\theta}} \quad (24)$$

$$\epsilon = h\nu = \hbar\omega$$

$K_0 =$ Bessel function

At high frequencies, (24) reduces to

$$G(\epsilon, \theta) = \sqrt{\frac{3}{\pi}} \frac{e^{-\epsilon/\theta}}{(\epsilon/\theta)^{1/2}} \quad (25)$$

The total continuum radiation source rate is a combination of the free-free rate of (23) and a free-bound contribution from Hydrogen-like ions above their recombination energy. The free-bound addition is approximately^[9]

$$S_{fb} \simeq \left(\frac{0.0136Z^2}{\theta} \right) S_{ff} \quad (26)$$

θ in keV

Thus, the total radiation source rate is given by

$$S = S_{ff} + S_{fb} = \left(1.0 + \frac{0.0136 Z^2}{\theta}\right) S_{ff} \quad (27)$$

These expressions can be used to obtain the time and spatially dependent x-ray emission spectrum.

The calculation of x-ray production at each timestep throughout a production run could be used to determine the integrated x-ray production per cm^3 per unit frequency. At the end of such a production run the emission spectrum could be integrated spatially and, when combined with the energy dependence of filter transmission and film sensitivity, used to obtain theoretical pinhole camera photographs.

The outer boundary of the time integrated x-ray pinhole camera photographs of the KMSF gas-jet have been plotted.^[11] A parametric scan of the flux-limiter will produce PICLE generated pinhole boundaries which can be compared to experimental results in order to determine an f that gives a best match to experiment.

2. Reproduction of Pinhole Photograph "Lobes"

As illustrated in Figure 6, and discussed earlier, pinhole photographs illustrate "lobes" to either side of the orifice where energy is accumulated and x-ray emission takes place. This may be due to the steep density gradient allowing energy to "pour" into this region. If this phenomenon is a property of the density profile, it should be observed in the theoretical pinhole plots generated by PICLE. If the lobes are a product of the gas jet structure, they will not appear on the PICLE plots. PICLE could be used to study the production of these lobes.

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APPENDIX A

The following is a source listing of PICLE. The input variables and associated units are listed at the top of MAIN. A sample input deck is included, following the source listing. Comments and references appear throughout the code. The newly added subroutines have many comments, whereas the original codes subroutines contain original comments (very few) and a few new comments.

MAIN

NAME	UNITS	DESCRIPTION	
ALFA	NONE	TIME STEP MULTIPLIER USED TO AVOID NEGATIVE INT. ENERGIES (SEE LA-3466 PG. 83 FOR FORM OF ALFA).	00002200
AVC	1/CM**3	ARTIFICIAL VISCOSITY.	00002300
COULOG	NONE	VALUE OF THE COULOMB LOGARITHM.	
CRITEF	NONE	ABSORPTION EFFICIENCY AT CRITICAL.	
DAT	NONE	SWITCH: =0 REGULAR PARTICLE INJECTION, =1 FOR STOCHASTIC PARTICLE INJECTION.	00002000 00002100
DENSO	PARTICLES/CM**3	DENSITY AT THE GASJET ORIFICE.	00001500
DIAM	CM	DIAMETER OF THE GASJET ORIFICE.	
DINT	SEC	TIME PARAMETER, (CURRENTLY NOT USED.)	00003000
DR	CM	INCREMENT IN R DIRECTION.	00002400
DTMAX	SEC	MAXIMUM TIME STEP.	00002500
DTMIN	SEC	MINIMUM TIME STEP.	00002600
FLXLIM	NONE	THE FLUX-LIMIT PARAMETER.	
HYDOFF	NONE	PERCENT OF CELL SPACING A PARTICLE IS ALLOWED TO TRAVEL PER TIMESTEP WITH THE HYDRO OFF. I.E. 0.000 CAUSES THE HYDRO TO ALWAYS BE ON; 0.500 MEANS A PARTICLES THAT WOULD MOVE UP TO 0.5* CELL SPACING ARE IGNORED AND SAID NOT TO MOVE SINCE THE HYDRO IS OFF.	
INSH	NONE	SWITCH: =2 FOR NO HEAT, =1 FOR HEAT.	00003300
LEND	NONE	MAXIMUM NUMBER OF CONVERSION STEPS.	00003100
LPLDT	NONE	SWITCH: =2 FOR NO PLOT, =1 FOR PLOTS.	00003200
LSHOW	NONE	TIME STEPS BETWEEN OUTPUT (PLOTS, ETC.)	00003310
MAXT	NONE	DISTANCE TO BACK SURFACE OF TARGET.	00001900
MCELL	SQRT(PARTICLES/CELL)	MCELL**2 = NO. OF PARTICLES PER CELL.	00001700
MINT	NONE	DISTANCE TO FRONT SURFACE OF TARGET.	00001800
NPHI	NONE	LAST DEPOSITION ZONE IN TARGET.	00002900
PHIEXP	RADIANS	ANGULAR LIMIT OF THE EXPONENTIAL REGION OF THE GASJET DENSITY PROFILE.	
PHIMAX	RADIANS	ANGULAR LIMIT OF THE INVERSE SQUARE REGION OF THE GASJET DENSITY PROFILE.	
PHIO	ERGS/(SEC*CM**2)	LASER INTENSITY	00002800
TEMPO	DEG. KELVIN	INITIAL TEMPERATURE.	00001600
TION	NONE	SWITCH: =1.0 FOR EQUAL ION AND ELECTRON TEMPERATURES.	

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MAIN

START
COL

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MOD
FLAGS

```
1 C                                     =0.0 FOR COLD IONS
1 C TOFF SEC PULSE DURATION OF THE LASER.
1 C WAVLEN *10-6 M LASER WAVELENGTH IN MICRO-METERS.
1 C ZMAT NONE Z OF THE TARGET MATERIAL.
1 C
8 DIMENSION X(65),R(65),DENS(65,35),XP(60000),RP(60000),VX(65,35),
6 >VR(65,35),TI(65,35),AMASSE(65,35),VXN(65,35),VRN(65,35),
6 >P(65,35),QX(65,35),QR(65,35),DIVPHI(65,35),ZMASSE(65,35),
6 >PMASS(60000),TAU(65),DENSE(65),PTAN(65),TAD(65),
6 >XPN(1),RPN(1),IND(65),ML(65),VXMED(65),VRMED(65),
6 >TMED(65),TOTM(65),AR(65),BR(65),CR(65),CITR(65),
6 >CITRD(65),AZI(65),BZI(65),CZI(65),
6 >G(65),AZZ(65),BZZ(65),CZZ(65),CIT(65),CITD(65),
6 >DUI(65),DU2(65),DU4(65),AI(65),BI(65),CI(65),DI(65),
6 >PMAX(65),XPLOT(15,2000),RPLOT(15,2000),ICOUNT(15),CFRATO(100,100),
6 >IEND(65),TEMP(65,35),BETA(165,35),EFFIN(65,10),EFFOUT(65,10)
1 C
1 C PARTICLE NUMBER PER CELL = MCELL*MCELL
1 C TARGET EXTENDS FROM MINT TO MAXT,THE PLASMA EXTENDS FROM MIN TO J.
1 C TAU(N) VOLUME OF A CELL,DT TIME STEP,I INDEX,XP(I),RP(I) PARTICLE
1 C COORDINATES,ALL QUANTITIES WITH INDEXES(M,N),EXCEPT QX AND ZR ARE
1 C CENTERED AT X(M+1/2),R(N+1/2). QX,OR ARE CENTERED AT X(M),R(N).
1 C THE VOLUMES TAU(N) REFER TO N+1/2.
1 C
7 DIMENSION XD(65),AX(65),AY(65)
7 DIMENSION WTIME(4)
7 EXTERNAL ABSORB
7 COMMON/LA/PHIN,DENSC,NP41
7 COMMON/INT /DENSO,RC,VPIST
7 COMMON/DIAGNO/PERIMP,PEREN,AMOM,COST,ELAS,PERENS,PEREND
7 COMMON/ERR/ TIME, TOFF, L, LEND
7 COMMON /D/ DENLI
7 COMMON /PLTPRM/ LUN, IBAUD, TO, TM, UO, UM, IFLAG, ILIMIT
7 COMMON /GASJT/ DIAM, PHTEXP, PHIMAX
7 COMMON /INVBRM/ CNULOG, WAVLEN, CRITEF, ZMAT, REFPWR, TION
7 DATA IY1 /3/,WTIME /' ' ' ' ' ' ' ' /,ISECS/'
7 DATA PLIM/3.000/,EPS1/0.100/,EPS2/0.800/,ANORM/5.0007/
7 IFLAG=0
7 ILIMIT=0
1 C REFPWR TABULATES THE REFLECTED POWER AS CALCULATED IN SUBROUTINE
1 C *DPOSIT*.
7 REFPWR=0.000
7 PERIMP=C.D0
7 PEREN=0.00
7 PEFENS=0.00
7 PEREND=0.00
7 ELAS=0.00
7 AMOM=0.00
7 COST=0.00
7 READ(3,PARMS)
7 READ(3,PLOT)
7 READ(3,GASJET)
7 READ(3,INVBRM)
7 DENLI=DENSO/1.06
```

00003400
00003500
00003600
00003700
00003800
00003900
00004000
00004100
00004200
00004300

00004400
00004500
00004600
00004700
00004800
00004900
00005000
00005100
00005200
00005300
00005400
00005500
00005600
00005700
00005900
00006000
00006100

00006200
00006300
00006310
00006320

00006500
00006700
00006800
00006900
00007000
00007100
00007200
00007300
00008500
00008910
00006400

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IN

START
COL

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MOD
FLAGS

```
1 C DENS0 IS THE CRITICAL DENSITY IN PARTICLES/(CM**2).
7 DENS0=1.0021/(WAVLEN)**2/ZMAT
7 WRITE(6,3000) DENS0,TEMPO
7 WRITE(6,3005) MCELL,MINT,MAXT,DAT,ALFA,AVC,DR,DTMAX,DTMIN
7 WRITE(6,3010) DENS0,PHI0,NPHI,LSHOW,T0FF
7 WRITE(6,3015) DINT,LEND,LPL0T,INSH
7 WRITE(6,3016) TION,ZMAT,FLXLIM
2 3000 FORMAT (1X,'DENS0=',E10.3,1X,'TEMPO=',E10.3)
2 3005 FORMAT (1X,'MCELL=',I3,1X,'MINT=',I3,1X,'MAXT=',I3,1X,
6 >'DAT=',E10.3,1X,'ALFA=',E10.3,1X,'AVC=',E10.3,1X,'DR=',
2 5010>E10.3,1X,'DTMAX=',E10.3,'DTMIN=',E13.6)
2 3010 FORMAT (' DENS0=',E10.3,1X,' PHI0=',E10.3,1X,' NPHI=',I4,' LSHOW='
6 <,I3,' T0FF=',E10.3)
2 3015 FORMAT (1X,' DINT=',E10.3,1X,'LEND=',I6,1X,'LPL0T=',I4,
6 >' INSH=',I4)
2 3016 FORMAT(1X,'TION=',F4.2,' ZMAT=',F4.1,' FLXLIM=',F4.2)
7 TM = DMIN1(TM, 1023.000)
7 TO = DMAX1(TO, 0.000)
7 UM = DMIN1(UM, 780.000)
7 UO = DMIN1(UO, 0.000)
7 NPHI0=NPHI
7 PHI00=PHI0
7 MIN=2
7 MINA=MINT-1
7 MINB=MINT+1
7 MAXX=60+MIN
7 MAXXA=MAXX-1
7 MAXXB=MAXX+1
7 MAXR=15+MIN
7 MAXRA=MAXR-1
7 MAXRB=MAXR+1
1 C BEAM DIAMETER IS 2*(NPHI-MIN)
1 C TARGET BEGINS WITH MINT AND ENDS WITH MAXT
7 MINTA=MINT-1
7 MINTB=MINT+1
7 MAXTA=MAXT-1
7 MAXP=(MAXR-MIN)*(MAXT-MINT)*MCELL**2
7 DO 31 N=1,MAXR
4 31 IEND(N)=0
1 C AM IS THE ATOMIC MASS OF THE TARGET ION. IT IS CALCULATED ASSUMING
1 C THAT THE ATOMIC NUMBER A=2*Z. MP IS THE PROTON REST MASS.
7 PROT=1.67264850-24
7 AM=12.000*ZMAT)*PROT
7 P1=3.1415926500
7 DX=DR
7 TAUIC=P1*DR*DX
7 DXCELL=DX/MCELL
7 DRCELL=DR/MCELL
7 BK=1.38040-16
7 X(MIN)=0.00
7 R(MIN)=0.00
7 R(MIN)=0.00
7 DO 1 M=MINB,MAXX
1 X(M)=X(M-1)+DX
```

00007400

00007500

00007600

00007700

00007800

00007900

00008000

00008100

00008200

00008300

00008400

00008500

00008600

00008700

00008800

00008900

00009000

00009100

00009200

00009300

00009400

00009500

00009600

00009700

00009800

00009900

00010000

00010100

00010200

00010300

00010400

00010500

00010600

00010800

00010900

00011000

00011100

00011300

00011400

00011500

00011600

00011700

00011800

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7		DO 2 N=MIN8, MAXR8							00011900		
5		2 R(N)=R(N-1)+DR							00012000		
1	C	SH=0.500							00012100		
1	C	CALL SHFT(SH,DX,MCELL,MIN,MINT,MAXTA,MAXRA,R,X,XP,RP,INP,							00012200		
1	C	> PMASS,CM,XDI							00012300		
1	C	THIS DO 21 LOOP SETS THE DEFAULT VALUES FOR THE DENSITY.								*	
7		DO 21 M=MIN,MAXX							00015100		
7		DO 21 N=MIN,MAXPA							00015000		
7		DENS(M,N)=DENLI							00015200		
4		21 CONTINUE								*	
7		DO 22 M=MIN,MAXX								*	
7		DO 22 N=MIN,10								*	
7		EFFIN(M,N)=0.000								*	
4		22 EFFOUT(M,N)=0.000								*	
1	C	SUBROUTINE DENSIN INSERTS THE DESIRED TARGET DENSITY PROFILE.								*	
1	C	CURRENTLY THIS PROFILE MODELS THAT OF THE GAS JET.								*	
7		CALL DENSIN(X,R,MIN,MAXRA,MINT,MINTA,MAXTA,DENS,DX,DR,MAXX,MAXR,						00017710		*	
6		< MINT8,MAXT,DENSO,IEND,MAXR8)								*	
7		I=0							00012400		
1	C	DO 3 M=MINT,MAXTA							00012500		
7		DO 3 M=MIN,MAXTA							00012500		
7		XM=X(M)							00012600		
7		DO 4 N=MIN,MAXRA							00012700		
7		RN=R(N)							00012800		
7		CM=DENSIN,N)*AM*DRCELL*DXCELL*PI							00011200		
7		DO 5 K=1,MCELL							00012900		
7		XV=XM+(K-1)*DXCELL							00013000		
7		DO 6 L=1,MCELL							00013100		
7		I=I+1							00013200		
1	C	STOCHASTIC PARTICLE INJECTION							00013300		
7		CALL RANDU(IY1,IX,YFL)							00013400		
7		IY1=IX							00013500		
7		XP(I)=XV+YFL*DXCELL*DAT+0.500*DXCELL*(1.00-DAT)							00013600		
7		RV=RN+(1-I)*DRCELL							00013700		
7		CALL RANDU(IY1,IX,YFL)							00013800		
7		IY1=IX							00013900		
7		RP(I)=RV+YFL*DRCELL*DAT+0.500*DRCELL*(1.00-DAT)							00014000		
1	C	PARTICLE MASS PMASS(I)							00014100		
7		PMASS(I)=(12.00*RV+DRCELL)*CM							00014200		
5		6 CONTINUE							00014300		
5		5 CONTINUE							00014400		
5		4 CONTINUE							00014500		
5		3 CONTINUE							00014600		
7		MAXP=I							00014700		
1	C	PRESSURE P, ARTIFICIAL VISCOSITY QX, OR OLD VELOCITY COMPONENTS VX, VR							00014800		
1	C	NEW QNES VXX, VRN							00014900		
7		DO 9 N=MINA,MAXR8							00015000		
7		DO 7 M=MINA,MAXXB							00015100		
1	C	MJD DENS(M,N)=1.D18							00015200		
7		VX(M,N)=0.00							00015300		
7		VXX(M,N)=0.00							00015400		
7		VR(M,N)=0.00							00015500		
7		VRN(M,N)=0.00							00015600		
7		P(M,N)=0.00							00015700		

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HSN

START COL	1	2	3	4	5	6	7	8	MOD FLAGS
7	OR(M,N)=0.00							00015800	
7	OX(M,N)=0.00							00015900	
1 C	T(M,N)=1.	SO THAT TA(M)	NOT=0	IN THE DTT CALCULATION.				00016000	
7	T(M,N)=1.00							00016100	
7	TEMP(M,N)=1.000							00016100	
7	BETA(M,N)=1.000								*
7	ZMASSE(M,N)=0.00							00016200	
1 C	STATEMENT SEG. PER ILPISTONE							00016300	
7	DIYPHI(M,N)=0.00							00016400	
7	AMASSE(M,N)=0.00							00016500	
5	7 CONTINUE							00016600	
5	9 CONTINUE							00016700	
7	DO 11 N=MIN,MAXR							00016800	
4	11 TAU(N)=TR(N)+R(N+1)*TAUC							00016900	
7	TAU(MAXR)=(2.00+R(MAXR)+DR)*TAUC							00017000	
1 C	THE TEMPERATURES OF THE COLUMNS TO THE LEFT OF THE LEFT-MOST TARGET								*
1 C	COLUMN ARE SET TO THE SAME TEMPERATURE AS THOSE IN THE LEFT-MOST								*
1 C	TARGET COLUMN. THIS IS DONE TO AVOID STRONG TEMPERATURE GRADIENTS.								*
7	DO 108 M=MIN,MAXTA							00017100	
7	DO 108 N=MIN,MAXRA							00017200	
3	108 T(M,N)=TEMP							00017300	
7	DO 111 I=1,MAXP							00017400	
7	M=XP(I)/DX+MIN							00017500	
7	N=RP(I)/DR+MIN							00017600	
3	111 AMASSE(M,N)=AMASSE(M,N)+PMASSE(I)							00017700	
7	DO 8 M=MIN,MAXX							00017800	
7	DO 8 N=MIN,MAXRA							00017900	
7	DENS(M,N)=AMASSE(M,N)/(AM*TAU(N))							00018000	
7	P(M,N)=(ZMAT+TION)*BK*DENS(M,N)*T(M,N)							00018100	
5	8 CONTINUE							00018200	
7	NDIM=65							00018300	
7	L=0								*
7	ADT=0.00							00018500	
7	TIME=0.00							00018600	
7	ILIM=1							00018700	
7	JLIM=1							00018800	
7	DTT=DTMAX							00018900	
7	DTLIM=DTMAX							00019000	
7	DO 10 M=MIN,MAXX							00019100	
14	TAO(M)=0.00							00019200	
7	DO 12 N=MIN,MAXR							00019300	
3	12 TAO(N)=TAO(M)+T(M,N)							00019400	
3	10 TAO(M)=TAO(M)/(MAXR-MIN+1)							00019500	
1 C	INTEGRATION OF THE HEAT CONDUCTION EQUATION.							00019600	
7	C A L L I N H E A T (A,BR,CR,CITR,CITRO,AZ1,BZ1,CZ1,G,AZ2,BZ2,							00019700	
6	CZ2,CIT,CITO,ETB,TH,NT,MT,MINA,MAXX,MAXRA)							00019800	
7	CALL OSTART							00019810	*
3	15 L=L+1							00019900	
7	K=JSTOP(L)							00019910	*
7	IF (L.GE.(LEND+1)) STOP							00020000	
1 C	SEARCH FOR DT MINIMUM VALID FOR BOTH EQUATIONS.							00020100	
2	1313 VMAX=1.00							00020200	
7	DO 301 N=MIN,MAXRA							00020300	
7	DO 301 M=MIN,MAXX							00020400	

MAIN

COL	1	2	3	4	5	6	7	8	MOD	FLAGS
7		IF (DABS(VX(M,N)).GT.VMAX) VMAX=DABS(VX(M,N))						00020500		
2	301	IF (DABS(VR(M,N)).GT.VMAX) VMAX=DABS(VR(M,N))						00020600		
7		DTV=ALFA*DX/VMAX						00020700		
7		GO TO (35,45),INSH						00020800		
6	35	DTLIM=Z L I M (PLIM,T,DENS,DX,NDIM,MIN,MAXX,MAXRA,ILIM,JLIM,IENS),						00020900		
2		MAXR,BETAI								*
7	45	DT=DMIN1(DTV,DTLIM,DTT)						00021000		
6		IF(DT.LT.5.0D-14) WRITE(6,7000) DTV,DTLIM,DTT,DT,ILIM,						00021100		
7		JLIM,DENS(ILIM,JLIM),T(ILIM,JLIM)								*
6		WRITE(6,7000) DTV,DTLIM,DTT,DT,ILIM,JLIM,DENS(ILIM,JLIM),						00021100		
2		T(ILIM,JLIM)						00021200		
6	7000	FORMAT(1X,'DTV=',E13.6,1X,'DTLIM=',E13.6,1X,'DTT=',E13.6,1X,						00021300		
7		'DT=',E13.6,1X,'ILIM',I3,'JLIM',I3,'DE=',E10.3,'TE=',E10.3)						00021400		
7		IF(DT.LT.1.0D-15) L=LEND								*
1		GO TO(30,40),INSH						00021600		
3	C	HEAT CONDUCTION INSERTION						00021700		
6	30	C A L L H E A T C (T,NT,NDIM,MT,DT,						00021800		
6		R,DX,TH,DENS,ETB,AR,BR,CR,						00021900		
6		AZ1,BZ1,CZ1,AZ2,BZ2,CZ2,						00022000		
6		A,B,C,D,DU1,DU2,DU4,CITR,CIT,G,MAXRB,CFRATO,						00022100		
2		BETAI,FLXLIM)								*
1	40	CONTINUE						00022200		
7	C	JWS CALL P I C (DT,NDIM,AMASSE,ZMASSE,VX,VXN,VR,VRN,P,XDENS,						00022300		
6		CALL P I C (DT,NDIM,AMASSE,ZMASSE,VX,VXN,VR,VRN,P,DENS,						00022400		
6		QX,QR,T,DIVPH,X,RP,TAU,PMASS,R,BK,DX,DR,AM,AVC,L,MAXP,						00022500		
6		MIN,MINA,MAXX,MAXR,MAXRA,ML,ABSORB,DENSC,HYDOFF,VMAX,TEMP,						00022600		
2		EFFIN,EFFOUT)								*
1	41	TIME=TIME+DT						00022700		
1	C	WRITE(6,9873)L,DT								*
7	C9873	FORMAT(' L=',I3,' DT=',D10.3)								*
7		RETMAX=1.D-70						00022800		
7		DO 913 M=MIN,MAXX						00022900		
7		PTAN(M)=0.D0						00023000		
2	910	DO 910 N=MIN,MAXR						00023100		
7		PTAN(M)=PTAN(M)+T(M,N)						00023200		
7		PTAN(M)=PTAN(M)/(MAXR-MIN+1)						00023300		
7		V=DABS((PTAN(M)-TAD(M))/TAD(M))						00023400		
7		IF (V.GT.RETMAX) RETMAX=V						00023500		
1	C	WRITE(6,6000) L,M,RETMAX						00023600		
1	C6000	FORMAT(1X,'L=',I6,'M=',I4,'RETMAX=',E13.6)						00023700		
2	913	TAD(M)=PTAN(M)						00023800		
7		DTT=EPS2*DT+EPS1/(RETMAX+1.D-06)						00023900		
7		IF(DTT.GT.CTMAX) DTT=CTMAX						00024000		
7		IF(DTT.LT.DTMIN) DTT=DTMIN						00024100		
7										

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START COL	1	2	3	4	5	6	7	8	MOD FLAGS
6	>	REFLECTED POWER=	D12.6,	ERGS	///			00025200	
7		WRITE(6,67)						00025300	
1	C								*
3	69	FORMAT(1X,	M,	X(M)	,,	DENS(M,MIN),	DENS(M,5),	00025400	
6	>	EFIN(M,MIN),	EFIN(M,3),	EFOUT(M,MIN),				00025500	
6	>	EFOUT(M,3),	T(M,MIN),	T(M,5),				00025600	
6	>	T(M,10),	T(M,15),					00025700	
6	>							00025800	
7		WRITE(6,68)	(M,X(M),DENS(M,MIN),DENS(M,5),	EFIN(M,MIN),EFIN(M,3),				00025900	
6	>	EFOUT(M,MIN),EFOUT(M,3),	T(M,MIN),T(M,5),T(M,10),T(M,15),					00026000	
6	>	M=MIN,MAXX)							*
1	C	69	FORMAT(1X,	M,	X(M)	,,	DENS(M,MIN),	DENS(M,3),	00025400
1	C	>	DENS(M,4),	DENS(M,5),	DENS(M,6),			00025500	
1	C	>	DENS(M,7),	DENS(M,8),	DENS(M,9),			00025600	
1	C	>	DENS(M,10),	DENS(M,11),				00025700	
1	C	>						00025800	
1	C		WRITE(6,66)	(M,X(M),DENS(M,MIN),DENS(M,3),DENS(M,4),DENS(M,5),				00025900	
1	C	>	DENS(M,6),DENS(M,7),DENS(M,8),DENS(M,9),					00026000	
1	C	>	DENS(M,10),DENS(M,11),M=MIN,MAXX)					00026000	
1	C		WRITE (6,77)	(M,VX(M,MIN),VR(M,MIN),VX(M,3),VR(M,3),VX(M,4),				00026100	
1	C	>	VR(M,4),VX(M,5),VR(M,5),M=MIN,MAXX)					00026200	
1	C		WRITE (6,67)	(T(15,M),VR (15,M),DENS (15,M),M=MIN,MAXX)				00026300	
1	C		WRITE(6,167)	ERRPA,ERRCE,ERRMA,ERREN,RK,RT				00026400	
7		WRITE (6,68)	(N,ML(N),N=MIN,NPHI)					00026500	
2	67	FORMAT (1X,1P3E12.4)						00026600	
2	167	FORMAT(1X,'ERRPA='	E10.3,1X,'ERRCE='	E10.3,1X,'ERRMA='	E10.3,1X,			00026700	
6	>	'ERREN='	E10.3,1X,'RK='	E10.3,1X,'BT='	E10.3)			00026800	
2	68	FORMAT (1' ML('	13,'')='	13)				00026900	
1	C	JWS	68	FORMAT (1X,13)				00027000	
1	C	JWS	66	FORMAT(1X,12,1P11E10.3)				00027100	
2	66	FORMAT(1X,12,1P11E11.3)						00027200	
2	77	FORMAT(1X,12,1P8E12.4)						00027300	
7		GO TO (501,502), LPLDT						00027400	
2	501	CONTINUE						00027500	
1	C		PARTICLE PLOT					00027600	
7		DER=0.00						00027700	
1	C	JWS	CALL	FRAME(=(MIN),-R(MAXR),3.*R(MAXR)+X(MIN),R(MAXR))				00027800	
1	C	JWS	CALL	PLOTXTI X(MIN)+0.1*(X(MAXX)-X(MIN)),R(MAXR)-0.1*(R(MAXR)-				00027900	
1	C	JWS	>	R(MIN)),2,WTIME)				00028000	
1	C	MJD	CALL	PLOTTERXP,RP,MAXP,MAXTA,MAXRA,MIN,MAXR,DENS,MCELL,MINT,DX,				00028100	
1	C	MJD	>	CR,T)					*
7			CALL	PLOTNT(XP,RP,MAXP,MAXTA,MAXRA,MIN,MAXR,DENS,MCELL,MINT,DX,				00028100	
6	>		DR,T,CFRATO,TIME,DENSC,DENSJ)						*
1	C	JWS	CALL	SCALE 1X(MIN),R(MAXR),3.*R(MAXR)+X(MIN),-R(MAXR))				00028200	
1	C	JWS	CALL	PLOTP (XP,RP,MAXP)				00028300	
2	502	DO 901	M=MIN,MAXX					00028400	
7		DENSA(M)=0.00						00028500	
7		TMED(M)=0.00						00028600	
7		VXMED(M)=0.00						00028700	
7		VRMED(M)=0.00						00028800	
7		TOTM(M)=0.00						00028900	
7		DO 902	N=MIN,MAXR					00029000	
7		DENSA(M)=DENSA(M)+DENS(M,N)						00029100	
7		TMED(M)=TMED(M)+MASSE(M,N)*T(M,N)						00029200	

MAIN

START	COL		MQO
		COLS	FLAGS
7		VXMED(M)=VXMED(M)+AMASSE(M,N)*VX(M,N)	00029300
7		VRMED(M)=VRMED(M)+AMASSE(M,N)*VR(M,N)	00029400
7		TOTM(M)=TOTM(M)+AMASSE(M,N)	00029500
2	902	CONTINUE	00029600
7		DENSA(M)=DENSA(M)/(MAXR-MIN+1)/6.D22	00029700
7		PTAN(M)=PTAN(M)/ANDRM	00029800
7		IF (TOTM(M).EQ.0.0) GO TO 903	00029900
7		TMED(M)=TMED(M)/(TOTM(M))	00030000
7		VXMED(M)=VXMED(M)/(TOTM(M))	00030100
7		VRMED(M)=VRMED(M)/(TOTM(M))	00030200
3	903	WRITE(6,80) M,DENSA(M),PTAN(M),TMED(M),VXMED(M),VRMED(M),TOTM(M)	00030300
3	901	CONTINUE	00030400
7		DD=0.D0	00030500
7		VEFFL=0.D0	00030600
7		DO 905 N=MIN, MAXRA	00030700
3	905	DD=DJ+AMASSE(MAXX,N)	00030800
7		IF(DD.EQ.0.001) GO TO 909	00030900
7		DO 906 N=MIN, MAXRA	00031000
3	906	VEFFL=VEFFL+AMASSE(MAXX,N)*VX(MAXX,N)	00031100
7		VEFFL=VEFFL/DD	00031200
3	909	WRITE(6, 701) VEFFL,VMAX	00031300
4	70	FORMAT(1X,'VEFFL=',E13.6,1X,'VMAX=',E13.6)	00031400
7		GO TO 15	00031500
2	1011	FORMAT(1X,'TIME=' ,E10.3,1X)	00031600
4	80	FORMAT(1X,(4,'DENSA=',E10.3,'PTAN=',E10.3,1X,'TMED=',E10.3,	00031700
6	>	'VXMED=',E10.3,'VRMED=',E10.3,'TOTM=',E10.3)	00031800
1	CCC	DEBUG UNIT(6), SUBTRACE, INIT(T)	00031900
1	CCC	AT 40	00032000
1	CCC	DISPLAY R	00032100
1	CCC	AT 41	00032200
1	CCC	DISPLAY R	00032300
7		END	00032400

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PIC

START
COL

MOD
FLAGS

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-----1-----2-----3-----4-----5-----6-----7-----8
7      SURROUTINE P I C (DT,NDIM,AMASSE,ZMASSE,VX,VXN,VR,VRN,P,DENS, 00032500
6      >      QX,OR,T,DIVPHI,XP,RP,TAU,PHASS,R,BK,DX,DR,AM,AVC,L,MAXP, 00032600
6      >      MIN,MINA,MAXX,MAXR,MAXRA,ML,ABSORB,DENSC,HYDFF,VMAX,TEMP, 00032700
6      >      EFFIN,EFFOUT)
1      C
7      IMPLICIT REAL*8 (A-H,O-Z) 00032800
1      C
7      DIMENSION AMASSE(NDIM,1),ZMASSE(NDIM,1),VX(NDIM,1),VR(NDIM,1), 00032900
6      >      P(NDIM,1),DENS(NDIM,1),QX(NDIM,1),OR(NDIM,1),T(NDIM,1), 00033000
6      >      DIVPHI(NDIM,1),XP(1),RP(1),TAU(1),PHASS(1),R(1), 00033100
6      >      VXN(NDIM,1),VRN(NDIM,1),INC(70),ML(1),TEMP(65,35),EFFIN(10,NDIM), 00033200
6      >      EFFOUT(10,NDIM) 00033300
7      COMMON/INT/DENSO,RC ,VPIST 00033400
7      COMMON/DIAGNO/PERIMP,PEREN,AMOM,COST,ELAS ,PERENS,PEREND 00033500
7      COMMON/D/ DENLI 00033600
7      COMMON/INVRM/ COULOG, WAVLEN, CRITEF, ZMAT, REFPWR, TION 00033700
7      LWRITE=0
7      PI=3.1415926500 00033800
7      BKT=3.00/2.00*BK*(ZMAT+TION)/AM 00033900
7      RKT=1.00/BKT 00034000
7      DTX=CT/DX 00034100
7      DTDX=2.00*PI*DT*DX 00034200
7      DTR=CT/DR 00034300
7      DXDR=DX*DR 00034400
7      DRDT=DR*DT*PI*1.07 00034500
7      DXDRCT=DXDR*DT*PI 00034600
7      DTXA=DTX/AM 00034700
7      DTRA=CTR/AM 00034800
7      DO 350 M=MIN,MAXX 00034900
7      AMASSE(M,MINA)=AMASSE(M,MIN) 00035000
2      350 AMASSE(M,MAXR )=AMASSE(M,MAXRA) 00035100
7      DO 10 M=MIN ,MAXX 00035200
7      DO 10 N=MIN ,MAXRA 00035300
7      QX(M,N)=0.00 00035400
7      QR(M,N)=0.00 00035500
7      IF((AMASSE(M,N).EQ.0.00).OR.(AMASSE(M+1,N).EQ.0.00)) GO TO 9 00035600
7      DVX=VX(M+1,N)-VX(M,N) 00035700
7      IF(DVX.LE.0.00) GO TO 9 00035800
7      VISC1=DABS(VX(M+1,N)+VX(M,N)) *.2500 00035900
7      QX(M,N)=+AVC+VISC1*(AMASSE(M,N)+AMASSE(M+1,N))*DVX/ 00036000
6      1 ( TAU(N)+2.00 ) 00036100
2      9 CONTINUE 00036200
7      DVP=VR(M,N)-VR(M,N+1) 00036300
7      IF(DVP.GE.0.00) GO TO 10 00036400
7      IF ((AMASSE(M,N).EQ.0.00).OR.(AMASSE(M,N+1).EQ.0.00)) GO TO 10 00036500
7      VISC1=DABS(VR(M+1,N)+VR(M,N)) *.2500 00036600
7      QR(M,N)=-AVC+VISC1*(AMASSE(M,N)+AMASSE(M,N+1))*DVR/ 00036700
6      1 (TAU(N)+TAU(N+1)) 00036800
3      10 CONTINUE 00036900
7      DO 12 M=MIN,MAXX 00037000
7      P(M,MINA)=P(M,MIN) 00037100
7      P(M,MAXP)=P(M,MAXRA) 00037200
7      DO 12 N=MIN,MAXRA 00037300
7      IF(AMASSE(M,N).EQ.0.00) GO TO 13 00037400
```


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START COL	1	2	3	4	5	6	7	8	MOD
COL	1	2	3	4	5	6	7	8	FLAGS
1	C	DENS0/...	INSERTED FOR AVOIDING "FLDV".					00037900	
7		DEN=DENS(M,N)+DENS0/1.0+6						00038000	
7		IF (AMASSE(M,N+1).EQ.0.00) P(M,N+1) = -P(M,N)						00038100	
7		IF (AMASSE(M-1,N).EQ.0.00) P(M-1,N) = -P(M,N)						00038200	
7		IF (AMASSE(M,N-1).EQ.0.00) P(M,N-1) = -P(M,N)						00038300	
7		IF (AMASSE(M+1,N).EQ.0.00) P(M+1,N) = -P(M,N)						00038400	
7		VXN(M,N)=VX(M,N)+DTYA*(.500*(P(M-1,N)-P(M+1,N))+QX(M-1,N)-QX(M+1,N))						00038500	
6		1 / DEN						00038600	
7		VRN(M,N)=VR(M,N)+OTRA*(.500*(P(M,N-1)-P(M,N+1))+QR(M,N-1)-QR(M,N+1))						00038700	
6		1 / DEN						00038800	
7		IF (DABS(VXN(M,N)+VRN(M,N)).LT.10.00) GO TO 14						00038900	
4	13	CONTINUE						00039000	
1	C	AXIAL BOUNDARY						00039100	
7		VR(M,MINA)=-VR(M,MIN)						00039200	
7		VRN(M,MINA)=-VRN(M,MIN)						00039300	
7		VXN(M,MINA)=VXN(M,MIN)						00039400	
1	C	WALL BOUNDARY						00039500	
7		VRN(M,MAXR)=-VRN(M,MAXR)*(R(MAXR)+DR/2.00)/(R(MAXR)+DR/2.00)						00039600	
7		VR(M,MAXR)=-VR(M,MAXR)*(R(MAXR)+DR/2.00)/(R(MAXR)+DR/2.00)						00039700	
7		VXN(M,MAXR)=VXN(M,MAXR)						00039800	
4	14	INDIM=N						00039900	
4	12	CONTINUE						00040000	
1	C	CALL ABSORB (INDIM,DIVPHI,DENS,MIN,MAXR,MAXX,DT,TAU,DX,ML,						00040100	
1	C	> AMASSE)						00040200	
1	C	WRITE(6,5335) (M,DENS(M,2),M=1,59)						*	
1	C5335	FORMAT(' BEFORE DPOSIT: DENS(' ,I2,' ,2)=' ,D10.4)						*	
7		CALL DPOSIT(INDIM,DIVPHI,DENS,MIN,MAXR,MAXX,DT,TAU,DX,ML,						00040100	
5		> AMASSE,TEMP,DR,EFFIN,EFFOUT)						00040200	
1	C	WRITE(6,5435) (M,DENS(M,2),M=1,59)						*	
1	C5435	FORMAT(' AFTER DPOSIT: DENS(' ,I2,' ,2)=' ,D10.4)						*	
7		DO 23 M=MIN,MAXX						00040300	
1	C	INDEX=MAX0(INDIM,NPHI)						00040400	
1	C	DO 23 N=MIN,INDEX						00040500	
7		DO 23 N=MIN,MAXR						00040600	
7		IF (AMASSE(M,N).EQ.0.00) GO TO 23						00040700	
7		SH=VXN(M-1,N)+VX(M-1,N)						00040800	
7		SMX=VXN(M,N)+VX(M,N)						00040900	
7		SV=VXN(M+1,N)+VX(M+1,N)						00041000	
7		VXH=(SH+SMX)*0.2500						00041100	
7		IF (AMASSE(M-1,N).EQ.0.00) VXH=SMX/2.00						00041200	
7		VXV=(SMX+SV)*0.2500						00041300	
7		IF (AMASSE(M+1,N).EQ.0.00) VXV=SMX/2.00						00041400	
7		S=VRN(M,N)+VR(M,N)						00041500	
7		SU=(VRN(M,N-1)+VR(M,N-1))*(R(N-1)+DR/2.00)						00041600	
7		SM=S*(R(N)+DR/2.00)						00041700	
7		SD=(VRN(M,N+1)+VR(M,N+1))*(R(N+1)+DR/2.00)						00041800	
7		VRU=(SU+SM)*0.2500						00041900	
7		IF (AMASSE(M,N-1).EQ.0.00) VRU=SM/2.00						00042000	
7		VRN=(SM+SD)*0.2500						00042100	
7		IF (AMASSE(M,N+1).EQ.0.00) VRN=SM/2.00						00042200	
7		DEPS=(DTX*TAU(N)*(P(M,N)*(VXH-VXV)+QX(M-1,N)*VXH-QX(M,N)*VXV-SMX*						00042300	
6		1(QX(M-1,N)-QX(M,N))*0.500)+DTDX*(P(M,N)*(VRU-VRN)+QR(M,N-1)*VRU-						00042400	
6		2QR(M,N)*VRN-TAU(N)*S*CTR*(QR(M,N-1)-QR(M,N))						00042500	
6		3 +DTVPHI(M,N)*TAU(N)*DT						1/AMASSE(M,N)	

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START COL	1	2	3	4	5	6	7	8	MOD	FLAGS
1	C	INNER ENERGY PER UNIT MASS	T(M,N)			00042700				
7		T(M,N)=T(M,N)*BKT+DEPS				00042800				
7		IF(T(M,N).LE.0.000) WRITE(6,3425) L,M,N,T(M,N)				00042810	*			
7		IF(T(M,N).LE.0.000) T(M,N)=1.000				00042820	*			
2	3425	FORMAT(' L=',I3,' T=',I2,' ',I2,' ')=',D10.4)				00042830	*			
4	23	CONTINUE				00042900				
1	C	WRITE(6,300) L,MAXP				00043000				
1	C	JWS 300 FORMAT(2I7)				00043100				
3	300	FORMAT(' L=',I7,' MAXP=',I7)				00043200				
7		DO 25 M=MIN,MAXX				00043300				
7		DO 25 N=MIN,MAXRA				00043400				
1	C	QX(M,N)=DENL=T(M,N)+TAUIN*AM				00043500				
7		QX(M,N)=0.00				00043600				
7		VX(M,N)=0.00				00043700				
7		VR(M,N)=0.00				00043800				
4	25	CONTINUE				00043900				
7		TR=0				00044000				
7		DO 27 I=1,MAXP				00044100				
7		DELTA X=0.00				00044200				
7		DELTA R=0.00				00044300				
7		XPP=XP(I)				00044400				
7		M=XPP/DX+MIN				00044500				
7		RPP=RP(I)				00044600				
7		N=RPP/DR+MIN				00044700				
7		DIST=VMAX*DT						*		
7		XXX=HYDOFF*DX						*		
7		RER=HYDOFF*DR						*		
7		IF(DABS(DIST).LT.XXX .AND. DABS(DIST).LT.RRR) GO TO 61						*		
1	C	TEST IF THE PARTICLE MOTION IS LESS THAN HYDOFF*CELL SPACING,						*		
1	C	IN WHICH CASE THE HYDRO PORTION OF THE CODE IS BYPASSED BECAUSE						*		
1	C	THE MOTION IS TOO SLOW ON THE TIME SCALE CURRENTLY IN USE.						*		
7		IF(DABS(VXN(M,N))+ABS(VRN(M,N)).LT.1.00) GO TO 61				00044600				
1	C	DETERMINATION OF THE QUADRANT. X ABSCISSA, R ORDINATE.				00044900				
7		IF(L.EO.LWRITE) GO TO 33						*		
7		WRITE(6,31) L						*		
4	31	FORMAT(' THE HYDRO IS ON AT L=',I4)						*		
7		LWRITE=L						*		
4	33	XQUADR=(M-MIN+C.500)*DX				00045000				
7		RQUADR=(N-MIN+C.500)*DR				00045100				
7		DIFFX1=XPP-XQUADR				00045200				
7		DIFFX2=DIFFX1+CX				00045300				
7		DIFFX3=XQUADR+CX-XPP				00045400				
7		DIFFR1=RPP-RQUADR				00045500				
7		DIFFR2=DIFFR1+CR				00045600				
7		DIFFR3=RQUADR+CR-RPP				00045700				
1	C	1. QUADRANT				00045800				
7		IF(XPP.GE.XQUADR.AND.RPP.GE.RQUADR) GO TO 51				00045900				
1	C	2. QUADRANT				00046000				
7		IF(XPP.GE.XQUADR.AND.RPP.LT.RQUADR) GO TO 52				00046100				
1	C	3. QUADRANT				00046200				
7		IF(XPP.LT.XQUADR.AND.RPP.LT.RQUADR) GO TO 53				00046300				
1	C	4. QUADRANT				00046400				
7		IF(XPP.LT.XQUADR.AND.RPP.GE.RQUADR) GO TO 54				00046500				
4	55	VXEFF=(A1*VXN(M+1,N+1)+A2*VXN(M+1,N)+A3*VXN(M,N)+A4*VXN(M,N+1))				00046600				

PIC

[illegible]

PIC

MOD
FLAGS

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44=DIFFX3*DIFFR2
7 IF (AMASSE(M+1,N).EQ.0.00) A1=0.00 00052200
7 IF (AMASSE(M+1,N-1).EQ.0.00) A2=0.00 00052300
7 IF (AMASSE(M,N-1).EQ.0.00) A3=0.00 00052400
7 AT=A1+A2+A3+A4 00052500
7 GO TO 56 00052600
4 53 CONTINUE 00052700
7 A1=DIFFX2*DIFFR2 00052800
7 A2=-DIFFX2*DIFFR1 00052900
7 A3=DIFFX1*DIFFR1 00053000
7 A4=-DIFFX1*DIFFR2 00053100
7 IF (AMASSE(M,N-1).EQ.0.00) A2=0.00 00053200
7 IF (AMASSE(M-1,N-1).EQ.0.00) A3=0.00 00053300
7 IF (AMASSE(M-1,N).EQ.0.00) A4=0.00 00053400
7 AT=A1+A2+A3+A4 00053500
7 GO TO 57 00053600
4 54 CONTINUE 00053700
7 A1=DIFFX2*DIFFR1 00053800
7 A2=DIFFX2*DIFFR3 00053900
7 A3=-DIFFX1*DIFFR3 00054000
7 A4=-DIFFX1*DIFFR1 00054100
7 IF (AMASSE(M,N+1).EQ.0.00) A1=0.00 00054200
7 IF (AMASSE(M-1,N).EQ.0.00) A3=0.00 00054300
7 IF (AMASSE(M-1,N+1).EQ.0.00) A4=0.00 00054400
7 AT=A1+A2+A3+A4 00054500
7 GO TO 58 00054600
3 327 PERIMP=PERIMP+PMASS(I)*VXN(M,N) 00054700
7 IF (MP.LT.MIN) PERENS=PERENS+0.500*PMASS(I)*(VXN(M,N)**2+ 00054800
6 X VRN(M,N)**2) +PMASS(I)*T(M,N) 00054900
7 IF (MP.GT.MAXX) PEREND=PEREND+0.500*PMASS(I)*(VXN(M,N)**2+ 00055000
6 X VRN(M,N)**2) +PMASS(I)*T(M,N) 00055100
1 C URA T(M,N) E L'ENERGIA INTERNA PER UNITA DI MASSA 00055200
7 PEREN=PEREN+0.500*PMASS(I)*(VXN(M,N)**2+VRN(M,N)**2)+PMASS(I) 00055300
6 > *T(M,N) 00055400
4 27 CONTINUE 00055500
7 MAXP=IR 00055600
7 DO 62 M=MIN,MAXX 00055700
7 DO 62 N=MIN,MAXRA 00055800
7 AMASSE(M,N)=ZMASSE(M,N) 00055900
7 DENSI(M,N)=AMASSE(M,N)/(TAU(N)*AM) 00056000
7 T(M,N)=1.00 00056100
7 IF (AMASSE(M,N).EQ.0.00) GO TO 68 00056200
7 VX(M,N)=VX(M,N)/AMASSE(M,N) 00056300
7 VR(M,N)=VR(M,N)/AMASSE(M,N) 00056400
7 T(M,N)=(OX(M,N)/AMASSE(M,N)-(VX(M,N)**2+VR(M,N)**2)/2.00)*BKT 00056500
7 IF (T(M,N).LE.0.000) T(M,N)=1.000 00056600
7 68 P(M,N)=(ZMAT+T(ION)*PK*PENS(M,N)*T(M,N) 00056700
7 ZMASSE(M,N)=0.00 00056800
7 VXN(M,N)=0.00 00056900
7 VRN(M,N)=0.00 00057000
7 TEMPI(M,N)=T(M,N) 00057100
4 62 CONTINUE 00057200
1 C RC=DEMAX/DENSO
7 RETURN

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START
COL

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MOD
FLAGS

1	CC	DEBUG UNIT(6), SUBTRACE, INIT(T)	00058600
1	CC	> SUBCHK(PMASS,R,VXN)	00058100
1	CC	> SUBCHK(MASSE,ZMASSE,VX,VR,	00058200
1	CC	> P,DENS,QX,QR,T,	00058300
1	CC	> VXN,VRN,IND,ML)	00058400
7		END	00058500

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ATRIG

START
COL

-----1-----2-----3-----4-----5-----6-----7-----8

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1 C SUBROUTINE ATRIG SOLVES TRIDIAGONAL SYSTEM OF EQUATIONS. 00091600
1 C 00091700
1 C AUTHOR 00091900
1 C J. STEUERWALD 00091900
1 C 00092000
1 C PARAMETER DESCRIPTION 00092100
1 C A -VEKTOR DER INTEREN NEBENDIAGONALE. DIMENSION N. 00092200
1 C DIESE WERTE SIND BEI RUECKKEHR INS AUFRUFENDE PRO- 00092300
1 C GRAMM NOCH ERHALTEN. 00092400
1 C MJD (UNDER NEAR-DIAGONAL VECTOR. DIMENSION N. THIS 00092500
1 C MJD DATA IS RETURNED TO CALLING PROGRAM, THEN KEPT.) 00092600
1 C B -VEKTOR DER HAUPTDIAGONALE. DIMENSION N. DIESE WERTE 00092700
1 C SIND NACH RUECKKEHR INS AUFRUFENDE PROGRAMM NOCH 00092800
1 C ERHALTEN. 00092900
1 C MJD (MAIN DIAGONAL VECTOR. DIMENSION N. THIS DATA IS 00093000
1 C MJD RETURNED TO CALLING PROGRAM, AND IS THEN KEPT.) 00093100
1 C C -VEKTOR DER AEREN NEBENDIAGONALE. DIMENSION N. NACH 00093200
1 C RUECKKEHR INS AUFRUFENDE PROGRAMM SIND DIESE WERTE 00093300
1 C ZERSTOERT. 00093400
1 C MJD (ABOVE NEAR-DIAGONAL VECTOR. DIMENSION N. THIS 00093500
1 C MJD DATA IS DESTROYED AFTER RETURNING IT TO THE CALLING 00093600
1 C MJD PROGRAM.) 00093700
1 C D -VEKTOR DER RECHTEN SEITE. DIMENSION N. NACH RUECK- 00093800
1 C KEHR INS AUFRUFENDE PROGRAMM SIND HIER DIE ERGEBNISSE 00093900
1 C GESPEICHERT. 00094000
1 C MJD (THE RIGHT HAND SIDE VECTOR. DIMENSION N. AFTER 00094100
1 C MJD RETURNING TO THE MAIN PROGRAM, THE RESULTS ARE 00094200
1 C MJD RECORDED HERE.) 00094300
1 C N -ZAHL DER GLEICHUNGEN. 00094400
1 C MJD (NUMBER THE EQUATIONS) 00094500
1 C 00094600
1 C REMARKS 00094700
1 C IST DIE LINKE SEITE IN FORM EINER MATRIX GEGEBEN, SO MUSS 00094800
1 C DER BENUTZER FUER DIE UMSPEICHERUNG IN DREI VEKTOREN SORGEN. 00094900
1 C EINE PRUEFUNG AUF SINGULARITAET ODER ZERFALL DES GLEICHUNGS- 00095000
1 C SYSTEMS WIRD NICHT DURCHGEFUEHRT. 00095100
1 C MJD (IF THE LEFT HAND SIDE IS GIVEN IN A MATRIX 00095200
1 C MJD FORM, THE USER MUST BE CONCERNED FOR THE 00095300
1 C MJD EXCHANGE IN THREE VECTORS. EXAMINE THE 00095400
1 C MJD SINGULARITY, OR THE SYSTEM FOR BREAKING 00095500
1 C MJD DOWN THE EQUATIONS WILL NOT EXECUTE.) 00095600
1 C 00095700
1 C BENDETIGTE SUBROUTINEN: KEINE 00095800
1 C MJD (REQUIRED SUBROUTINES: NONE) 00095900
1 C 00096000
1 C VERFAHREN: VERKUERZTE ELIMINATION NACH GAUSS. 00096100
1 C MJD (PROCEDURE: ABBREVIATED GAUSS ELIMINATION.) 00096200
1 C 00096300
7 SUBROUTINE ATRIG (A,B,C,D,N) 00096400
1 C 00096500
7 IMPLICIT REAL*8 (A-H,O-Z) 00096600
1 C 00096700
7 DIMENSION A(1),B(1),C(1),D(1) 00096800
7 DATA E//1.000/ 00096900
```

PROJECT: MJO
LIBRARY: PIC
TYPE: TEMP

MEMBER: ATRIG

DATE: 81/12/09
TIME: 10:30
PAGE: 2

ATRIG

START
COL

-----1-----2-----3-----4-----5-----6-----7-----8

7	N1=N-1	00097000
7	E=E1/B11	00097100
7	C(1)=C(1)*E	00097200
7	D(1)=D(1)*E	00097300
7	DO 10 I=2,N	00097400
7	IM=I-1	00097500
7	AI=A(I)	00097600
7	E=E1/(B(I)-AI*C(IM))	00097700
7	C(I)=C(I)*E	00097800
4	10 D(I)=(D(I)-AI*D(IM))*E	00097900
7	DO 20 J=1,N1	00098000
7	I=N-J	00098100
1	C WRITE(6,1928)I,D(I),C(I),D(I+1)	00098200
1	C1928 FORMAT(' ATRIG D(',I3,')=',D10.3,'C(I)=',D10.3,'D(I+1)=',D10.3)	00098300
7	D(I)=D(I)-C(I)*D(I+1)	00098400
4	20 CONTINUE	00098420
7	RETURN	00098500
1	CCC DEBUG UNIT(6), SUBSPACE, INIT(A,B,C,D)	00098500
1	CCC AT 6363	00098700
1	CCC TRACE ON	00098800
7	END	00098900

DENGIN

MOD
FLAGS

1	C	SUBROUTINE DENSIN(X,R,MIN,MAXR,MINI,MINTA,MAXTA,DENS,	00000210
7		< DX,DR,MAXX,MAXR,MINTB,MAXT,DENSO,IEND,MAXRB)	00000220
1	C	THIS PROGRAM INSERTS AN INITIAL DENSITY PROFILE INTO THE PIC	00000010
1	C	CODE. IT CURRENTLY MODELS THE GAS JET.	00000100
1	C		00000200
7		IMPLICIT REAL*8 (A-H,O-Z)	00000230
7		DIMENSION X(65),R(65),DENS(65,35),RMAX(65),IEND(65)	00000300
7		COMMON/GASJT/DIAM,PHIEXP,PHIMAX	00000400
7		COMMON /D/ DENLT	00000500
7		PI=3.1415926570	00000600
7		X1=2.000/1.700*DIAM	00000700
1	C		
1	C	THIS OPTION SETS THE LIMIT ON THE EXPONENTIAL REGION OF THE	00000800
1	C	INPUT DENSITY PROFILE. IT "DRAWS" A LINE FROM X1 USING THE	00000900
1	C	INVERSE SQUARE FIT, AND "WITHIN" THIS AREA DENSITIES ARE "MIXED"	00001000
1	C	AS HALF INVERSE SQUARE AND HALF EXPONENTIAL DENSITY FITS.	00001100
1	C		
7		DO 25 I=1,MAXRB	
4		25 IEND(I)=MIN	
7		MLIM=X1/DX+MIN	00001200
7		DENLIM=DENSO*DEXP(-2.000)*42.000/1.700*D(IAM/X(MLIM))**2	00001300
7		DO 50 I=1,MLIM	00001400
4		50 RMAX(I)=0.000	00001500
7		DO 100 M=MINT,MLIM	00001600
7		COSARG=(DENLIM/(DENS0*DEXP(-2.000)))*(X(M)/X1)**21**(1/3)	00001700
7		TANARG=12.000*PHIMAX/PI*(DARCOS(COSARG))	00001900
7		RMAX(M)=X(M)*LTAN(TANARG)	00002000
3		100 CONTINUE	00002100
1	C	THIS NEXT PORTION GIVES ALL CELLS A DENSITY ACCORDING TO THE INVERSE	00002200
1	C	SQUARE RELATIONSHIP.	00002300
7		DO 500 M=MINT,MAXTA	00002400
7		DO 500 N=MIN,MAXR	00002500
7		PHI=DATAN(R(N)/X(M))	00002600
7		ARG=PI/2.000*PHI/PHIEXP	00002700
7		DENS(M,N)=DENS0*DEXP(-2.000)*(X1/X(M))**2*(DCOS(ARG))**3	00002800
7		IF(DENS(M,N).LT.0.000) DENS(M,N)=DENLT	
3		500 CONTINUE	00002900
1	C	NOW THE MIXING OF THE DENSITY IN THOSE CELLS DETERMINED TO FALL	00003000
1	C	WITHIN THE PREDETERMINED EXPONENTIAL REGION TAKES PLACE. THE	00003100
1	C	DENSITY IS CALCULATED FROM THE EXPONENTIAL FORMULA, AND THE CELL	00003200
1	C	DENSITY IS AVERAGED TO BE 50% OF EACH THE EXPONENTIAL AND THE	00003300
1	C	INVERSE SQUARE DENSITY FOR THAT CELL.	00003400
7		DO 700 M=MINT,MLIM	00003500
7		NLIM=RMAX(M)/DR+MIN	00003600
7		DO 700 N=MIN,NLIM	00003700
7		XX=X(M)/1.100	00003800
7		RR=R(N)*2.570	00003900
1	C	THE CONSTANTS USED TO CALCULATE XX AND RR WERE	00004000
1	C	DETERMINED BY FITTING HOLOGRAPHIC INTERFEROGRAMS.	00004100
7		PHI=DATAN(RR/XX)	00004200
7		ARG=PI/2.000*PHI/PHIEXP	00004300
7		EXPDEN=DENS0*DEXP(-XX*1.700*DIAM)/(DCOS(ARG))**3	00004400

PROJECT: MJD
LIBRARY: PIC
TYPE: TEMP

MEMBER: DENSIN
LEVEL: 01.20
USERID: MJD

DATE: 81/12/08
TIME: 10:30
PAGE: 02 OF 02

DENSIN

START
COL

-----1-----2-----3-----4-----5-----6-----7-----8

MOD
FLAGS

```
7      DENS(M,N)=(DENS(M,N)+EXP(DEN)/2.000      00004500
3      700 CONTINUE      00004600
1      C THIS NEXT PORTION CHECKS THE DENSITY GRADIENT TO ENSURE THAT IT
1      C IS NOT TOO STEEP (ESPECIALLY AT THE BOUNDARIES) AS TO CAUSE BAD
1      C CALCULATIONS. IF THE DENSITY OF THE CELL TO THE LEFT OF THE
1      C CELL BEING EXAMINED IS LESS BY A FACTOR OF 10 (OR MORE), THE
1      C CELL ON THE LEFT IS GIVEN A DENSITY EQUAL TO THAT OF THE CELL
1      C TO ITS RIGHT, DECREASED BY A FACTOR OF 10.
7      MQ=MAX(T-MIN
7      DO 935 N=MIN,MAXRA
7      DO 935 M=MIN,MO
7      K=MO-M+MIN
7      DRATIO=DENS(K+1,N)/DENS(K,N)
7      IF(DRATIO.LE.10.000) GO TO 935
7      DENS(K,N)=DENS(K+1,N)/10.000+DENL1
7      IF(K.GT.IEND(N)) IEND(N)=K
3      935 CONTINUE
7      RETURN
7      END      00004700
              00004800
```

PROJECT: MJD
LIBRARY: PIC
TYPE: TEMP

MEMBER: DPOSIT
LEVEL: 01.45
USERID: MJD

DATE: 81/12/08
TIME: 10:30
PAGE: 01 OF 02

DPG511

START COL	1	2	3	4	5	6	7	8	MOD
COL	1	2	3	4	5	6	7	8	FLAGS
7	SUBROUTINE	DPOSIT	(NDIM,DIVPHI,DENS,MIN,MAXRA,MAXX,CT,TAU,DX,ML,	00010002	*				
6	>	AMASSE,T,DR,EFFIN,EFFOUT)	00020003	*					
1	C		00030000						
7	IMPLICIT	REAL*8 (A-H,O-Z)	00040000						
1	C		00050000						
7	DIMENSION	DIVPHI(NDIM,1),DENS(NDIM,1),TAU(1),ML(1),	00060000						
6	>	AMASSE(NDIM,1),F(65),T(NDIM,1),EFFIN(65,10),	00070000						
6	>	EFFOUT(65,10)		*					
7	COMMON	/LA/PHIO,DENSC,NPHI	00080000						
7	COMMON/ERR/	TIME, TOFF, L, LEND	00090002	*					
7	COMMON/INVAR/	COULOG, WAVLEN, CRITEF, ZMAT, REFPWR	00100003	*					
7	PI=3.1415926535			*					
7	MO=MAXX-MIN+1		00110000						
7	DO 16 N=MIN,NPHI		00120000						
7	DO 15 I=1,MO		00130000						
7	IF (DENS(MAXX+1-I,N1,GE,DENSC) GO TO 16		00140000						
4	15 CONTINUE		00150000						
4	16 ML(N)=MAXX+1-I		00160000						
7	DO 17 N=MIN,MAXRA		00170000						
7	DO 17 M=MIN,MAXX		00180000						
4	17 DIVPHI(M,N)=0.00		00190000						
1	C	TEST TO SEE IF WE ARE AT THE TIME AT WHICH THE LASER IS TO BE	00200002	*					
1	C	TURNUED OFF (IF TIME > TOFF, TURN OFF THE LASER).	00210002	*					
7	IF (TIME,GT,TOFF) GO TO 199		00220002	*					
1	C	WE NOW DETERMINE THE ENERGY DEPOSITED BY THE LASER DUE TO INVERSE	00230002	*					
1	C	BREMSSTRAHLUNG. THE LASER IS ASSUMED TO BE INFINITELY FAST, HENCE	00240002	*					
1	C	IT HAS PENETRATED TO AND REFLECTED FROM THE CRITICAL SURFACE WITHIN	00250002	*					
1	C	EACH TIME-STEP. WHILE DOING THIS, IT DEPOSITS ENERGY VIA INVERSE	00260002	*					
1	C	BREMSSTRAHLUNG IN THE CELLS BEFORE THE CRITICAL SURFACE AS WELL AS	00270002	*					
1	C	DEPOSITING ENERGY AT THE CRITICAL SURFACE.	00280002	*					
7	DO 100 I=MIN,NPHI		00290002	*					
7	PHI=PHIO			*					
7	MDM1=MO-1		00300002	*					
7	MLI=ML(1)			*					
7	DO 40 J=ML1,MDM1		00320002	*					
7	K=MO-J+ML(1)		00330002	*					
7	AVDENS=(DENS(K,1)+DENS(K+1,1))/2.000		00340002	*					
7	AVTEMP=(T(K,1)+T(K+1,1))/2.000		00350002	*					
1	C	WRITE(6,5541)K,1,AVDENS,AVTEMP		*					
1	C5541	FORMAT(' AVDENS(',12,' ',12,' ')=' ,D10.4,' AVTEMP=' ,D10.4)		*					
1	C	THE TEMPERATURE MUST BE INPUT IN THE ABSORPTION EFFICIENCY	00360002	*					
1	C	EXPRESSION IN UNITS OF KEV.	00370002	*					
7	AVTEMP=AVTEMP/1.1607		00380002	*					
7	EXPARG=-(3.360*COULOG*ZMAT/(WAVLEN**2*(AVDENS/DENSC)**2*DX/		00390002	*					
6	>	DSORT(AVTEMP**3*(1.000-AVDENS/DENSC)))	00400002	*					
1	C	CALCULATE THE NONLINEAR FACTOR (FNLN) TO 18 ABSORPTION:		*					
7	VOVERV=(WAVLEN**2*(PHI/1.0622)/(3.000*AVTEMP)			*					
7	FNLN=DSORT(1.000/(1.000+VOVERV**3))			*					
7	ABSEFF=1.000-DEXP(EXPARG+FNLN)		00550002	*					
7	DIVPHI(K,1)=PHI*ABSEFF/DX		00420002	*					
7	PHI=PHI*(1.000-ABSEFF)		00430002	*					
7	EFFIN(K,1)=ABSEFF			*					
7	IF (PHI.EQ.0.000) GO TO 100			*					
4	40 CONTINUE		00440002	*					

PROJECT: MJD
LIBRARY: PIC
TYPE: TEMP

MEMBER: OPOSIT
LEVEL: 01.45
USERID: MJD

DATE: 81/12/08
TIME: 10:30
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OPOSIT

START COL	1	2	3	4	5	6	7	8	MOD
COL	1	2	3	4	5	6	7	8	FLAGS
1	C	AT THE CRITICAL SURFACE (WHICH IS WHERE WE ARE NOW) DEPOSIT AN				00450002	*		
1	C	AMOUNT OF ENERGY ACCORDING TO THE INPUT EFFICIENCY: CRITEF.				00460002	*		
7		DIVPHI(ML(I),I)=PHI*CRITEF/DX				00470002	*		
7		MLP1=ML(I+1				00480002	*		
7		DO DO J=MLP1,MOM1				00490002	*		
7		AVDENS=(DENS(J,I)+DENS(J+1,I))/2.000				00500002	*		
7		AVTEMP=(T(J,I)+T(J+1,I))/2.000				00510002	*		
7		AVTEMP=AVTEMP/1.1607				00520002	*		
7		EXPARG=-(2.300*COULOG*ZMAT/(WAVLEN)**2*(AVDENS/DENSC)**2*DX/				00530002	*		
6	>	DSORT(AVTEMP**3*(1.000-AVDENS/DENSC))				00540002	*		
7		VOVERV=(WAVLEN**2)*(PHI/1.0022)/(3.000*AVTEMP)					*		
7		FNLIN=DSORT(1.000/(1.000+VOVERV**3))					*		
7		ABSEFF=1.000-DEXP(EXPARG*FNLIN)				00550002	*		
7		EFFOUT(J,I)=ABSEFF					*		
7		DIVPHI(J,I)=DIVPHI(J,I)+PHI*ABSEFF/DX				00560002	*		
2	C	WRITE(6,5544)J,I,ABSEFF,PHI					*		
1	C5544	FORMAT(' ABSEFF(',I2,',',I2,',')=',D10.4,' PHI=',D10.4)					*		
7		PHI=PHI*(1.000-ABSEFF)				00570002	*		
7		IF(PHI.EQ.0.000) GO TO 100					*		
4	80	CONTINUE				00580002	*		
7		R1=(I-0.500-MIN)*DR					*		
7		IF(R1.LT.0.000)R1=0.000					*		
7		R2=(I+0.500-MIN)*DR					*		
7		AREA2=PI*(R2)**2					*		
7		AREA1=PI*(R1)**2					*		
7		AREA=AREA2-AREA1					*		
7		REFPWR=REFPWR+AREA*PHI*DT					*		
1	C	WRITE(6,3522)I,AREA1,AREA2,AREA,PHI,REFPWR					*		
1	C3522	FORMAT(' I=',I3,' AREA1=',D10.3,' AREA2=',D10.3,' AREA=',D10.3,/,					*		
1	C	<' PHI=',D10.3,' REFPWR=',D10.3)					*		
3	100	CONTINUE					*		
3	199	RETURN				00590000			
1	CCC	DEBUG UNIT(6), SUBTRACE				00600000			
1	CCC	AT 9090				00610000			
1	CCC	TRACE ON				00620000			
7		END				00630000			

$$\tau = ATC$$

START CPL	-----1-----2-----3-----4-----5-----6-----7-----8	MOD FLAGS
7	SUBROUTINE HEATC (U,NT,NTD,MT,DT,R,DZ,TH,DENS,ETB,AR,BR,CR,	00067400
6	> AZ1,BZ1,CZ1,AZ2,BZ2,CZ2,A,B,C,D,DU1,DU2,DU4,C1TR,	00067500
6	> C1T,G,MAXPB,CFRATD,BETA1,FLXLM)	00067600
1 C		00067700
7	IMPLICIT REAL*8 (A-H,O-Z)	00067800
1 C		00067900
1 C	THE FIRST INDEX REFERS TO X,THE SECOND ONE TO R.	00068000
1 C	SOLVES INHOMOGENEOUS HEAT CONDUCTION EQ. OF FORM:	00068100
1 C	DU/DT = AQ*(1/R*D /DR*BETA*R*D/DR U**7/2 +D/DZ*BETA*D/DZ U**7/2)	00068200
1 C	WITH HEAT FLUX LIMITATION USING YANENKO'S TIME SPLITTING METHOD	00068300
1 C	AND IMPLICIT DERIVATIVE FORMULATION	00068400
1 C	BOUNDARY CONDITIONS USED	00068500
1 C	IN R=0 D/DR U =0.	00068600
1 C	IN R=R(NT-0.5) AR*D/DR (DU/DT)+BR*(DU/DT)=CR/DT	00068700
1 C	IN Z=Z(0.5) AZ1*D/DZ (DU/DT +BZ1*(DU/DT)=CZ1/DT	00068800
1 C	IN Z=Z(MT-0.5) AZ2*D/DZ (DU/DT) +BZ2*(DU/DT)=CZ2/DT	00068900
1 C	DIMENSIONS (FIXED IN MAIN PROGRAM)	00069000
1 C	U(NTD,GE.MT),DEPS(NTD,GE.MT),R(GE.NT),	00069100
1 C	AR,BR,CR, GE.MT	00069200
1 C	AZ1,BZ1,CZ1,AZ2,BZ2,CZ2, GE.NT	00069300
1 C	A,B,C,D,DU1,DU2, GE.(LARGER ONE OF NT,MT)	00069400
1 C		00069500
1 C	COMMON/ERR/ L,TIME ,LEND	00069600
7	COMMON/ERR/ TIME,TOFF, L, LEND	00069700
7	COMMON/INVRM/ COULOG, WAVLEN, CRITEF, ZMAT, REFPWR, TION	*
7	DIMENSION U(NTD,1),ABL(100),DENS(NTD,1),R(1),AR(1),BR(1),	00069800
6	> CR(1),AZ1(1),BZ1(1),CZ1(1),	00069900
6	> AZ2(1),BZ2(1),CZ2(1),C1TR(1),C1T(1),G(1),	00070000
6	> A(1),B(1),C(1),D(1),DU1(1),DU2(1),DU4(1),	00070100
6	> CFRAT(100),CFRAT(100,100),BETA(65,35)	00070110
7	DATA AK1/1.0D-05/,AK/1.38D-16/	00070200
1 C		*
1 C	AKO WAS SCALED FROM MULSER'S VALUE BY USE OF THE FOLLOWING REFERENCE:	*
1 C	TRHYD1 PHYSICS (U): K4SF-U18	*
1 C		*
7	AKO=AK1*ZMAT/(ZMAT+TION)**2	*
7	AQ1=(2.DO/7.DO)*(AKO/(3.DO*AK1)	00070300
1 C	THE DENSITY THAT MUST BE USED TO CALCULATE THE HEAT CONDUCTION MUST	*
1 C	BE THE ELECTRON DENSITY: HENCE WE MUST CONVERT THE DENSITY WHICH IS	*
1 C	PASSED TO THIS ROUTINE AND TO THE ROUTINES CALLED FROM HERE INTO THE	*
1 C	ELECTRON DENSITY=ZMAT*ION DENSITY.	*
7	MTM1=MT-1	00070700
7	NTM1=NT-1	00070800
1 C	RIGHT BOUND. COND.	00070900
7	DR=R(3)-R(2)	00071000
7	DO 10 I=1,NT	00071500
13	U(I,MT)=(C1TR(I)-U(I,MT-1)*(1-AR(I)/DR+BR(I)/2.DO))/(AR(I)	00071700
6	> /DR+BR(I)/2.DO)	00071800
7	IF (U(I,MT).LT.0.00) U(I,MT)=0.00	00071900
2 10	CONTINUE	00072000
1 C		00072100
7	DO 220 I=2,MTM1	00072200
7	DO 332 J=1,MT	00072300
15	DU4(J)=DENS(I,J)	00072400

PROJECT: MJD
LIBRARY: PIC
TYPE: TEMP

MEMBER: HEATC
LEVEL: 01.24
USERID: MJD

DATE: 81/12/08
TIME: 10:30
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HEATC

START COL	1	2	3	4	5	6	7	8	MOD
15	IF(U(I,J).LT.0.00) GO TO 70							00072500	
15	DU2(J)=U(I,J)							00072600	
15	ABL(J)=(U(I+1,J)-U(I,J))/CZ							00072700	
2	332	CONTINUE						00072800	
7	>	C A L L R I C Y L 1	(DU2,ABL,DUI,MT,AQ1,DU4,DT,TH,ETB,AR11,					00072900	
6	>		BR11,CR11,A,B,C,D,R,DZ,AKO,AK,FLXLIM,					00073000	
6	>		CFRAT1						*
7		DO 335 J=1,MT						00073100	
7		U(I,J)=DU2(J)						00073200	
7		CFRAT(I,J)=CFRAT(J)						00073210	*
7		BETAI(I,J)=CFRAT(J)+1.000							*
2	335	CONTINUE						00073220	*
3	220	CONTINUE						00073300	
1	C	RIGHT AND LEFT BOUND.COND						00073400	
7		DO 20 J=1,MT						00073500	
13		U(NT,J)=(C1(I,J)-U(NT-1,J))*(-A72(J)/DZ+B72(J)/2.00)/(AZ2(J)						00073600	
6	>		/DZ+B72(J)/2.00)					00073700	
13		IF (U(NT,J).LT.0.00) U(NT,J)=0.000						00073800	
12		U(I,J) = (G(J)-U(2,J)+(AZ1(J)/DZ+B71(J)/2.00)/(1-AZ1(J)/DZ+						00073900	
6	>		B71(J)/2.00)					00074000	
13		IF (U(I,J).LT.0.00) U(I,J)=0.00						00074100	
2	20	CONTINUE						00074200	
1	C							00074300	
7		DO 330 J=2,MT-1						00074400	
7		DO 331 I=1,NT-1						00074500	
7		ABL(I)=(U(I,J+1)-U(I,J))/DR						00074600	
2	331	CONTINUE						00074700	
7		C A L L R I C A R	(U(I,J),ABL,DUI,NT,AQ1,DENS(I,J),DT,TH,ETB,					00074800	
6	>		BZ1(J),BZ1(J),CZ1(J),AZ2(J),BZ2(J),CZ2(J),A,B,C,D,DZ,					00074900	
6	>		CR,AKO,AK,FLXLIM,CFRAT1					00074910	*
7		DO 334 I=1,NT						00074920	*
7		CFRAT(I,J)=CFRAT(I)						00074930	*
7		BETAI(I,J)=CFRAT(I)+1.000							*
3	334	CONTINUE						00074940	*
3	330	CONTINUE						00075000	
1	C	WRITE(6,7889)I,CFRAT(28,3),BETAI(28,3)							*
1	C7889	FORMAT(' L=',I2,' CFRAT(28,3)=',D10.4,' BETAI(28,3)=',D10.4)							*
7		RETURN						00075100	
4	70	WRITE(6,1000) L,TIME,I,J						00075200	
2	1000	FORMAT(1X,'U(I,J)<0',1X,'L=',I3,'TIME=',E13.6,'I=',I3,'J=',I3)						00075300	
7		L=LEND						00075400	
7		RETURN						00075500	
1	CCC	DERUG UNIT(6), SUBSPACE, INITIU), SUBCHKIAR,BR,C1TR)						00075600	
1	CCC	AT 4678						00075700	
1	CCC	TRACE ON						00075800	
7		END						00075900	

PROJECT: MJD
LIBRARY: PIC
TYPE: TEMP

MEMBER: INHEAT

DATE: 81/12/08
TIME: 10:30
PAGE: 1

INHEAT

```
START
COL  -----1-----2-----3-----4-----5-----6-----7-----8
7      SUBROUTINE INHEAT (AR,RR,CR,CITR,CITRD,AZ1,BZ1,CZ1,G,AZ2,BZ2, 00063000
6      >CZ2,CIT,CITD,ETB,TH,NT,MT,MINA,MAXX,MAXRA) 00063100
1 C 00063200
7      IMPLICIT REAL*8 (A-H,O-Z) 00063300
1 C 00063400
1 C START OF HEAT CONDUCTION SUBROUTINE 00063500
7      DIMENSION AR(1),BR(1),CR(1),CITR(1),CITRD(1),AZ1(1),BZ1(1),CZ1(1), 00063600
6      > G(1),AZ2(1),BZ2(1),CZ2(1),CIT(1),CITD(1) 00063700
1 C MJD.ETB=0.5512D05 00063710
1 C THE ABOVE VALUE FOR ETB SEEMS TO ASSUME A FLUX LIMITER OF F=0.3. 00063720
1 C THE F=0.3 VALUE BELOW IS MADE ASSUMING A FLUX LIMITER OF F=1.0. 00063730
7      ETB=0.1597D05 00063800
7      TH=0.5D0 00063900
7      MT=MAXRA+1-MINA+1 00064000
7      NT=MAXX+1-MINA+1 00064100
1 C R-DIRECTION 00064200
1 C CITF=AR(1)*TDER(R(MT-1/2)) + BR*TMED(R(MT-1/2)) AT TIME T 00064300
1 C IF REQUIRED TDER(R(MT-1/2))=0 WITH AR(1)=1, BR(1)=0 00064400
1 C IT MUST BE CITR=0 00064500
7      DO 10 I=1,NT 00064600
12      AR(I)=1.0D0 00064700
12      BR(I)=0.0D0 00064800
12      CITR(I)=0.0D0 00064900
12      CITRD(I)=0.0D0 00065000
4      10 CR(I)=CITR(I)-CITRD(I) 00065100
1 C X-DIRECTION 00065200
1 C G(J)=AZ1(J)*TDER(X(1+1/2)) + BZ1(J)*TMED(X(1+1/2)) AT TIME T 00065300
1 C IF REQUIRED TDER(X(1+1/2))=0 WITH AZ1(J)=1, 00065400
1 C BZ1(J)=0 PUT G(J)=0 00065500
7      DO 20 J=1,MT 00065600
12      AZ1(J)=1.0D0 00065700
12      BZ1(J)=0.0D0 00065800
12      CZ1(J)=0.0D0 00065900
12      G(J)=0.0D0 00066000
16      AZ2(J)=1.0D0 00066100
16      BZ2(J)=0.0D0 00066200
16      CIT(J)=0.0D0 00066300
16      CITD(J)=0.0D0 00066400
4      20 CZ2(J)=CIT(J)-CITD(J) 00066500
1 C CITR(1)=AZ2(1)*TDER(X(NT-1/2)) + BZ2(1)*TMED(X(NT-1/2)) 00066600
1 C IF REQUIRED TDER(X(NT-1/2))=0, WITH AZ2(1)=1 00066700
1 C BZ2(1)=0, PUT CIT(1)=0 00066800
7      RETURN 00066900
1 CCC DEBUG UNIT(6), SUBTRACE 00067000
1 CCC AT 4554 00067100
1 CCC TRACE ON 00067200
7      END 00067300
```

PLOTNT

MOB
FLAGS

```

1 C SUBROUTINE PLOTNT(XP,RP,MAXP,MAXTA,MAXRA,MIN,MAXI,DENS,MCELL, 00099200
6 > MINT,DX,DR,T,CFRATO,TIME,DENSC,DENSO) 00099300
1 C 00099400
7 IMPLICIT REAL*8 (A-H,O-Z) 00099500
7 REAL*4 TT, UU, XFLX, RFLX 00099600
1 C
7 DIMENSION XP(60000),RP(60000),XPLOT(15,300),RPLOT(15,300), 00099700
6 > ICOUNT(30),DENSEE(15),DENS(65,35),TSEE(15),T(65,35), 1.
6 > TT(700),UU(700),CFRATO(100,100),XFLX(600),RFLX(600),
6 > IAFTER(15),ISEC(15),TTIME(20),LINTYP(15),ISOLID(15),
6 > IDOT(15),IDTDSH(15),ISDASH(15),ILDASH(15),IKEV(7),TTEMP(20)
1 C
7 COMMON /PLTPRM/ LUN, IBAUD, TO, TM, UD, UM, IFLAG, ILIMIT 00099800
7 COMMON /GASJT/ DIAM,PHIEXP,PHIMAX 00099800
1 C
1 C THE DENSITIES TO BE PLOTTED ARE INPUT VIA 'DATA DENSEE' AS
1 C A FRACTION OF THE CRITICAL DENSITY. HENCE, A VALUE OF 2.0 WILL
1 C PLOT THE DENSITIES EQUAL TO 2.0*CRITICAL DENSITY. THE LAST VALUE
1 C MUST BE 0.000.
1 C
7 DATA DENSEE /10.000,2.000,1.000,0.500,0.000/
1 C
1 C THE TEMPERATURES TO BE PLOTTED ARE INPUT VIA 'DATA TSEE' IN UNITS
1 C OF KEV. FOR EXAMPLE, A VALUE OF .5 WILL PLOT THE ISO-THERM FOR
1 C .5 KEV. THE LAST VALUE MUST BE 0.000. CURRENTLY, ONLY 5 NON-ZERO
1 C VALUES MAY BE CHOSEN.
1 C
7 DATA TSEE /0.2000,0.500,1.000,1.500,2.000,0.000/
1 C
1 C THE FOLLOWING INPUT ARE FOR THE TITLE APPEARING ON THE GRAPHS.
1 C
7 DATA IAFTER/6,65,70,84,69,82,32/
7 DATA ISEC/9,32,83,59,67,79,78,68,83,46/
7 DATA ISOLID/12,32,32,32,32,32,83,79,76,73,68,58,32/
7 DATA IDOT/12,32,32,32,32,32,32,68,79,84,58,32/
7 DATA IDTDSH/12,32,32,68,79,84,47,68,65,83,72,58,32/
7 DATA ISDASH/12,83,72,79,82,84,32,68,65,83,72,58,32/
7 DATA ILDASH/12,32,76,79,78,71,32,68,65,83,72,58,32/
7 DATA IKEV/4,32,75,101,86/
1 C
7 IFLAG=IFLAG+1 00099901
7 WRITE(6,9393) IFLAG 00099910
2 9393 FORMAT(' PLOTNT IS CALLED',I3,' TIMES.')
```


PLOTNT

```

START COL -----1-----2-----3-----4-----5-----6-----7-----8 MOD
PAGE: 03 OF 07 USERID: HJG FLAGS
7 IF (TPLOT.GT.T(M,N) .OR. TPLOT.LT.T(M,N+1)) GO TO 801 *
7 ICOUNT(NCURVE)=ICOUNT(NCURVE)+1 *
7 ICOUN=ICOUNT(NCURVE) *
7 CELDIF=T(M,N)-T(M,N+1) *
7 PNTDIF=T(M,N)-TPLOT *
7 RDIST=(PNTDIF/CELDIF)*DR *
7 XPLOT(NCURVE,ICOUN)=XP(1) *
7 RPLOT(NCURVE,ICOUN)=RP(1)+RDIST *
7 LINTYP(NCURVE)=NTEMP-1 *
3 801 CONTINUE *
7 I=0 *
7 II=0 *
7 DO 802 M=MINT,MAXTA *
7 DO 802 N=MIN,MAXRA *
7 II=II+1 *
7 I=I+(MCELL*MCELL) *
7 IF (TPLOT.LT.T(M,N) .OR. TPLOT.GT.T(M,N+1)) GO TO 802 *
7 ICOUNT(NCURVE)=ICOUNT(NCURVE)+1 *
7 ICOUN=ICOUNT(NCURVE) *
7 CELDIF=T(M,N)-T(M,N+1) *
7 PNTDIF=T(M,N)-TPLOT *
7 RDIST=(PNTDIF/CELDIF)*DR *
7 XPLOT(NCURVE,ICOUN)=XP(1) *
7 RPLOT(NCURVE,ICOUN)=RP(1)+RDIST *
7 LINTYP(NCURVE)=NTEMP-1 *
3 802 CONTINUE *
1 C THIS PORTION INTERPOLATES IN THE FORWARD X-DIRECTION. *
7 I=0 *
7 II=0 *
7 DO 811 M=MINT,MAXTA *
7 DO 811 N=MIN,MAXRA *
7 II=II+1 *
7 I=I+(MCELL*MCELL) *
7 IF (TPLOT.LT.T(M+1,N) .OR. TPLOT.GT.T(M,N)) GO TO 811 *
7 ICOUNT(NCURVE)=ICOUNT(NCURVE)+1 *
7 ICOUN=ICOUNT(NCURVE) *
7 CELDIF=T(M,N)-T(M+1,N) *
7 PNTDIF=T(M,N)-TPLOT *
7 XDIST=(PNTDIF/CELDIF)*DX *
7 XPLOT(NCURVE,ICOUN)=XP(1)+XDIST *
7 RPLOT(NCURVE,ICOUN)=RP(1) *
7 LINTYP(NCURVE)=NTEMP-1 *
3 811 CONTINUE *
7 I=0 *
7 II=0 *
7 DO 812 M=MINT,MAXTA *
7 DO 812 N=MIN,MAXRA *
7 II=II+1 *
7 I=I+(MCELL*MCELL) *
7 IF (TPLOT.GT.T(M+1,N) .OR. TPLOT.LT.T(M,N)) GO TO 812 *
7 ICOUNT(NCURVE)=ICOUNT(NCURVE)+1 *
7 ICOUN=ICOUNT(NCURVE) *
7 CELDIF=T(M,N)-T(M+1,N) *
7 PNTDIF=T(M,N)-TPLOT

```

PLOTNT

16

PROJECT: MJD
LIBRARY: PIC
TYPE: TEMP

MEMBER: PLOTNT
LEVEL: 01.99
USERID: MJD

DATE: 81/12/08
TIME: 10:30
PAGE: 05 OF 07

PLGINT

START
CNL

-----1-----2-----3-----4-----5-----6-----7-----8

MOD
FLAGS

1 C THIS SECTION SORTS FOR PROPER K-DIRECTION ORDER.

7 DO 860 L=1,NCURVE

7 ICNT=ICOUNT(L)

7 ICNTM1=ICNT-1

7 RTOP=RPLLOT(L,1)

7 MTOP=1

7 DO 870 M=1,ICNT

7 IF(RPLLOT(L,M).LE.RTOP)GO TO 870

7 RTOP=RPLLOT(L,M)

7 MTOP=M

7 MTOPM1=MTOP-1

3 870 CONTINUE

7 DO 880 M=1,MTOPM1

7 MP1=M+1

7 DO 880 N=MP1,MTOP

7 IF(RPLLOT(L,M).LE.RPLLOT(L,N)) GO TO 880

7 XHOLD=XPLLOT(L,M)

7 XPLLOT(L,M)=XPLLOT(L,N)

7 XPLLOT(L,N)=XHOLD

7 RHOLD=RPLLOT(L,M)

7 RPLLOT(L,M)=RPLLOT(L,N)

7 RPLLOT(L,N)=RHOLD

3 880 CONTINUE

7 DO 890 M=MTOP,ICNTM1

7 MP1=M+1

7 DO 890 N=MP1,ICNT

7 IF(RPLLOT(L,M).GE.RPLLOT(L,N)) GO TO 890

7 XHOLD=XPLLOT(L,M)

7 XPLLOT(L,M)=XPLLOT(L,N)

7 XPLLOT(L,N)=XHOLD

7 RHOLD=RPLLOT(L,M)

7 RPLLOT(L,M)=RPLLOT(L,N)

7 RPLLOT(L,N)=RHOLD

3 890 CONTINUE

3 860 CONTINUE

1 C WE NOW PLOT THE DENSITY CURVES.

3 511 CALL INITT(1BAUD)

7 CALL INITT

7 CALL TKSAYE(LUN)

7 L=1

7 LTYPE=3

7 IF(DENSEE(L).EQ.1.000) LTYPE=0

7 ICNT=ICOUNT(L)

7 TT(1)=ICNT

7 UU(1)=ICNT

7 DO 502 I=1,ICNT

7 TT(I+1)=XPLLOT(L,I)

7 UU(I+1)=RPLLOT(L,I)

3 502 CONTINUE

7 CALL DLINX(0.0,0.150)

7 CALL DLINY(0.0,0.120)

7 CALL XMTCS(5)

7 CALL YMTCS(5)

7 CALL LINE(LTYPE)

00000209

00000211

00000212

00000213

00000215

00000216

00000217

PLOTNT

[illegible]

PLC...

MOD
FLAGS

```

7 CALL ENUMXITEMPSE,10,4,TTEMP1
7 CALL ETITLE(600,625,10,TTEMP1
7 CALL HSTRIN(IKEV)
7 TEMPSE=TSEE(4)
7 IF(TEMPSE.EQ.0) GO TO 666
7 CALL NOTATE(450,600,12,1SDASH)
7 CALL ENUMXITEMPSE,10,4,TTEMP1
7 CALL ETITLE(600,600,10,TTEMP1
7 CALL HSTRIN(IKEV)
7 TEMPSE=TSEE(5)
7 IF(TEMPSE.EQ.0) GO TO 666
7 CALL NOTATE(450,575,12,1LDASH)
7 CALL ENUMXITEMPSE,10,4,TTEMP1
7 CALL ETITLE(600,575,10,TTEMP1
7 CALL HSTRIN(IKEV)
7 CALL FINITT(10,1000)
00000220
1 C WRITE THE DENSITIES CORRESPONDING TO THE ISD-DENSITY LINES PLOTTED. 00000221
3 666 WRITE(6,91)DENSO 00000222
4 91 FORMAT(' THE DENSITY AT THE OFFICE IS ',D10.3) 00000223
7 DO 920 NN=1,NDENS 00000224
7 WRITE(6,92)DENSEE(NN) 00000225
4 92 FORMAT(' THE DENSITY PLOTTED IS ',D10.3,' TIMES CRITICAL') 00000226
3 920 CONTINUE
1 C WRITE THE TEMPERATURES CORRESPONDING TO THE ISD-THERMS PLOTTED.
7 NTEMP=NTEMP-1
7 DO 930 NN=1,NTEMP 00000224
7 WRITE(6,93)TSEE(NN) 00000225
4 93 FORMAT(' THE TEMPERATURE PLOTTED IS ',D10.3,' KEV') 00000226
3 930 CONTINUE
7 RETURN 00102000
7 END 00000240

```

210 AK

```

7 SUBROUTINE RICAR (UD,ABL, BE,NT,AQ1,DENS,DT,T4,ETA,A1,B1,C1, 00078500
6 > A2,B2,C2,A,P,C,D,DX,DR,AKO,AK,FLXLIM,CFRAT) 00078600
1 C 00078700
1 C THE EQUATION TO BE SOLVED HAS THE FORM : 00078800
1 C  $A(J)*W(J-1)+B(J)*W(J)+C(J)*W(J+1)=D(J)$  00078900
1 C 00079000
1 C 00079100
7 IMPLICIT REAL=8 (A-H,O-Z) 00079200
1 C 00079300
7 COMMON/DR/ DENLI 00079400
7 DIMENSION ABL(100),BE(1),A(1),B(1),C(1),D(1),DENS(1) 00079500
7 DIMENSION ETA(100),UD(100),CFRAT(100) 00079600
1 C UD(1)=UD(2) 00079700
7 AC=AQ1*DT/DX**2 00079800
7 ELMASS=0.100D-28 00079900
7 NTM2=NT-2 00080000
7 NTM1=NT-1 00080100
7 DO 51 J=1,NTM1 00080200
1 C MJD ETA(J)=2.DO*ETA(B/(DENS(J)+DENS(J+1)+2.DO*DENLI)) 00080300
7 ETA(J)=2.00D/7.00D*AKO/FLXLIM*DSQRT(ELMASS/AK**3)/ 00080400
6 > ((DENS(J)+DENS(J+1))/2.DO*DENLI) 00080500
7 REI=1+ETA(J)*(UD(J)+UD(J+1))/2.DO*DSQRT(((UD(J+1)-UD(J))/DX) 00080600
6 > **2+ABL(J)**2) 00080700
7 CFRAT(J)=BEI-1.00D 00080800
2 51 BEI(J)=1.00/REI 00080900
7 DO 100 J=2,NTM1 00081000
7 ALTHAC=TH*AC/(DENS(J)+DENLI) 00081100
7 A(J)=-ALTHAC*BE(J-1) * (7.DO/2.DO*UD(J-1)**(5./2.)) 00081200
6 X -ETA(J-1)/DX*BE(J-1) * DABS(UD(J)**(7./2.)-UD(J-1)**(7./2.)) 00081300
6 X *UD(J-1)) 00081400
7 B(J)= 1 00081500
6 X +ALTHAC*BE(J) * (7.DO/2.DO*UD(J) ** (5./2.)) 00081600
6 X -ETA(J)/DX*BE(J) * DABS(UD(J+1)**(7./2.)-UD(J) ** (7./2.)) 00081700
6 X *UD(J) ) 00081800
6 X +ALTHAC*BE(J-1) * (7.DO/2.DO*UD(J) ** (5./2.)) 00081900
6 X -ETA(J-1)/DX*BE(J-1) * DABS(UD(J) ** (7./2.)-UD(J-1)**(7./2.)) 00082000
6 X *UD(J) ) 00082100
7 C(J)= -ALTHAC*BE(J) * (7.DO/2.DO*UD(J+1)**(5./2.)) 00082200
6 X -ETA(J)/DX*BE(J) * DABS(UD(J+1)**(7./2.)-UD(J) ** (7./2.)) 00082300
6 X *UD(J+1) ) 00082400
7 D(J)=ALTHAC/TH*( BE(J) *UD(J+1)**(7./2.)) 00082500
6 X -(BE(J) +BE(J-1) ) *UD(J) ** (7./2.) +BE(J-1) 00082600
6 X *UD(J-1)**(7./2.)) 00082700
3 100 CONTINUE 00082800
2 9999 CONTINUE 00082900
1 C GENERAL BOUNDARY CONDITION AT Z(0.5) 00083000
7 B(2)=B(2)-( B1 /2.DO+A1/DX )/( B1/2.DO-A1/DX ) *A(2) 00083100
7 D(2)=D(2)-A(2) * (C1/(B1/2.DO-A1/DX)) 00083200
1 C GENERAL BOUNDARY CONDITION AT Z(NTM1+0.5D0) 00083300
7 B(NTM1)=B(NTM1)-( (R2/2.DO-42/DX)/(R2/2.DO+A2/DX) ) *C(NTM1) 00083400
7 D(NTM1)=D(NTM1)- C(NTM1)*(C2/(B2/2.DO+A2/DX) ) 00083500
7 C(NTM1)=0.DO 00083600
7 A(2)=0.DO 00083700
7 CALL ATRIG ( A(2),B(2),C(2),D(2),NTM2) 00083800

```

PROJECT: MJD
LIBRARY: PIC
TYPE: TEMP

MEMBER: RICAR
LEVEL: 01.00
USERID: MJD

DATE: 81/12/08
TIME: 10:30
PAGE: 02 OF 02

RICAR

START
COL

-----1-----2-----3-----4-----5-----6-----7-----8

MOD
FLAGS

7	DO 200 J=2,NTM1	00083500
3	200 UD(J) 1=UD(J) 1+D(J)	00083600
7	D(1)=(C1-(A1/DX+B1*0.5D0)*D(2))/(B1*0.5D0-A1/DX)	00083700
7	UD(1)=UD(1) +D(1)	00083800
7	D(NT)=(C2 - (-A2/DX+ B2*0.5D0)*D(NT-1))/(B2*0.5D0+A2/DX)	00083900
7	UD(NT)=UD(NT)+D(NT)	00084000
7	DO 300 J=1,NT	00084100
3	300 IF (UD(J).LT.0.D0) UD(J)=0.D0	00084200
7	RETURN	00084300
1	CCC DEBUG UNIT(6), SUBTRACE	00084400
1	CCC AT 9780	00084500
1	CCC TRACE ON	00084600
7	END	00084700

PROJECT: MJD
LIBRARY: PIC
TYPE: TEMP

MEMBER: RICYL1
LEVEL: 01.00
USERID: MJD

DATE: 81/12/08
TIME: 10:30
PAGE: 01 OF 02

RICYL1

START COL	1	2	3	4	5	6	7	8	MOD FLAGS
7	SUBROUTINE RICYL1 (UD,ABL, BE,NT,AQ1,DENS,DT,TH,ETB,A1,B1,C1,A,B,C								00084800
6	>,D,R,DX,AKQ,AK,FLXLIM,CFRAT)								00084900
1 C	THE EQUATION TO BE SOLVED HAS THE FORM:								00085000
1 C	A(J)*W(J-1)+B(J)*W(J)-C(J)*W(J+1)=D(J)								00085100
1 C									00085200
7	IMPLICIT REAL*8 (A-H,O-Z)								00085300
1 C									00085400
7	COMMON/D/ DENLI								00085500
7	DIMENSION UO(100),ABL(100),RE(1),A(1),B(1),C(1),D(1),R(1),DENS(1)								00085600
7	DIMENSION ETA(100),CFRAT(100)								00085700
7	UO(1)=UO(2)								00086100
7	DR=R(3)-R(2)								00086200
7	AC=AQ1*DT/DR**2								00086800
7	ELMASS=9.109D-28								00086810 *
7	NTM2=NT-2								00086900
7	NTM1=NT-1								00087000
7	DO 51 J=1,NTM1								00087100
1 C MJD	ETA(J)=2.00*ETB/(DENS(J)+DENS(J+1)+2.00*DENLI								00087200
7	ETA(J)=2.00D/7.00D*AKQ/FLXLIM*DSQRT(ELMASS/AK**3)/								00087220 *
6	> ((DENS(J)+DENS(J+1))/2.00D+DENLI)								00087230 *
7	BEI=1.00+ETA(J)*(UO(J)+UO(J+1))/2.00*DSQRT(((UO(J+1)-UO(J))/								00087300
6	> DR)**2+ABL(J)**2)								00087400
7	CFRAT(J)=BEI-1.00D								00087410 *
4	51 BE(J)=1.00/BEI								00087500
7	DO 100 J=2,NTM1								00087600
7	RO=1.00/ (R(J)+DR/2.00)								00087700
7	ALTHAC=TH*AC *RO /(DENS(J)+DENLI)								00087800
7	A(J)=-ALTHAC*BE(J-1) *R(J)*(7.00/2.00*UO(J-1)**(5.00/2.00)								00087900
6	X-ETA(J-1)/DR*BE(J-1)*DABS(UO(J)**(7.00/2.00)-UO(J-1)**(7.00/2.00))								00088000
6	X*UO(J-1))								00088100
7	B(J)= 1.00								00088200
6	Y+ALTHAC*BE(J) *R(J+1)*(7.00/2.00*UO(J)**(5.00/2.00)								00088300
6	X-ETA(J)/DR*BE(J) *DABS(UO(J+1)**(7.00/2.00)-UO(J)**(7.00/2.00))								00088500
6	Y*UO(J)								00088500
6	X+ALTHAC*BE(J-1) *R(J)*(7.00/2.00*UO(J)**(5.00/2.00)								00088600
6	X-ETA(J-1)/DR*BE(J-1)*DABS(UO(J)**(7.00/2.00)-UO(J-1)**(7.00/2.00))								00088700
6	Y*UO(J-1)								00088800
7	C(J)= -ALTHAC*BE(J) *R(J+1)*(7.00/2.00*UO(J+1)**(5.00/2.00)								00088900
6	X-ETA(J)/DR*BE(J) *DABS(UO(J+1)**(7.00/2.00)-UO(J)**(7.00/2.00))								00089000
6	X*UO(J+1)								00089100
7	D(J)=ALTHAC/TH*(BE(J) *R(J+1)*UO(J+1)**(7.00/2.00)								00089200
6	X-(BE(J) *R(J+1)+BE(J-1) *R(J))*UO(J)**(7.00/2.00) +BE(J-1)								00089300
6	X*R(J)								00089400
6	X*UO(J-1)**(7.00/2.00)								00089500
3	100 CONTINUE								00089600
1 C	SYMMETRY BOUNDARY CONDITION AT R=0								00089700
7	B(2)=R(2)+A(2)								00089800
1 C	GENERAL BOUNDARY CONDITION AT R(NTM1+0.5)								00089900
7	B(NTM1)=B(NTM1)-(B(1/2.00-A(1)/DR)/(B(1/2.00+A(1)/DR)) *C(NTM1)								00090000
7	D(NTM1)=D(NTM1)-C(NTM1)*(C(1/2.00+A(1)/DR))								00090100
7	A(2)=0.00								00090200
7	C(NTM1)=0.00								00090300
7	CALL ATRIG (A(2),B(2),C(2),D(2),NTM2)								00090400
7	DO 200 J=2,NTM1								00090500

PROJECT: MJD
LIBRARY: PIC
TYPE: TEMP

MEMBER: RICYL1
LEVEL: 01.00
USERID: MJD

DATE: 81/12/08
TIME: 10:30
PAGE: 02 OF 02

RICYL1

START
COL

-----1-----2-----3-----4-----5-----6-----7-----8

MOD
FLAGS

```
3 200 UO(J)=UO(J)+D(J) 00090500
7 D(NT)=(C1 - (-A1/GR+ B1*0.5D0)+D(NT-1) 1/(B1*0.5D0+A1/DR) 00090700
7 UO(NT)=UO(NT)+D(NT) 00090800
7 DO 300 J=1,NT 00090900
3 300 IF (UO(J).LT.0.D0) UO(J)=0.D0 00091000
7 RETURN 00091100
1 CCC DEBUG UNIT(6), SUBSPACE 00091200
1 CCC AT 9808 00091300
1 CCC TRACE ON 00091400
7 END 00091500
```

PROJECT: MJD
LIBRARY: PTC
TYPE: TEMP

MEMBER: ZLIM
LEVEL: 01.25
USERID: MJD

DATE: 81/12/08
TIME: 10:30
PAGE: 01 OF 01

ZLIM

START COL	1	2	3	4	5	6	7	8	MOD FLAGS
7	REAL FUNCTION ZLIM*(PLIM,T,DENS,DR,NDIM,MIN,MAXX,MAXRA,ILIM,JLIM,	00076006	*						
6	> IEND,MAXR,BETA1)	00076109	*						
1	CCCCCOTLIM=Z L I M (PLIM,T,DENS,DR,NDIM,MIN ,MAXX ,MAXRA,ILIM,JLIM)	00076200							
1	C CALCULATES THE MAXIMUM DT ALLOWED FOR THE HEAT COND.EC.	00076300							
1	C (IN SUBR. HEATC)	00076400							
1	C	00076500							
7	IMPLICIT REAL*8 (A-H,D-Z)	00076600							
1	C	00076700							
7	DIMENSION T(NDIM,1),DENS(NDIM,1),IEND(30),BETA1(65,35)	00076826	**						
7	COMMON/D/ DENLI	00076900							
7	COMMON/INVRM/ COULOG, WAVLEN, CRITEF, ZMAT, REFPWR, TION	00077001	*						
7	DATA AK1/1.0D-05/,AK/1.38D-16/	00077104	*						
1	C AK1 IS GENERALIZED FROM MULSER'S VALUE TO ALLOW FOR MATERIALS WITH	00077201	*						
1	C Z OTHER THAN THAT FOR DEUTERIUM. SEE REF:	00077301	*						
1	C	00077401	*						
1	C	00077501	*						
1	C WRITE(6,3221)AK0,ZMAT,TION	00077605	*						
1	C3221 FORMAT(' AK0=',D10.4,' ZMAT=',D10.4,' TION=',D10.4)	00077705	*						
1	C WRITE(6,7890)BETA1(29,3)	00077816	*						
1	C7890 FORMAT(' BETA1(29,3)=',D10.4)	00077916	*						
7	AK0=AK1*ZMAT/(ZMAT+TION)**2	00078004	*						
7	AQ1=2.D0/7.D0*AK0/(3.D0*AK)	00078100							
7	AMIN=1.D70	00078200							
1	C TO AVOID TIME-STEP DETERMINATION FROM REGIONS WHERE THE DENSITY HAD	00078300							
1	C TO BE ALTERED, ONLY THE CELLS WHERE THE DENSITIES WERE GENERATED	00078400							
1	C NEARLY CORRECT ARE USED.	00078500							
7	DO 10 J=MIN,MAXRA	00078612	*						
7	IT=IEND(J)	00078706	*						
7	DO 10 I=1,MAXX	00078911	*						
7	TLIM=PLIM*(DENS(I,J)+DENLI)*DR**2/(AQ1*3.500*(I(I,J)+1.D0)	00079408	*						
6	> ** 2.5)*BETA1(I,J)	00079509	*						
7	IF (TLIM.LT.AMIN) GO TO 5	00079900							
7	GO TO 10	00080000							
5	5 AMIN=TLIM	00080100							
7	ILIM=I	00080200							
7	JLIM=J	00080300							
4	10 CONTINUE	00080400							
7	ZLIM=AMIN	00080500							
7	RETURN	00081000							
7	END	00090000							

INPUT DECK

The following is an input deck for a typical run of PICKLE. The space allotments may be larger than necessary.

PROJECT: MJD
LIBRARY: PTC
TYPE: CNTL

DATE: 8/12/68
TIME: 10:24
PAGE: 1

START
COL

-----1-----2-----3-----4-----5-----6-----7-----8

```
1 //MJDPIC JOB 340501,MJD,PTY=8,REGION=8000K,MSGCLASS=4,MSGLEVEL=(1,1),
1 // NOTIFY=MJD,CLASS=E
1 /**
1 //FTNLG PROC
1 //LOAD EXEC PGM=LOADER,PARM='LET,SIZE=8000K' 00000010
1 //SYSLIB DD DSN=SYS1.FORTFIX,DISP=S+R 00000020
1 // DD DSN=SYS1.FORTLIB,DISP=SHR 00000030
1 //SYSPRINT DD SYSOUT=* 00000040
1 //SYSLIN DD DDNAME=SYSIN 00000050
1 //SYSLOUT DD SYSOUT=* 00000060
1 // PEND
1 /**
1 // EXEC FTNLG
1 //LOAD.SYSLIB DD DISP=SHR,DSN=MJD.BIGPIC.LOAD
1 // DD DISP=SHR,DSN=KMS.USER.LOAD
1 // DD DISP=SHR,DSN=SYS1.SSPLIB.LOAD
1 // DD DISP=SHR,DSN=SYS1.TEKPLDT
1 // DD DISP=SHR,DSN=SYS1.TFORTLIB
1 // DD DISP=SHR,DSN=SYS1.FORTFIX
1 // DD DISP=SHR,DSN=SYS1.FORTLIB
1 //LOAD.SYSIN DD DSN=MJD.BIGPIC.LOAD(MAIN),DISP=SHR
1 //LOAD.FT05F001 DD DUMMY
1 //LOAD.FT03F001 DD *
2 EPARMS
4 DEHSO=0.4022, TEMPO=1.0E3,
4 MCELL=7, MINT=03, MAXT=60, DAT=0.0, ALFA=0.37500, AVC=0.2,
4 DR=2.5E-3, DTMAX=1.0E-13, DTMIN=1.0E-12,
4 PHIO=3.82022, NPHI=03, HYDOFF=0.0200,
4 DINT=2.0E-15, LEND=0500, LPLDT=1, INSH=1,
4 LSHOW=020, TOFF=1.000-10, TIDN=1.000, FLXLIN=0.32000
2 EEND
2 EPLOT
4 TRAND=960, LUN=4, TO=100.0, TM=200.0, UO=10.0, UM=750.0,
2 EEND
2 EGASJET
4 DIAM=170.00-4, PHIEXP=2.3600, PHIMAX=1.1500,
2 EEND
2 EINVRM
4 COULOG=7.000, WAVLEN=0.5300, CRITEF=0.0000, ZMAT=18.000
2 EEND
1 /*
1 //LOAD.FT04F001 DD DSN=KMS.PIC.PLOT,DISP=S+R
1 //LOAD.FT06F001 DD SYSOUT=*
1 //SYSWDUMP DD SYSOUT=*
1 //
```

Figure Captions

- Figure 1: Sample PICLE output profile. The iso-density lines are 10.0, 2.0, 1.0, and 0.5 in units of critical density. All subsequent figures plot these densities as well.
- Figure 2: PICLE generated density profile superimposed on a holographic interferogram.
- Figure 3: Schematic of Inverse Bremsstrahlung Absorption for a "slice" in the r-direction.
- Figure 4: Progress of Electron Thermal Conduction. $\tau_{\text{laser}} = 30$ psec., $f = 0.32$, $I_0 = 3.7 \times 10^{15} \text{ W/cm}^2$, the "x" implies heat conduction is flux-limited in that region.
- Figure 5: Temperature profile at $t \simeq 6 \tau_{\text{laser}}$.
- Figure 6: Enhanced X-Ray Pinhole Photograph.
- Figure 7: Progress of Electron Thermal Conduction. Same as Figure 4, except $f = 0.032$.
- Figure 8: Startup, Illustrating Linear Inverse Bremsstrahlung Absorption.

AFTER 0.09999901E-12 SECONDS.

Figure 1

Figure 2.

Figure 3.

AFTER 0.10023123E-10 SECONDS.

Figure 4a

AFTER 0.24666384E-10 SECONDS.

Figure 4b.

AFTER 0.31077760E-10 SECONDS.

Figure 4c.

AFTER 0.53842848E-10 SECONDS.

Figure 4d.

AFTER 0.81764816E-10 SECONDS.

Figure 4e.

AFTER 0.11176460E-09 SECONDS.

Figure 4f.

AFTER 0.18855392E-09 SECONDS.

Figure 5

NITROGEN GAS JET X-RAY PINHOLE IMAGE
ISO-DENSITY CONTOUR PLOT
SHOT #4816

Energy on Target = 75.6 joules
Plenum Pressure = 2000 psi
X-Ray Filtered Through
3.0 μm Mylar & 1500 $\text{\AA}$ Aluminum

Figure 6

AFTER 0.18989008E-10 SECONDS.

Figure 7a.

AFTER 0.40985872E-10 SECONDS.

Figure 7b.

AFTER 0.62125168E-10 SECONDS.

Figure 7c.

AFTER 0.80693568E-10 SECONDS.

Figure 7d.

AFTER 0.15119963E-09 SECONDS.

Figure 7e.

AFTER 0.23011376E-09 SECONDS.

Figure 7f.

AFTER 0.09999901E-12 SECONDS.

Figure 8a.

AFTER 0.31715392E-12 SECONDS.

Figure 8b.

AFTER 0.13874804E-11 SECONDS.

Figure 8c.

AFTER 0.24939200E-11 SECONDS.

Figure 8d.

AFTER 0.39202960E-11 SECONDS.

Figure 8e.

AFTER 0.53251856E-11 SECONDS.

Figure 8f.