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LAMP CODE USERS GUIDE

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LAMP CODE USERS GUIDE

I. INTRODUCTION

LAMP (i.e. Laser AMPlifier) is a radially symmetric, time-dependent laser propagation code that solves Maxwell's wave equation in either active or passive host media. The method involves a parabolic approximation to the wave equation and utilizes a method of cubic spline interpolation in solving the wave equation that insures continuity of the 1st and 2nd derivatives of the light field. Additionally, the code can describe linear propagation, non-linear self-focusing, and saturable coherent gain or absorption that is governed by a homogeneously broadened two-level system. The code uses an adaptive axial space increment which is determined internally by the code to achieve an inputted percent amplitude of absolute increment in phase per axial space step. A complete description of the computational methods employed in LAMP can be obtained from the report "A Cubic Spline Method for Solving the Wave Equation of Nonlinear Optics" by J. A. Fleck, March 1974, UCRL-75532.

The code can be operated to simulate the propagation of a light pulse through a laser amplifier system consisting, typically, of amplifier elements, passive glass media, apertures, diverging or converging lenses, and air gaps. The user has the option of specifying the number of components (i.e. "stages") in a system, the properties of each stage, and the initial beam spatial and temporal profiles. Input data delineating these properties can be entered either at the users TTY or via a card deck. The code can be operated in one of three data input modes: fully automatic, partially automatic, or fully interactive. Output consists of DD80 plots, HSP output, restage data files, and restart dump file.

II. DESCRIPTION

LAMP can be run as a stand alone controllee from a user's TTY or under a controller such as ORDER. The type of propagation problem to be run must be defined by initializing the program variables listed below under the seven data input groupings. Input can be made either at a user's TTY or via an ASCII or MONITOR format data file. Input variables must conform to CHAT NAMELIST specifications as described in LTSS Chp. 207.

LAMP can be used to propagate a light pulse through either a single or multi-element system. Each element of the system is referred to as a stage with the 1st element designated as the ϕ -stage. New data parameters must be input to LAMP at the start of each stage by the user. At the end of each stage, the user has the option of either ending the problem or continuing to the next stage.

The code was written in LRLTRAN for use on the LLL 7600 computer system. A STAR version of LAMP does not exist as of this writing. The code at present consists of 27 subroutines. The total current size of LAMP is ~ 430 K words with an SCM size of ~ 103 K words and an LCM size of ~ 325 K words.

LAMP resides in public files* and may be initialized by entering the following execute line from a teletype:

LAMP / T V

The subsequent sections of this report describe the operating features of the code. The section dealing with Program Logic discusses the steps the code goes through when a problem stage is initialized. The only steps during which the user directly interacts with the code are steps A, B, C, and O, and therefore these steps should be understood by the user. The remaining steps are included for completeness and the user is not required to be cognitive of their functions.

The section dealing with Data Input Groupings describes the input parameters the user must specify in setting up a calculation. Explanation is given of the format structure for both teletype and datafile input. This section is intended primarily as a reference glossary of LAMP input terms.

The final section describes a sample calculation that includes an explanation of the input parameters and a brief discussion of some of the graphical output. This section is designed to serve as a relatively painless entree to the practical use of LAMP. It is suggested that the reader peruse this section initially to get a "feel" for the mode of operation of the code.

As of this writing, not all options and permutations of code use have been thoroughly checked out. The author would appreciate hearing about any real or suspected code problems. We also invite requests and suggestions for new options, different operational features, etc.

III. PROGRAM LOGIC

The functional flowchart illustrated in Fig. 1 is described as follows:

- A. Upon execution, the program will request the user's box number, a maximum 5 character problem name, and a data filename. If the problem is being run under ORDER, this information must be supplied on the *XEQMES card. The code will error check this line and allow the user to retype the line if an error is detected. All items typed on the line must be blank delimited and only the data filename may be omitted from the line. A sample input line is:

T85 PROB DATA

LAMP will next change its executing controllee name to +PROB00 and create a restage data filename titled INPROB00. The last two digits of these names refer to the problem stage number and are incremented by one upon each restage. LAMP will also create a DD80 file having the 10 character name DXXXPROB0Y. LAMP will fill out the space between the leading D and the Problem name with a sufficient number of X's to produce a 10 character file name. Finally, LAMP will create

* LAMP will be available in public files after July 8, 1974. Prior to this date a copy may be obtained from the photostore directory .890625:LAMP

Figure 1

a 200,000 word printer file entitled HPROB0. The last character of both the DD80 and HSP files refer to the family file number. If the user overflows the allotted file size, the system will create a family of files and increment this last character accordingly.

If the user is generating the problem from a restart dump file, he should type only the restart dump file name. The dump file name must have an asterisk as the first character of the name (i.e. *PROB00). If the code is unable to read in the dump file, an error message will be sent to the user and he will be given an opportunity to retype the input line. In general, the restart dump file used to regenerate a problem must have been created by a previous LAMP calculation.

- B. DATA INPUT - LAMP will next try to read in the datafile whose name was entered on the input line. If an error occurs while trying to read in the datafile, the user is sent a message and allowed to retype the input line. On a problem restage, the user is notified on his TTY of the stage number and he may then type in a restage datafile name if he wishes. If the code is operating in an automatic data input mode, there will be no TTY interaction and the data file specified by the file pointer variable, NDATA, will be read in.
- C. Teletype Input - If the code is operating in an automatic data input mode, this step will be bypassed. If the user is interacting with LAMP, the code will ask the user for any comments which he may wish to have written to both the DD80 and printer files. LAMP will then instruct the user to type one of the thirteen input options listed below. Options 1 thru 6 will cause data listed under the six data input groupings to be printed out and then the user has the option of modifying any item via CHAT namelist input. Option No. 7 will cause all input data to be written out and then the code will enter a CHAT namelist input mode. Also note that even though a user may be operating under one of the listed data input groupings, he may enter data from any other input grouping if desired. Option No. 8 is a CHAT namelist input mode in which no data will be written out. Options 9 thru 11 will place the user in a least squares data fitting mode (see explanation below). Option 12 allows the user to terminate TTY interaction and start the calculation. Option 13 prints out a help package.

Option Character(s)	<u>Description</u>
S	Sentinel Parameters
P	Pulse Shape Parameters
E	Edit Parameters
M	Material Parameters
O	Optics Parameters
Z	Zoning Parameters
A	All input parameters will be typed out.
I	Input Mode. User is in a CHAT name- list input mode and no data will be written on the TTY.
RF	Radial fit mode
TF	Time fit mode
PI	Population Inversion fit mode
ST	Start the calculation. TTY input will be terminated. Linefeed may also be used.
13	HELP Types out a help package

- C₁. Least Square Fitting - If the user is operating in an interactive mode and wishes to perform least squares fitting, he must type either RF, TF, or PF to enter a fitting mode. If the user is in an automatic data input mode, fitting will be performed at this point by setting IR, IT or IV to an appropriate value as described below in the Input Data Grouping section. If fitting is not asked for, this step will be bypassed.
- D. Error Check - The code will error check the following data input parameters (see Data Input Grouping section for an explanation of these variables):

1. DZIN - If $DZIN(1) = 0$, then $DZIN(1)$ will be reset to either $\frac{2 \cdot \pi \cdot DR^2}{LAMBDA}$ for $DR > 0$. or $\frac{2 \cdot \pi \cdot DR1^2}{LAMBDA}$ for $DR = 0$.
 2. JWARDZ - If $IVARDZ = 1$ and $JWARDZ = 0$ then $JWARDZ$ will be set equal to $JMAX$ if $SIGR = 0$. If $SIGR > 0$ then $JWARDZ$ will be set to $MR1 + MR2$ when $DR = 0$ or 1.5 SIGR when $DR > 0$.
 3. ZEDIT - If $ZEDIT(1) = 0$ then $ZEDIT(1)$ will be set equal to $ZCHANGE(1)$.
 4. AIMAXI - If $AIMAXI = 0$ an error message will be sent to the users TTY and control will return to the Teletype Input Mode.
 5. JMAX or KMAX - If $JMAX > 400$ an error message will be sent to the users TTY and $JMAX$ will be reset to 400 . If $KMAX > 31$ then $KMAX$ will be reset to 31 . Furthermore if $KMAX$ is even, it will be decremented by one (i.e. $KMAX = 24$ will be reset to $KMAX = 23$).
- E. Constants and Spline Parameters - LAMP will next calculate a variety of physical constants (e.g. phase modulation, wave number, polarization, etc.) from the initial input data as well as initialize the problem time, frequency, and radius arrays. In addition the code will calculate the initial spline parameters $\alpha, \beta, \gamma, \alpha', \beta', \gamma', \gamma'_{2j}, A, B$, and C described by Fleck (Eqs. 3.8a-3.8g and 3.12a-3.12c) in UCRL-75532.
- F. WRITE INPUT DATA - All input data has now been properly massaged and will be written out to the printer, DD80, and restage data files under the six data groupings described below. The restage datafile (e.g. INPROB00) will be created at a size 10000_8 words and can subsequently be used as restage input data to other LAMP problems. If the code is unable to write into the datafile, an error message will be sent to the user and the problem will be continued.
- G. Pulse Initialization - If the problem stage number is greater than 0, this step will be bypassed. The initial electric field array, EF, will be calculated with a temporal and spatial amplitude profile as prescribed by the variables IT, IR, SIGR, SIGT, AIMAXI, TZ, and TG. The 2nd derivative of EF will be calculated and stored in the array EMS. A test of the spline fit to EF is performed and if the absolute difference between the function and its fit is 10^{-5} a difference table will be written to the HSP file and the problem continued.
- H. Population Inversion - The population inversion array, EN, is initialized to ENIN if $IV = 0$ or to the least squares fitted function POP if $IV = 1$. If $IV = 1$, POP will be written to the HSP and DD80 files.

- I. Magnify Beam - Arrays EF and EMS will now be scaled by the factor BMAG1.
- J. Aperture Beam - The beam (i.e. arrays EF and EMS) will be truncated for either an inside aperture (i.e. RAP1 > 0.) or an outside aperture (i.e. RAP2 < RMAX). If aperturing is not requested, this step is bypassed.
- K. FOCUS BEAM - The beam is focused at this step when the user specifies a nonzero value for ZFOCUS. A quadratic phase front of the form $\frac{i K R^2}{2 \cdot ZFOCUS}$ is imposed on the beam, where K is the optical wave number and R is the variable radial position.
- L. ENERGY CHECK - On the zero stage of a problem, the total integrated pulse energy is printed on the user's TTY. This number is obtained from the calculated intensity by a trapezoidal integration.
- M. Main Loop - All initialization has been completed and the problem now will enter the main integration loop. The solution is stepped forward in Z according to the instantaneous value of DZ. Edits are taken as specified by the user and the loop is exited from when the solution has advanced to the last non-zero value contained in the array ZCHANGE. A check is made on the distortion of the phase front due to non-linear effects and if these effects are too great the problem is terminated. Typing linefeed while the code is executing in the mainloop will elicit a problem status report stating the stage number, current number of loop cycles, N, and the values of DZ, ZSTAGE, and ZTOT.
- N. Restart Dump File - At the end of a stage, the code will take a problem dump if the user has so stipulated. The dump file name will be formed from the executing controllee name and will have an asterisk appended as the 1st character of the name (e.g. *PROB00). The last two digits refer to the problem stage number. Each dump taken at the end of a stage will overwrite the contents of the dump taken on the previous stage. These dump files may be used to regenerate a problem at any given stage. If the code has been unable to perform the dump, an error message will be sent to the user and the problem continued.
- O. End Problem or Continue - After dropping out of the mainloop, the user must decide whether to restage the problem or exit. In an interactive mode (i.e. NDATA = 3HITY) the user must enter his choice via the TTY. If it is decided to restage, he may then type in the name of a restage data file and the code will read in the file and proceed through the initialization cycle again. If the user decides to terminate the problem, all problem buffers will be emptied and files will either be sent to the system or retained on disc dependent upon the value of NKEEP. In an automatic data input mode, there will be no TTY interaction and the value of NDATA will determine the program flow direction as explained below.

IV. DATA INPUT GROUPINGS

Problem Parameter input to LAMP may be made via a TTY or a disc file. The input data is grouped under the seven general headings listed below. All input must conform to CHAT NAMELIST conventions. All data is free field formatted and blank delimited. A typical input line from either the TTY or a data file is as follows:

```
SIGR = .02      SIGT = 1.E-2    AIMAXI = 3000.
DD80 = 1 2 4 5   JMAX = 300      DZIN = 1. 2.
DZIN(4) = 4.     SIGR = .2      NDATA = 3HEND
ENDSTAGE
```

In the above example, the values 1, 2, 4, and 5 will be filled into the 1st four elements of DD80. DZIN will contain the values 1. 2. 0 4. 0. , SIGR will be .2, and NDATA = 3HEND will cause the problem to terminate after completing the current stage. ENDSTAGE is a symbol delimiter that terminates the current Namelist read. In the case of input from a datafile, any subsequent read from this file will commence with the first variable after ENDSTAGE assuming the file has not been closed. If the file was closed prior to the read, input will start at the beginning of the file.

The units employed are cgs. Gaussian; time = nsec.; distance (radius and z-propagation) = cm.; Pulse power = megawatts. All problem input parameters (with the exception of a few optics parameters, as noted below) will remain constant upon a restage unless changed by the user. It should be kept in mind that these parameters refer to propagation over the current stage only and that none of the parameters can be altered until a stage terminates. Data input parameters to LAMP are described as follows:

A. Problem Sentinels (S):

These parameters control the logical flow of the code. They also determine the functions to be performed by a problem.

1. IDUMP - restart dump file sentinel. Default value = 0.

IDUMP = 0. The code will create a restart dump file and write into it after each problem stage.

IDUMP = 1. A restart file will not be created.

2. IV - Population Inversion control sentinel. This sentinel must be specified when a gain calculation is to be done. Default value = 0.

IV = 0 will cause the inversion population at the leading edge of the pulse to be set to NACT*ENIN for all Radial zones.

IV = 1 will cause the inversion population to be set to $NACT * POP(J)$. $POP(J)$ is a radially dependent, least squares fitted, population inversion function calculated by the user after specifying a PF input option.

IV = 2 will generate a population₂ inversion profile of the form $COEFP(1) + COEFP(2) \cdot R + COEFP(3)R^2 + \dots + COEFP(m)R^{m-1}$ where $COEFP$ is a user input population inversion coefficient array.

3. IVARDZ - DZ Step size control sentinel. Default value = 1.

IVARDZ = 0 The problem will use a constant DZ step size obtained from the Array DZIN.

IVARDZ = 1 The problem will use a variable DZ step size. The starting DZ for a stage will be obtained from DZIN(1). At the completion of the stage, DZIN(1) will be set to the last value of DZ. The code will ignore all the elements in DZIN except the 1st one. Additional variables which the user may wish to specify when using this option are: JWARDZ, FIMIN, DZLIM, DZMAX, and DZMIN.

4. IR & IT - Input pulse shape sentinel. These sentinels are recognized only for a 0 problem stage. IR determines the radial profile of the pulse and IT determines the time profile. The default values are $IR = 0$ and $IT = 0$. All the listed options refer to intensity (mW/cm^2) patterns. The pulse input options are summarized as follows:

a. Radial Profile:

<u>IR</u>	<u>Description</u>
0	Gaussian Pulse User must specify AIMAXI and SIGR.
1	"Super-Gaussian" Pulse. Requires variables AIMAXI, SIGR, and NREXP.
2	Mth order Polynomial Pulse. Pulse is generated from AIMAXI and the user input coefficient array, COEFR. Pulse will be defined by the expression $AIMAXI * (COEFR(1) + COEFR(2) \cdot R + COEFR(3) \cdot R^2 + \dots + COEFR(m)R^{m-1})$.
3	Least Squares fit to Radial pulse data. User must specify the fitting variables IFL, M and the input data points RADIUS, and RINT. (See explanation of least square fit option below.)

<u>IR</u>	<u>Description</u>
4	Airy Pattern. User must specify AIMAXI and SIGR.

b. Time Profile:

<u>IT</u>	<u>Description</u>
0	Gaussian Pulse. User must specify AIMAXI, SIGT, TZ, and TG.
1	Quadratic Pulse. User must specify AIMAXI and TZ.
2	Mth order polynomial pulse generated from the expression $AIMAXI * (COEFT(1) + COEFT(2)*T + COEFT(3)*T^2 + \dots COEFT(n)*T)$
3	Least Squares fit to Time Pulse data. User must specify the fitting variables n and IFL and the input data points TIME and TINT

5. MAT - Media identification Sentinel. Default value is MAT = 1. Setting MAT to one of the values listed below will initialize the media parameters as follows.

<u>MAT</u>	<u>Media</u>	<u>Variables</u>
0	-	No Effect
1	Air	ETA = 1., GF = 1., TAU = T2 = 1.E-16, SIGAMP = SIGA = 0., N2 = 1.E-99, GAMTP = 0.
2	CO ₂	ETA = 1. GF = 2. SIGAMP = 1.E-19 T2 = .2 N2 = 1.E-99
3	ED-2 Glass	ETA = 1.556 N2 = 1.6E-13 GF = 1.1 SIGA = .0007 T2 = 1.E-4
4	Neodymium-Yag	ETA = 1.823 N2 = 3.2E-13 GF = .57 SIGAMP = 8.7E-19 T2 = 2.5E-3 SIGA = .0007
5	EY-1 Farady Rotator Glass	ETA = 1.61 N2 = 1.8E-13 SIGAMP = 8.7E-19 SIGA = .0007 T2 = 2.5E-3

In using this option, the user should be aware that a value of $MAT > 0$ will override any value of ETA , GF , etc. entered by the user. If the user wishes to enter media values that differ from those listed above, he should set $MAT = 0$.

6. $NDATA$ - Data input file pointer. The value of $NDATA$ will determine the data input mode the code will follow upon the completion of a problem stage. $NDATA$ can assume one of the three following values:
 - a. $NDATA = 8HFILENAME$. This value of $NDATA$ instructs the code to automatically read Namelist input data from the input file $FILENAME$ upon the completion of the present stage. After finishing the read, $LAMP$ will immediately start the next stage of calculation without an opportunity for user interaction. If the read was not completed successfully, the code will enter the TTY input mode and await instructions from the user.
 - b. $NDATA = 3HTTY$. This value of $NDATA$ instructs $LAMP$ to enter the TTY input mode after the completion of the present stage. The code is defaulted to operate in this mode.
 - c. $NDATA = 3HEND$. This value of $NDATA$ instructs $LAMP$ to exit the calculation after the current stage is completed. All buffers will be emptied, and the appropriate files sent to the system if so instructed by the user. If the user is in an automatic data input mode, this value of $NDATA$ must be specified on the last input stage in order to terminate the problem correctly.

When either the fully automatic or the fully interactive modes described above are used, the code will remain in the prescribed mode until $NDATA$ points the user out of the mode. The sample problem given later illustrates more clearly some of these features.

7. $NKEEP$ - Output file control sentinel. The value of $NKEEP$ on the last stage of a problem will determine the disposition of the problems printer and $DD80$ files when the problem terminates. $NKEEP$ can assume one of two values:
 - a. $NKEEP = 0$. All $DD80$ and Printer files will be retained on disk upon problem completion. This is the problem default value.
 - b. $NKEEP = 1$. $DD80$ and Printer files will be sent to the system upon problem completion. $DD80$ files will be sent by the utility routine FROG according to the options specified in the array $DD80OPT$. Printer files will be sent by the utility routine ALLOUT according to the options specified in the array $PRINTOPT$.

8. IEDIT - Edit control Sentinel. Problem edits during a stage can be taken in one of the following two modes:
 - a. Z-location based edits. IEDIT = 0. Edits will be taken at the Z-locations given by the arrays DZEDIT AND ZEDIT. This is the recommended mode of operation and the code is default to operate in this mode.
 - b. Cycle Based Edits. IEDIT = 1. Edits will be taken at a user designated problem cycle frequency (i.e. ICYCLE) irrespective of the calculated Z-location. The arrays DZEDITOT and ZEDIT are ignored under this option. MAXEDIT should also be specified when using this option.
9. DR - Radial Zone size sentinel. Radial zone sizes can be set in one of two ways:
 - a. Constant zone size. DR > 0. The user specified value of DR > 0. will be filled into all radial zones. This is the recommended mode of operation for most problems. Default value is DR = 2.5E-3.
 - b. Variable zone size. The problem's radii will be divided into three regions. The first region will contain MR1 zones of size DR1. The second region will contain MR2 zones of size DR2. Zone size in the third region is set by the code and will increase arithmetically out to the problem boundary, RMAX.

B. Pulse Shape Parameters(P):

Input data under this grouping is used to generate an initial, ϕ -stage radius-time pulse shape. Most of these parameters will be ignored after the problem ϕ -stage.

1. AIMAXI - Initial, ϕ -stage, on axis maximum beam intensity (mw/cm²). A value must be entered for all pulse shape options with the exception of least squares fitting (i.e. IR = 3 or IT = 3). The user specified pulse shape will be generated from this value. The default value is 1.E3 mw/cm².
2. COEFR - 10 element, radial polynomial coefficient array. This array is only used when IR = 2 to generate a radial input pulse shape given by the expression $AIMAXI * (COEFR(1) + COEFR(2)*R + COEFR(3)*R^2 + \dots + COEFR(m)*R^{m-1})$, where m = number of coefficients in the array. m is determined in the code by counting the number of array elements in COEFR up to the last nonzero array element. For example the array values COEFR = 1.1 .0 -1.2 +21.3 will generate a third order polynomial pulse of the form $AIMAXI (1.1 - 1.2R^2 + 21.3R^3)$. The user cannot enter a value of m directly.

3. COEFT - 10 element, time polynomial coefficient array. This array is used to generate an input time pulse shape when IT = 2 in a manner similar to COEFR above.
4. ESUMI - Estimated Total input beam energy in joules. After ϕ -stage initialization, the actual total integrated beam energy is compared with this number and a value of AIMAXI needed to match these two quantities is printed on the users TTY. ESUMI is strictly a check parameter and has no effect on the calculation. It may be omitted if desired. Default = .3 joules.
5. FIMIN - Intensity scale factor. Parameter is used only when variable DZ step size control is requested (i.e. IVARDZ = 1). The product of FIMIN and the instantaneous on-axis maximum intensity (i.e. $FIMIN * EF(1,1)^2$) will determine the minimum intensity that will be considered for performing a DZ step size change test. This parameter has the effect of preventing small intensities that may undergo large relative field changes during a z-step from controlling the problem propagation rate (i.e. the DZ step size) of the calculation. Default = .001.
6. NREXP - Exponent value for a "super-gaussian" pulse when IR = 1. Default = 10.
7. SIGR - Radial location of the 1/E power point for a gaussian input radial pulse (IR = 0) or for a "super-gaussian" (IR = 1). It is also the radial location of the 1st zero for an input Airy pattern (IR = 4). Default = .25 cm.
8. SIGT - Time location of the 1/E power point for a gaussian input time pulse. Default is .25 nsec.
9. TG & TZ - These parameters control the generation of the problem time pulse and its positioning within the problem's "time window".
 - a. TZ - This parameter is the half-width of the problem's "time window". It is also the central time position when a Quadratic time pulse (i.e. IT = 1) is generated. In this case, the pulse will be characterized by an intensity value of 0. at both time 0. and time 2TZ. The pulse will assume its maximum value (i.e. AIMAXI) at time TZ. Default value = 1. nsec.
 - b. TG - This parameter centers a gaussian pulse (i.e. IT = 0) at time TG within the problem "time window" defined by TZ. Default value = 1. nsec.

An illustrative example demonstrating the relationship between TG and TZ for a gaussian time pulse is shown below in Fig. 2.

Fig. 2

C. Problem Edits (E):

Input data under this grouping is used to take DD80 and printer file edits as required by the user. In general, edits may be taken at either predesignated z-locations (i.e. option IEDIT = 0) or at a predesignated problem cycle frequency (i.e. IEDIT = 1). Printer file and DD80 edits are both taken simultaneously. Edit Parameters are as follows:

1. DD80 - 14 element array for listing DD80 graph numbers to be deleted on each edit. When the default value DD80 = 0 is used, all graphs will be plotted. If DD80 > 1, only those graphs listed will be plotted. Graphs available are as follows:

- 1 - Beam Intensity vs Time
- 2 - TPF Intensity vs Time
- 3 - Frequency vs Time
- 4 - Phase lead vs Time
- 5 - Intensity vs R(JMAX)
- 6 - Intensity vs R(JZ3)
- 7 - Intensity profiles vs R(JMAP). Plots are at consecutive times on the back of the pulse.

- 8 - Time Integrated Energy Density vs Radius (JMAP)
 - 9 - Half Power Radius vs Time
 - 10 - Half Intensity Radius vs Time
 - 11 - Phase Front Plots. Three seaprte graphs:
 - a. Phase vs R(JPHS)
 - b. 1st derivative of phase vs R(JPHS)
 - c. 2nd derivative of phase vs R(JPHS)
 - 12 - Spectral Power vs Fourier frequency
 - 13 - On axis population inversion vs Time. Plotted only for gain calculations (i.e. SIGAMP > 0.)
 - 14 - Radial population iversion profiles vs R(JMAX). Plots at consecutive times on the back of the pulse. Plotted only for gain calculations.
2. DD80OPT - 10 element array containing output option messages for FROG. This array is used only when NKEEP = 1. The array is defaulted to give the family of DD80 files generated by the problem away to the microfiche camera, i.e. DD80OPT = 4HFAM. 10H[DD80FILENAME] 6H105mm. The user may specify additional options as described in the FROG writeup (OC-515 and OC-606).
 3. DZEDIT - 5 element edit frequency array. This array is used only when z-location based edits are specified by the user (i.e. IEDIT=0). The array instructs LAMP to take an edit every DZEDIT(1) cm up to z-stage location ZEDIT(1) and then take an edit every DZEDIT(2) cm up to z-stage location ZEDIT(2), etc. Default value = 1. cm.
 4. ICYCLE - Edit cycle frequency parameter stated in terms of cycles/edit. Parameter is used only when cycle based edits are taken (i.e. IEDIT = 1). Default value = 1.
 5. JMAP - Radial zone number used to define the maximum radius to be plotted on graphs Nos. 7 and 8. Default = 400.
 6. JPHS - Radial zone number used to define the maximum radius to be plotted on the phase plots No. 11. Default value = 400.
 7. JVARZ - Radial zone number of the maximum radial field point to be considered for determining DZ step size when the variable DZ step size option (i.e. IVARZ = 1) is used. Default value = 300.

8. JZ3 - Radial zone number used to define the maximum radius to be plotted on graph No. 6. Default value = 200.
9. MAXEDIT - Maximum number of edits to be taken during a stage when the code is operating in a cycle based edit mode (i.e. IEDIT = 1). The code will take edits up to the specified number and then cease taking edits until the problem terminates a stage at which time a final edit will be taken. Default value = 40.
10. PRINTOPT - 10 element array containing out put option messages for ALLOUT. This array is used only when NKEEP = 1. The array is defaulted to send the printer files generated by the problem to the microfiche camera, i.e. PRINTOPT = 4HFR80 10H[Printer file] 4HETC. The user may specify additional options as described in the ALLOUT writeup (UR-405).
11. ZEDIT - 5 element array specifying z-locations within a stage for changing edit frequencies (i.e. DZEDIT) when z-location based edits are being taken (i.e. IEDIT = 0). Default value = 1. cm.

D. Materials Properties (M):

The optical and gain properties of the host propagation media are grouped under this heading. These parameters are as follows:

1. COEFP - 10 element population inversion, polynomial coefficient array. This array is used only when a gain problem of the type IV = 2 is to be performed. The array will initialize a gain profile at the leading edge of the pulse having a polynomial form given by the array coefficient, COEFP. The number of array elements will determine the degree of the polynomial. For example the array values COEFP = 1. -3.12 +21.1 -35.0 will produce a radial inversion profile of the form $(1.+3.2R+21.1R^2-35.0R^3)$.
2. ENIN - Constant population inversion factor. This parameter is used only when IV = 0. All radial zones at the leading edge of the pulse will have a constant inversion factor of ENIN. Default value = 1.0.
3. ETA - Linear index of refraction of host media. Default value = 1.0.
4. GAMTP - Two photon absorption coefficient. Default value = .0 cm/mw.
5. GF - Factor in population equation. Set GF = 2. if lower level depletes instantaneously. Set GF = 1.5 for Nd-Yag. Default value = .0.

6. LAMBDA - Wavelength of light. Default value = 1.06E3 cm.
7. NACT - Number of active atoms/cm³. The product of NACT and the inversion factors calculated when IV is set defines the inversion population at the leading edge of the pulse during a stage. Default value = 1.E-18 atoms/cm³.
8. N2 - Nonlinear index of refraction of host media. Default value = 1.E-99.
9. SIGA - linear, unsaturated absorption coefficient. Default value = .0 cm⁻¹.
10. SIGAMP - Cross section for amplification process. Default value = .0 cm².
11. TAV - Kerr effect time constant. Default value = 1.E-16 nsec.
12. T2 - Atomic polarization dephasing time. Default value = 1.E-16 nsec.

E. Optics Parameters (0):

The various optical components that may be used during a problem stage are grouped under this heading. Optical parameters are described as follows:

1. BMAG - Magnification factor for either expanding or telescoping the whole beam. Beam energy will be conserved and all plots will be appropriately rescaled. Default value = 1.0. BMAG will always be reset to 1.0 at the end of a stage.
2. BMAG1 - Factor for rescaling (i.e. increasing or decreasing) whole beam intensity. Beam energy will not be conserved. Default value = 1.0. BMAG1 will always be reset to 1.0 at the end of a stage.
3. CEX - Logarithmic attenuation factor used for reducing beam intensity at an aperture whenever RAP1 or RAP2 is specified. Intensity will reduce approximately at a rate given by,

$$e^{\frac{1}{\ln CEX}}$$
 . Default value = .75.
4. RAP1 - Radial location for an inside aperture. Beam will be attenuated by the factor CEX at all points inside RAP1. Default value = .0 cm means no aperture is specified. RAP1 will always be reset to .0 cm at the end of a stage.

5. RAP2 - Radial location for an outside aperture (i.e. optical stop). Beam will be attenuated by the factor CEX at all points outside RAP2. When RAP2 > RMAX no aperture will be specified. Default value = 1.E30 cm. RAP2 will always be reset to 1.E30 cm at the end of a stage.
6. ZFOCUS - Focal length of a simple thin lens. A positive value of ZFOCUS will simulate a focusing lens and a negative value will simulate a diverging lens. The default value = .0 cm will result in no lens. ZFOCUS will always be reset to .0 cm at the end of a stage.

F. Zoning Parameters (Z):

The radius-time mesh for a calculation as well as various z-propagation parameters are grouped under this heading. These input parameters are described as follows:

1. DR - Radial zone size for constant radial zoning, i.e. DR > 0. Default value = 2.5E-3 cm.
2. DR1 - Radial zone size in 1st region when variable radial zoning (i.e. DR = 0) is specified. Default value = .0 cm.
3. DR2 - Radial zone size in 2nd region when variable radial zoning is specified. Default value = .0 cm.
4. DZIN - 5 element DZ step size array. When variable DZ step size is specified (i.e. IVARDZ = 1) the initial DZ step size will be set equal to DZIN(1) and any remaining elements in DZIN will be ignored. If IVARDZ = 0, the problem will be run with a fixed DZ or DZIN(1) up to the Z-location ZCHANGE(1) and then changed to DZIN(2) and run to Z-location ZCHANGE(2), etc. When IVARDZ = 1, DZIN(1) will be set equal to the last DZ step size at the end of a problem stage. This has the effect of carrying over to the next stage the last DZ step size of the previous stage. Default value = .15 cm.
5. DZLIM - Step size control factor used only when variable DZ step size (i.e. IVARDZ = 1) is specified. DZLIM controls the amount by which DZ can change on a problem cycle. DZ is calculated according to the formula $DZ_{NEW} = DZ_{OLD} * DZLIM / EEMAXP$ where EEMAXP is the maximum fractional change in the field on the previous z-step. Default value for DZLIM = .05. DZLIM can be thought of as determining the degree of sensitivity with which DZ will respond to changes in the field. Finally, DZ is not allowed to increase by more than a factor of 1.2 between Z-steps.

6. DZMAX - The maximum DZ step size allowed when IVARDZ = 1. Default value = .5 cm.
7. DZMIN - The minimum DZ step size allowed when IVARDZ = 1. Default value = 1.E-5 cm.
8. JMAX - Total number of radial zones for a problem. This value must be ≤ 400 and should not be changed after the problem ϕ -stage. Default value = 400.
9. KAMX - Number of time zones for a problem. This value must be ≤ 31 , it must be an odd number, and should not be changed after the problem ϕ - stage. Default value = 31.
10. MR1 - Number of radial zones of size DR1 in region 1 when variable radial zoning is specified (i.e. DR = .0). Default value = 0.
11. MR2 - Number of radial zones of size DR2 in region 2 when DR = 0. Default value = 0.
12. RMAX - Maximum problem radius. When DR = .0 the user must enter a value of RMAX. If DR > .0, the code will calculate an RMAX from the product JMAX*DR and overwrite any value that may presently be in RMAX. Default value = 1. cm.
13. ZCHANGE - 5 element array specifying z-locations for changing DZ when IVARDZ = 0. The last non-zero element in the array will determine the Z-location for ending the problem stage for both IVARDZ = 0 and 1. Default value = 1. cm.

G. Least Squares Fitting (RF, TF, or DF)

Least squares fitting of user supplied data points can be specified for generating either an initial, 0-stage beam input pulse or a radially dependent population inversion profile on any stage.

1. Interactive Data Fitting:

If the user is in an interactive data input mode (i.e. NDATA = 3HTTY), he must type either RF, TF, or PF when he is asked to type an input option. The user will then enter the requested least-squares fitting mode and will remain there until he types in another fitting mode symbol or the command END. Typing END will terminate the fitting mode and return the user to a normal data input sequence.

Upon entering an interactive fitting mode, the user will be asked to type one of the commands listed below.

<u>Command</u>	<u>Action Taken by LAMP</u>
1. DATA	Types out the user supplied data points for the fitting mode presently being executed (i.e. RF, TF, or PF). The code will also type out the present values of IFL, M and NUM. After all the Data has been typed the user will be asked for Namelist input.
2. INPUT	The user will enter a Namelist data input mode. No data will be typed out.
3. FIT	Code will perform a least squares fit of the user supplied data and plot the fit into the problem DD80 file. After the fit is done, the code will type out on the user's TTY the values for M, IFL, NUM, RMS (the calculated standard deviation of the fit) and the calculated coefficient values for the fit.
4. RF, TF, or PF	Typing one of these commands will cause the code to terminate the present fitting mode, empty the plotting buffer and enter the new data fitting mode indicated.
5. END	This command terminates the present data fitting mode, empties the plotting buffer, and returns the user to a normal TTY input mode. This instruction will not end the problem.

Several different fits to the same data can be performed and then viewed by the user while in a fitting mode. The last fit performed in a mode will be the fit to be used for initialization. Initialization will not be performed until the user returns to normal TTY input mode and then starts the calculation.

2. Automatic Data Fitting:

If the user is in an automatic data input mode (i.e. NDATA = 10H filename) all information relating to the fit(s) to be performed must be entered via the data input deck. The user should specify IR = 3, IT = 3, or IV = 1 as desired and the appropriate experimental data arrays. The interactive fitting mode commands listed above must not be entered. If an error occurs during the fitting process, the problem will cease execution.

3. Data Fitting Input Parameters:

The following input data is required to perform least squares fitting:

		IFL = 1	IFL = 0
IR = 3	Fit Performed	* ln RINT vs RADIUS ²	RINT vs RADIUS
	Generated Function	AIMAXI*[COEFR(1) + COEFR(2)R ² COEFR(3)(R ²) ² + . . . + COEFR(m+1)(R ²) ^m]	AIMAXI*[COEFR(1) + COEFR(2)*R + COEFR(3)*R ² + . . . + COEFR(m+1)*R ^m]
IT = 3	Fit Performed	* ln TINT vs TIME	TINT vs TIME
	Generated Function	AIMAXI*[COEFT(1) + COEFT(2)*T) COEFT(3)*T ² + . . . + COEFT(m+1)T ^m]	AIMAXI*[COEFT(1) + COEFT(2)*T + . . . + COEFT(m+1)*T ^m]
IV = 1	Fit Performed	ln PINV vs RINV	* PINV vs RINV
	Generated Function	COEFP(1) + COEFP(2)*R + COEFP(3)*R ² + . . . + COEFP(m+1)*R ^m	COEF(1) + COEFP(2) + . . . COEFP(m+1)*R ⁿ

Figure 3

a. Experimental Data Arrays:

All input data arrays are 25 elements in length. The code will count the number of elements entered and return this value (i.e. NUM) to the user.

<u>Fitting Option</u>	<u>X-Array Name</u>	<u>Y-Array Name</u>
Intensity vs Radius (IR = 3)	RADIUS	RINT
Intensity vs Time (IT = 3)	TIME	TINT
Pop. Inv. vs Radius (IV = 1)	TINV	PINV

b. M - order of polynomial fit. Default value = 3.

- c. IFL - type of fit to be performed. IFL = 0 will result in a fit of the type Y vs X thereby minimizing absolute fit residuals in Y. IFL = 1 will produce a fit of the type $\ln Y$ vs X thereby minimizing relative fit residuals in $\ln Y$. The type of fit to be performed (i.e. IFL = 0 or 1) along with the three different fitting options (i.e. IR = 3, IT = 3, IV = 1) and the resultant polynomial functions are listed below in Fig. 3. The coefficient arrays COEFR, COEFT, and COEFP are set by the routine and the user, generally, should not attempt to manually alter these arrays. The recommended default fitting modes are indicated with asterisks.

V. SAMPLE CALCULATION:

A sample calculation is presented of a typical laser system experiment as show below in fig. 4.

.06 cm dia. 1.02 cm dia.
Divergence = 4.34×10^{-3}

Fig. 4

An input, plane wave beam has been propagated from the left through the pinhole aperture (.06 cm dia) and then allowed to travel 230 cm to the 2nd aperture. The beam has evolved into a far field Airy pattern at this 2nd aperture. The aperture will truncate the beam at its first minimum and then propagate 15 cm to the 1st Nd. glass rod. The total input beam energy to this 1st rod is .005 joules and the experimentally measured small signal gain (i.e. ssg) through the rod was 120x. After emerging from the first rod, the beam will be spread by the $F = -222$ cm diverging lens as shown and then enter the 2nd Nd amplifier rod. SSG through the 2nd rod was 25x and the experimentally measured output energy was 5.6 joules.

In simulating this experiment with LAMP, we choose to start the problem at the 2nd aperture rather than the 1st aperture. This choice was prompted by the maximum 400 radial zone size limitation in the current version of LAMP. To characterize a hard apertured beam to within 10% accuracy at the pinhole aperture with LAMP, would require approximately 100 radial zones inside the aperture. Since the beam will spread by a factor of ~ 34 by the time it emerges from the 2nd rod, this would require that ~ 3400 radial zones be carried throughout the problem and this cannot be done with the present version of LAMP.

As can be seen in Fig. 4, the problem 0-stage refers to propagation between the 2nd aperture and the face of the 1st rod, the problem 1-stage refers to propagation through the 1st rod, the 2-stage and 3-stage identify propagation between the rods, and the 4-stage describes propagation through the 2nd rod. Two separate calculations of this problem using identical data parameters for both calculations were performed to demonstrate two common operational methods for inputting data to LAMP. The first method involves fully automatic input of all data from a single datafile and requires no user interaction. The 2nd method involves partially automatic data input in which data for the 0-stage and 1-stage will be input from a 1st datafile, input for the 2-stage will come from the TTY, and data for the 3-stage and 4-stage will originate from a 2nd datafile. Totally interactive use of the code is not discussed. The user will find that in this mode the code will "lead" him with a series of queries that require fairly self-evident responses from the user.

Automatic Data Input Calculation

All input for this calculation is contained in the datafile named DATAFILE show below in Fig. 6. All input parameters up to the symbol delimiter STAGE1 will be used to initialize the 0-stage calculation. The pointer variable NDATA = 8HDATAFILE will instruct the code to read in the 0-stage data and then proceed with the 0-stage calculation. If NDATA did not point to DATAFILE on the 0-stage (i.e. no value for NDATA was entered) the code would input data properly from DATAFILE but would then enter a TTY input mode and await instructions from the user. For automatic data input, it is necessary to set NDATA to the input file name only in the first stage of data to be input from the file.

After the 0-stage is completed, the code will read in the data contained between the delimiters STAGE1 and STAGE2 then proceed to calculate the 1-stage. The calculation will proceed in a similar manner up through 4-stage. The parameter NDATA = 3HEND must be specified in order to properly terminate the problem at the end of the 4-stage.

The problem was initialized by typing

LAMP / T V ,

and then, upon request, inputting the line,

T85 SYSTA DATAFILE

The code then changed its name to +SYSTA00, input the file DATAFILE, and proceeded to calculate the problem 0-stage.

```

.1  IVARDZ=1 IT=0 IP=4 DR=3.75E-3 MAT=1 NDATA = 8HDATAFILE
2
3  AIMAXI=1.4066E2 ESUMI=.005 SIGR=.51 SIGT=.103 TG=.4 TZ=.4
4  FIMIN=.01
5
6  JMAP=400 JZ3=120 JPHS=300 JVARDZ=200 DD80= 2 3 4 7 13 14
7  DZEDIT=15. ZEDIT=15.
8  LAMBDA=1.06E-4
9
10 RAP2=.51 ZFOCUS=-2.35E2
11
12 DZLIM=.1 JMAX=400 KMAX=31 DZIN=.5 ZCHANGE=15. DZMAX=2.
13
14
15          STAGE1
16 DD80=14(0) MAT=3 NACT=3.99E18 ZEDIT= 40. DZEDIT= 10. BMAG1=.976
17 ZCHANGE=40. DZIN=.1
18
19
20          STAGE2
21 DD80= 2 3 4 7 13 14 MAT=1 ZEDIT=60. 78. DZEDIT=20. 10. BMAG1=.976
22 ZCHANGE=78. DZMAX=5.
23
24
25          STAGE3
26 ZEDIT=10. 0. DZEDIT=54. 0. ZFOCUS=-222. BMAG1=.953 ZCHANGE=54.
27
28
29          STAGE4
30 DD80=14(0) MAT=3 NACT=2.682E18 ZEDIT=40. DZEDIT=5. BMAG1=.976
31 DZIN=.1 ZCHANGE=40. DZMAX=2. NDATA=3HEND
32          ENDSTAGE4

```

Figure 6

The parameters contained in DATAFILE are discussed as follows:

1. 0-stage Set the initial radial beam shape to an Airy pattern, IR=4, with a 1st minimum at SIGR = .51 cm. Set the initial time pulse shape gaussian, IT = 0, centered at TG = .4 nsec within a time window of width 2 TZ (TZ = .4 nsec). The 1/e time point, SIGT = .108 nsec, will be set relative to TG. The on-axis maximum beam intensity is AIMAXI = 1.0066E2 and the initial beam energy check is ESUMI = .005 joules. The beam is to be apertured, RAP2 = 51. cm, and a divergent pulse front (ZFOCUS = -235. cm) superimposed on the beam at this point. The initial divergence given for the experiment was 4.34×10^{-3} radius and ZFOCUS was calculated from the expression, $ZFOCUS = -\frac{2 \cdot \text{SIGR}}{\text{DIVERGENCE}}$. The initial beam pulse shapes are shown below in figs. 7 and 8. The beam is to be propagated through air, MAT = 1, at a wavelength of LAMBDA = 1.06E4 cm.

The problem zoning requirements are determined by first estimating a value of DR from the relationship,

$$DR < \frac{ZFOCUS \cdot LAMBDA}{2 \cdot \pi \cdot RMAX}$$

We used a value of DR = 3.75E-3 which, although it does not quite meet the requirement, appears to be adequate. We next calculated an initial DZ step size from the stability estimate

$$DZ \leq \frac{2 \cdot \pi \cdot DR^2}{LAMBDA}$$

A value of DZIN = .5 was used. A full 400 radial zones, JMAX = 400, and 31 time zones, KMAX = 31, were used. The problem is to be propagated for 15 cm, ZCHANGE = 15., and an edit will be taken at this point, DZEDIT = 15., ZEDIT = 15. DD80 plots relating to gain information will be deleted, DD80 = 2 3 4 7 13 14. Radial zone numbers for scaling appropriate DD80 plots are set, JMAP = 400, JZ3 = 120, JPHS = 300.

Finally, we specify that the problem propagate using the variable DZ step size control, IVARDZ = 1. The minimum intensity for DZ testing will be FIMIN = .01 multiplied by the on axis maximum intensity. JWARDZ = 200 specifies the maximum radius for applying the DZ step size test. The maximum DZ step size allowed will be DZMAX = 2 cm.

2. 1-stage Upon entering the 1st Nd glass rod, MAT = 3 we decide to attenuate the beam by the factor BMAG1 = .976 to account for reflective loses at this interface. The gain population, NACT, of the media is set by calculating

$$NACT = \frac{\ln SSG}{SIGAMP \cdot ZCHANGE}$$

FIG 7 - GAUSSIAN TIME PULSE

FIG 8 - TRUNCATED AIRY PATTERN

The problem will propagate for ZCHANGE = 40 cm and we will force the initial DZ step to be DZIN = .1 cm. We will take all edits, DD80 = 14(0) every DZEDIT = 10 cm, up to the end of the rod, ZEDIT = 40 cm.

3. 2-stage After leaving the 1st Nd glass rod and entering the air MAT = 1, we again attenuated the beam to account for reflective losses, BMAG1 = .976. We do not reset DZIN and therefore the initial DZ for this stage will be set to the last value of DZ on the previous stage, i.e. DZIN = .414. The beam will be propagated for ZCHANGE = 78 cm. and the maximum DZ step size permitted will be DZMAX = 5 cm. We will edit every 20 cm up until 60 cm and then edit every 10 cm until 78 cm, i.e. DZEDIT = 20. 10., ZEDIT = 20. 10.
4. 3-stage At this point we will run the beam through a diverging lens, ZFOCUS = -222. cm taking into account reflective losses at both lens surfaces, BMAG1 = .953. We will edit every 10 cm, DZEDIT = 10. 0. , for 54 cm, ZEDIT = 54. 0. Note that the 2nd element in DZEDIT and ZEDIT must explicitly be set to 0. otherwise these arrays will contain their previously set values. The problem is propagated up to ZCHANGE = 54. cm.
5. 4-stage This is the last stage of the problem. The beam enters a Nd glass rod, MAT = 3, with an experimentally measured small signal gain of 25x and therefore we set NACT = 2.682E18. The reflective loss at the front face of the rod is set at BMAG1 = .976. The initial DZ step size is faced to value of DZIN = .1 cm and the problem will be propagated a distance of ZCHANGE = 40. cm. All edits, DD80 = 14(0), will be taken every DZEDIT = 5. cm up to the end of the rod, ZEDIT = 40 cm. The maximum DZ step size allowed on this stage will be DZMAX = 2. cm. The file pointer parameter NDATA = 3HEND will instruct LAMP to end the problem at the termination of this stage. The symbol delimiter, ENDSTAGE4, may be deleted.

During propagation between the 1st and 2nd amplifier rods, the beam developed a diffractive "ripple" as shown in Fig. 9 below (this figure portrays the beam just prior to entering the 2nd amplifier). After 30. cm of propagation inside the rod, the beam has catastrophically self-focused as shown in fig. 10 and the beam energy is 4.3 joules. The DZ step size has decreased at this point to a value between 10^{-2} - 10^{-3} cm. This situation represents a DZ "crash" and the calculation was manually discontinued at this point. The calculation could have been "forced" through to completion by either setting DZMIN = .05 cm rather than the default value of 1.E-5 cm, or switching to a constant DZ step size mode, IVARDZ = 0.

FIG. 9

RADIAL INTENSITY PROFILES FOR CONSECUTIVE TIMES IN PULSE

FIG. 10 - 30 cm inside 2nd amplifier

Partially Automatic Data Input Calculation

The input data and the results for this calculation were similar to the previous calculation. The two separate datafiles used were entitled FILE1 and FILE2. The problem ID line to LAMP was,

T85 SYSTB FILE1

FILE1 contained the following input data,

```

ALL DONE
TRIX AC / 1 2
.O!FILE1
21 LINES. (80A)
.T
1   IVARDZ=1 IT=0 IR=4 DR=3.75E-3 MAT=1   NDATA = 5HFILE1
2
3   AIMAXI=1.4066E2 ESUMI=.005 SIGR=.51 SIGT=.108 TG=.4 TZ=.4
4   FIMIN=.01
5
6   JMAP=400 JZ3=120 JPHS=300 JVARDZ=200 DD80= 2 3 4 7 13 14
7   DZEDIT=15. ZEDIT=15.
8   LAMBDA=1.06E-4
9
10  RAP2=.51 ZFOCUS=-2.35E2
11
12  DZLIM=.1 JMAX=400 KMAX=31 DZIN=.5 ZCHANGE=15. DZMAX=2.
13
14
15          STAGE1
16  DD80=14(0) MAT=3 NACT=3.99E18 ZEDIT= 40.  DZEDIT= 10. BMAG1=.976
17  ZCHANGE=40.  DZIN=.1
18  NDATA=3HTTY
19          ENDSTAGE1

```

The pointer parameter NDATA = 3HTTY contained in the 1-stage input data will direct the code to enter a TTY input mode after completing the 1-stage calculation. The code-user interaction is shown below.

LAMP: STAGE NO. 1 COMPLETED...TYPE 1 TO CONT. WITH NEW INPUT, 0 TO EXIT.
 USER: 1

***** START OF NO. 2 PROBLEM STAGE *****
 LAMP: {PROB STATUS: CYCLES= 92 DIST= 5.5000E+01 CM. TIME= 1.7784E+00 MIN
 {TYPE NEW DATA FILE OR HIT LF IF NONE.

USER: (LINEFEED)

LAMP: TYPE NO OF DD80 COMMENT LINES(9 MAX). HIT LF IF NONE.

USER: (LINEFEED)

LAMP: TYPE INPUT OPTION.

USER: 1

LAMP: ..ENTER DATA. TERMINATE WITH GO.

USER: {DD80=2 3 4 7 13 14 MAT=1 ZEDIT=60. 78. DZEDIT=20. 10. BMAG1=.976
 {ZCHANGE=78. DZMAX=5. NDATA=5HFILE2 GO

LAMP: TYPE INPUT OPTION.

USER: ST

Please note that the pointer NDATA = 5HFILE2 will instruct LAMP to re-enter the automatic data input mode after completing the 2-stage and data will be input from FILE2. A listing of FILE2 is presented as follows:

```
.O!FILE2
9 LINES. (80A)
T
.1
2
3 ZEDIT=10. 0. DZEDIT=54. 0. ZFOCUS=-222. BMAG1=.953 ZCHANGE=54.
4 NDATA = 5HFILE2
5
6 STAGE4
7 DD80=14(0) MAT=3 NACT=2.682E18 ZEDIT=40. DZEDIT=5. BMAG1=.976
8 DZIN=.1 ZCHANGE=40. DZMAX=2. NDATA=3HEND
9 ENDSTAGE4
.
```

Distribution

LLL Internal

W. Bischel	L-215	
E. Bliss	L-217	
T. Burgess	L-156	
J. Creighton	L-402	
J. Emmett	L-212	
M. Feit	L-71	
J. Fleck	L-71	
A. Glass	L-215	
J. Glaze	L-217	
J. Greene	L-71	
R. Harrach	L-71	
A. C. Hausmann	L-212	
J. Holzrichter	L-217	
G. Kachen	L-215	
N. Keeler	L-71	
R. Kidder	L-71	
W. Krupke	L-212	
G. Leppelmeier	L-216	
K. Manes	L-213	
J. Morris	L-71	
R. Nelson	L-216	
W. Simmons	L-156	
G. Sommargren	L-217	
P. Thompson	L-71	(10)
J. Trenholme	L-216	
T. Wainwright	L-71	
T-Division	L-71	(3)
T.I.D.	L-9	(5)

External

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