vertical coordinates and plotting ranges. By saving the current settings and configuration before ending a DsTool session, the user may preserve virtually all the program working environment. Later, the user can restart DsTool, load the saved configuration and data file and continue working essentially as if the session had not been terminated.

Trajectories: All trajectories (whether or not they are currently displayed) are saved to the data file specified in the Filename text field. Be warned that by using this option it is easy to generate massive data files. Trajectory data is displayed in a view window whenever no coordinate of the view window is a parameter. Flow objects (generated using the Multiple Orbits Panel) are also saved when this option is chosen.

Fixed Points: All fixed points (which may be found using the Fixed Point Panel) are saved to the data file specified in the Filename text field. Fixed points are displayed in a view window whenever no coordinate of the view window are parameters. Any computed stable or unstable manifolds are also saved.

Continuation Data: All continuation trajectories (whether or not they are currently displayed) are saved to the data file specified in the Filename text field. Continuation data may be displayed in any view window, regardless of which variables are being displayed.

Parameter Data: Parameter data and selected point data are similar in that they both contain elements of the cross-product of phase and parameter space. The main difference lies in how these data sets are displayed in view windows. Parameter data is only displayed in a view window if all coordinates are parameters.

Selected Points: Selected Point data contains elements of the cross-product of phase and parameter space. If the coordinates of a view window does not consist completely of parameters, then Selected Point data are displayed in that window.

Function Values: Function values are not stored in memory but they can be written to a data file. Function values are *never* read back into DsTool; DsTool will stop reading when it encounters a function value.

- Save command button: The data of the selected data types are written from memory to the file specified in the File text field. If the file already exists, the user is presented with a notice for confirmation.

2.4 The Load Window

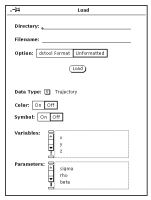

Figure 2.4: The Load Window.

Window title: Load

Function: The Load Window controls the loading of data from an external file into memory.

Description: The Load Window is opened by selecting the Load option of the File menu button located on the Command Window. Selecting the Load command button initiates the loading procedure, which is discussed in the DsTool reference Manual.

Panel items:

- Directory read-write text field: Displays the currently selected directory from which DsTool will load data. The default is the current value of the unix environmental variable `DSTOOL_DATA_DIR`.
- Filename read-write text field: Displays the currently selected file from which DsTool will load data. There is no default.
- Option exclusive setting:

  DsTool Format: The data file was saved by DsTool or is in a format which DsTool can read. (The DsTool format is discussed at greater length in the DsTool Reference Manual.) This is the default load option. If the load

window is elongated (see below), then selecting this option will return the load window to its abbreviated size.

Unformatted: Data was created by an application which wrote an ASCII data file. The data can be read into any memory object. When this option is chosen, the load window extends to reveal additional panel items which control the loading of unformatted data. Choosing this setting causes the load panel to lengthen, revealing additional panel items described below.

- Load command button: Loads data from the file specified in the Filename text field into active memory. In the event that the data does not exist, the user is presented with a notice. In the event that the data does not match the data structure of the current installed system (e.g., dimensions wrong) then an error message is displayed. If the Unformatted option is selected, then the data is loaded according to the specified unformatted options (described below).

  There are seven types of formatted data which DsTool can load: current settings data, configuration data, trajectory data, fixed point data, continuation data, parameter data, and selected point data. Current setting data is displayed on the Selected Point Window and the Defaults Settings Window. Configuration data consists of the size and placement of DsTool windows and panels. The remaining data types are discussed briefly in the Save Window section of this document (and in detail in the Reference Manual). We note here that function values are special in that they are not stored in memory but are derived from parameter and function values whenever they are needed.

  The following panel items are visible only when the user chooses the Unformatted option setting.

- Data Type stack setting: Unformatted data may be loaded into one of five data types. The value of this setting determines which data type will be filled with the unformatted data. The possible data types are trajectory, fixed point, continuation, parameter, and selected point data. The default setting is trajectory.

- Color exclusive setting: Does the unformatted data include color-coding information? If so, the color setting should be On. Each data object in DsTool has two colors associated with it: an alternating color (for use with alternating colormaps), and a "pick color" (for use with colormaps of "pick color type.") All unformatted data is assigned the current alternating color. If the data does *not* contain color-coding information, then the data is assigned the current pick color; otherwise, the pick color is determined by the color-coding information.

  Within an unformatted data file, color is coded as an integer; The integer appears immediately after all variable and parameter values. If this integer is k, then the associated data object will be color-coded with the kth color of the currently installed colormap. Obviously, $0 \leq k \leq N$ where N is the maximum number of colors in the current colormap. For the colormaps provided with DsTool, $N = 131$. As an example, if the user has specified that an unformatted data file contains fixed point data, values for the variables x and y, and color-coding information, then if the file has the line

```
0.0  0.5  12
```

then DsTool will store the data point $(x, y) = (0.0, 0.5)$ and whenever a colormap is of the pick color type, then the point $(0.0, 0.5)$ will be plotted in the 12th color of that colormap.

Trajectories cannot currently be assigned colors from within an unformatted data file; they automatically receive the current pick color. All other data objects can be assigned colors.

- Symbol exclusive setting: Does the unformatted data include symbol-coding information? If so, the symbol setting should be On. If the data does *not* contain symbol-coding information, then the data is assigned the current symbol (visible in the Defaults Setting Window); otherwise, the symbol is determined by the symbol-coding information.

  Within an unformatted data file, a symbol is coded as an integer; The integer must be the last item in the field which defines the data object. If this integer is k, then the associated data object will be symbol-coded with the kth symbol. Currently, valid symbols require $1 \leq k \leq 16$. The values $1 \leq k \leq 4$ specify dots; $5 \leq k \leq 8$ specifies triangles; $9 \leq k \leq 12$ is the range for crosses; and $13 \leq k \leq 16$ specifies boxes. In each case, there are four possible sizes, with the smaller values corresponding to smaller symbols.

  As an example, if the user has specified that an unformatted data file contains fixed point data, values for the variables x and y, and symbol-coding information, then if the file has the line

  ```
  0.0  0.5  8
  ```

  then DsTool will store the data point $(x, y) = (0.0, 0.5)$ and the point $(0.0, 0.5)$ will be plotted with the 8th symbol, which happens to be the largest triangle. If the user wanted both color *and* symbol information (say the 12th color and the 8th symbol), then the data file might read something like this:

  ```
  0.0  0.5  12  8
  ```

  As with colors, trajectories cannot currently be assigned symbols.

- Variables read-only non-exclusive list: This list contains the phase space variables of the current dynamical system. Any or all of these variables may be selected independently of each other. Unformatted data is loaded into variables in the same order as the variables appear on the list: the first number encountered is stored in the first selected variable on the list, the second number is stored on the second variable on the list, and so on. If k of these variables are selected and if j parameters are selected, then DsTool will load the first k pieces of data into the selected variable, load the next j pieces of data into the selected parameters, and then repeat the process until it reaches the end of the data. Any variables not selected are assigned their current value (visible in the Selected Point Window).

- Parameters read-only non-exclusive list: This list contains the parameters of the current dynamical system. Any or all of these parameters may be selected

independently of each other. When the load command button is pressed, DsTool proceeds as above. Unformatted data is loaded into parameters in the same order as the parameters appear on the list. Any parameters not selected are assigned their current value (visible in the Selected Point Window).

As an example, suppose a dynamical system has variables (x, y, z) and parameters (α, β, γ). If the current values of these quantities are (x_0, y_0, z_0) and $(\alpha_0, \beta_0, \gamma_0)$ and if the user specifies that an unformatted data file contains values for x, z, and γ, then a line in the file of the form

```
8.3  -2.3 0.01
```

will create a data object of the requested type and this data object will contain the variable data $(8.3, y_0, -2.3)$ and the parameter data $(\alpha_0, \beta_0, 0.01)$. Associated to the data object will be the current pick point color and the current symbol, since these quantities were not specified. See the Reference Manual for more details on how DsTool loads unformatted data.

2.5 The 2-D View Window

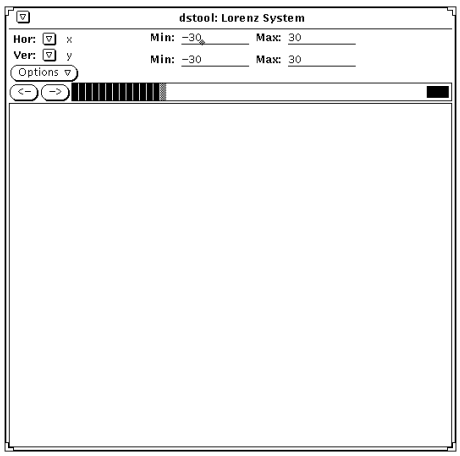

Figure 2.5: The 2-D View Window.

Window title: DsTool - *modelname*

Function: This window graphically displays computed data. The user can select the plotting coordinates from all available variables, parameters, and functions associated with the current dynamical system. Additionally, the range of each axis is displayed, and the size of the window and various other plotting options may be specified.

Description: The 2-D Window is opened by selecting the 2-D Image option of the View menu button located on the Command Window. When the window is open, data is displayed as it is computed. When iconized, the canvas is not updated. When reopened, the window will be in an identical state as when it was closed, except that the canvas will now display all appropriate currently stored data.

When the user resizes the window, the current variable ranges are maintained, but the scaling is adjusted accordingly.

There is an optional color bar which is displayed across the upper part of the drawing canvas. This bar displays the current color map associated with the view window. If the "pick colors" colormap is active then the user may select a color by clicking the SELECT mouse button while the pointer is in the desired color. The currently selected color is indicated in a rectangle at the end of the colorbar. The color bar stretches across the width of the window and has fixed height. The width is changed as the user changes the size of the window. Two arrow buttons to the left of the color bar may be used to scroll through the color bar.

As the user moves the mouse in the drawing canvas, the current coordinates of the mouse position are displayed in the window's panel. This region is blank when the mouse does not point into the canvas.

Mouse events in the main drawing canvas have the following effects:

- The SELECT button sets the direction of the integrator or iterator to "forward." It also reads the values indicated by the cursor. If one or both of these values are variables or parameters, then these values are adjusted in the current settings window. If a secondary coordinate system (such as polar coordinates) is in use, then these secondary coordinates are set. *Not yet implemented.*
- Dragging the SELECT button while holding down SHIFT creates an elastic rectangle used to rescale the window. When the user releases SELECT, a notice appears with the options to enlarge the view (the default, also known as "zoom in"), shrink the view (also known as "zoom out"), or cancel the selection. In the case of enlarge, the scaling is adjusted so that the selected region fills the canvas. If the shrink option is selected then the view is rescaled so that the whole view is put into the selected rectangle. The values in the ordinate and abscissa Min and Max text fields are updated automatically and a screen refresh is performed.
- Dragging the SELECT button while holding down CONTROL creates an elastic rectangle used to input a region for the Multiple Orbit Window. See Section 2.12 for details on this operation.
- The MENU button behaves identically to the SELECT button except that the direction of the integrator or iterator is set to "backwards."
- Clicking the ADJUST button is equivalent to selecting the Continue button on the Orbits Panel.
- Clicking the ADJUST button while holding down CONTROL deletes stored data. The actual points deleted depend upon the coordinates of the view window when the action is taken. If every coordinate of the view window is a parameter, then the action clears the parameter data. If no coordinate of the view window is a parameter, then the action clears the trajectory data. In the remaining cases, the action clears the selected point data. See the Reference Manual or Sections 2.3 and 2.4 for more information on different types of data.

Panel items:

- Hor stack setting: Allows the user to choose the coordinate of the abscissa. The user may choose between all variables, time, all parameters, and all user functions (and alternate coordinate systems if the user has specified them). The window is refreshed after the user selects the Refresh option.
- Ver stack setting: Allows the user to choose the coordinate of the ordinate. The user has the same choices as for the Hor stack setting. Again, the canvas is refreshed after the user selects the Refresh option.

- Hor Min read-write text field: Displays the current low value of the displayed range of the abscissa. The user may adjust this value. The canvas is refreshed after the user selects the refresh option.
- Hor Max read-write text field: Displays the current high value of the displayed range of the abscissa. The user may adjust this value. The canvas is refreshed after the user selects the refresh option.
- Ver Min read-write text field: Displays the current low value of the displayed range of the ordinate. The user may adjust this value. The canvas is refreshed after the user selects the refresh option.
- Ver Max read-write text field: Displays the current high value of the displayed range of the ordinate. The user may adjust this value. The canvas is refreshed after the user selects the refresh option.
- Options menu button:

  Refresh: Clears the drawing canvas and redraws with the appropriate projection of currently stored data as selected by the user in the above settings.

  Display...: Opens a 2D View Option pop-up window.

  Print...: Opens the Print Window.

  Size menu button: Use Default: Change the max and min values of the ordinate and abscissa to the default values. The default values are visible in the Defaults Settings Window.

  Set Default: Change the default max and min values of the ordinate and abscissa to the ones which are currently displayed.

2.6 The View Options Window

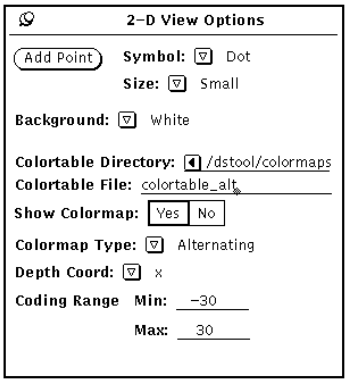

Figure 2.6: The View Options Window.

Window title: View Options

Function: This window allows the user to select display options for the 2-D or 3-D View Window.

Description: The View Options Window is opened by selecting the Display option on the Option menu button located in the View Window. If multiple 2-D or 3-D View Windows are in use, then several View Options Windows may be opened at the same time. They will be labeled or colored so that it is clear to which view window they belong. *Labels for monochrome displays not implemented.*

Panel items:

- Add Point command button: Selection of this button adds a point to a stored set of points. If only parameters are displayed, then the current parameter values are added to the parameter point list. Otherwise, the point is added to the selected point list. (Note: time is considered to be a member of phase space.)
- Symbol exclusive setting: The selection of one of these symbols determines the symbol to be associated with the point which is saved by the Add Point button. The Size setting controls the size of this symbol. The point is displayed in the view canvas by the symbol with which it is saved. The default value is a Dot. The other choices are Cross, Triangle, and Box.
- Size exclusive setting: Controls the size of the symbol selected. See the entry for the Symbol exclusive setting. The default value is Small. The other choices are Medium, Large, and Huge.

  The following panel items will not appear if DsTool is running on a monochrome display.

- Background stack setting: Allows the user to choose the background color of the viewing canvas. The default background color is white. The other choices are black and light blue.
- Colortable Directory read-write text field: This field specifies a directory containing colortables. The default is the current value of the unix environmental variable `DSTOOL_COLOR_DIR`.
- Colortable File read-write text field: This field specifies the colortable file. The file is loaded into DsTool upon hitting return while in this field. There are three colortables included with DsTool: colortable_alt, colortable_id, and colortable_iv. The default is colortable_alt. Each colortable consists of a permutation mapping into a gradient colormap. The permutation mapping for colortable_alt is a systematic "shuffle" of indices; the mapping for colortable_id is the identity mapping; and the permutation for colortable_iv maps each index to its additive inverse (modulo the number of colors).

  The user is free to design and incorporate additional colormaps into DsTool. The file `$DSTOOL/colormaps/colormap` demonstrates the correct format for colormaps: the first number in the file in the total number of entries in the colormap. Each entry is an integer triplet (r, g, b) which defines a color by specifying a proportion of red, green, and blue hues. Each of r, g, and b must be an integer between 0 and 255. Examples: the triple $(255, 0, 0)$ is pure red, $(255, 0, 255)$ is purple, $(255, 255, 255)$ is pure white, and $(0, 0, 0)$ is black.
- Show Colormap exclusive setting: Allows the user to decide whether the colormap is displayed at the top of the drawing canvas. By default, the colormap is displayed.
- Colormap Type exclusive setting: Allows the user to select the colormap type for the drawing window. If the colormap is of Alternating type, each color changes as each new trajectory is viewed. For the Pick Color type, the user must manually select the color whenever a new color is desired. For a colormap of Depth type, the user selects a coordinate as coding range as detailed below. All colormaps may be used as any of the above types. The trajectories will only take on the colors specified by this colormap after refreshing the view window. The Alternating type is the default selection.
- Depth Coord stack setting: This item is only activated if the user has selected a colormap of Depth type. Then the user may select a coding coordinate from between all the variables, parameters, and functions. Changes made to this field will only be applied to the trajectories after refreshing the view windows. By default, the first variable is selected.
- Coding Range Min read-write text field: This item is only activated if the user has selected a colormap of Depth type. This plus the item in the max field define a range over which to distribute the colors in a depth coding scheme. If the value of the coding coordinate value falls below or above the range then it is plotted in the first or last color, respectively. (By first and last, we are referring to the