Merger App Software

A Guide for Users of the

Target Preparation and Simulation Search Activities

March 3, 2013

Introduction

This guide describes how to perform the Target Preparation and Simulation Search activities of the Merger App Software. The purpose of the software is to determine likely orbit parameters that can be used to reconstruct, via simulation, the disturbed morphologies of interacting galaxies. This is accomplished by performing simple measurements on an image of the pair of galaxies. These measurements, when combined with astronomical catalog data, can be used to constrain the simulation parameters to a range of values. A search of the phase space represented by these values is conducted first with random samples used to rapidly perform simulations. The user is able to select a number of candidate matches. Through a process of review, and an optional enhancement step, the user can refine the list of candidate matches to determine the best set of simulation parameters.

Running the Software

The software is written in Java. It requires a Java Runtime Environment, version 1.6 or later. It has mainly been tested with the Sun® (now Oracle®) virtual machine, but should work with other Java implementations as well. Once you have downloaded the software package and extracted it from the archive you should see several scripts in the directory.

To launch the target preparation script on Mac/*nix systems run the `tgt.sh` script. On windows run the `tgt.bat` script. The search software is launched via the `search.sh` or `search.bat` script.

Some common problems include not having java installed (the JRE, you don't need a browser plugin) or not having version 1.6 or later available as the default java on your system. Additionally, double-clicking the scripts from a file browser may not work. You may have to open a terminal window or command prompt and execute the command that way to ensure the relative classpath definition works.

When the software runs, it will create a `.jspam` directory in your user home directory. In there is a preferences file called `merger.props`. This will be the default directory for downloading target information later on.

The function of the two activities are described below.

Target Preparation

Preparing a target will result in the creation of several image files and a text file for simulation parameter ranges. The process includes identifying the target and obtaining an image on the "Target" tab. Next the centers of each galaxy are identified and have a distance and mass set on the "Disk Info" tab. On the "Disk Orientation" tab the disk size and orientation angles are set. On the final tab, "Parameter Ranges", the software will estimate the likely ranges of the simulation parameters.

Target Tab

The first step is to assign a name to this target and then pick a directory for where these files can be saved. This information is entered in the "Target Name" box and by clicking the "Pick Dir" button at the top of the software. See Figure 1 below. Once the name is entered and the directory is picked, click Save.

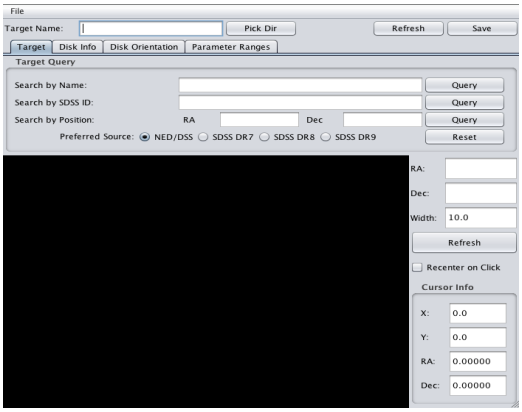

Figure 1: The target identification screen.

The next step is to query an image server and a catalog database for information about and an image of the merger of interest. The Sloan Digital Sky Survey (SDSS) provides both of these online resources for each of its data releases. The software is able to query SDSS DR7, DR8, and DR9 (when it becomes available). The software is also capable of querying imagery from the Digitized Sky Survey (DSS) of the Space Telescope Science Institute. The catalog database used to support those images is the NASA/IPAC Extragalactic Database hosted at JPL/Caltech.

To search for a target by name, type the name into the "Search by Name" box and click "Query". You can also search the SDSS object ID or by a position on the sky. To search by position enter both Right Ascension and Declination in degrees.

Clicking "Query" will retrieve an image from the image server. DSS has image data that covers the whole sky. However, SDSS does not, so when using that as your source, the query may not return imagery.

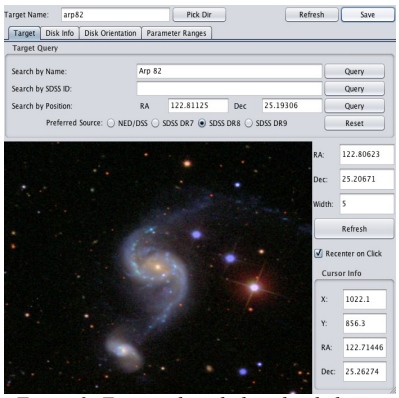

Figure 2: Target tab with downloaded image

Once an image has been downloaded, you can move the mouse cursor over the image to see the RA/Dec coordinates for each pixel. If you want to zoom on the image, the software will actually download a new copy of the image for you. Just update the value for the width, measured in arc minutes, and the software will download a new image with equal height and width. To recenter an image, make sure the check box next to "Recenter on click" is checked, and then the next time you click the left mouse button in the image, the software will download a new image centered at the RA/Dec that you clicked on. After you have the image centered on the primary or larger galaxy and scaled to show all of the features of both galaxies, click "Save" again. Figure 2 shows how it looks for Arp 82.

Disk Info

On this tab you need to identify the center of each galaxy. Start with the primary tab selected on the left. Click the "Select" button. Now, click on the image at the center of the primary galaxy. This should be close to the center of the image. Once you've selected a center, the pixel coordinates and RA/Dec should appear in the coordinates boxes.

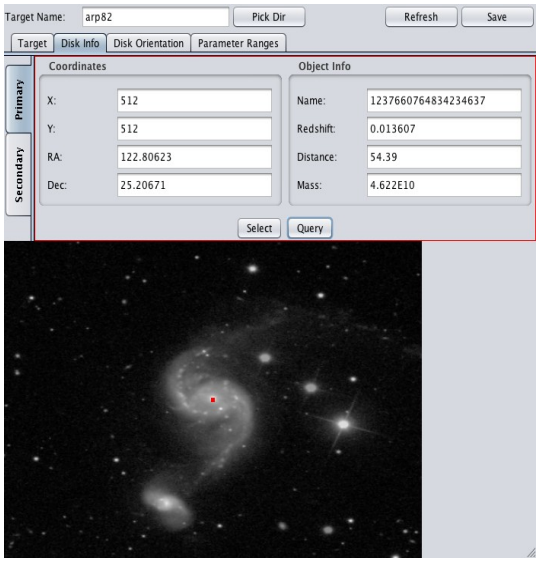

Figure 3: Disk Info with primary center selected

Next, click on the "Query" button to query the catalog database for information about the galaxy at that point in the sky. The software will retrieve the catalog name and redshift. The redshift will be converted to a distance in Mpc. This distance will be combined with apparent magnitude information from the catalog to estimate absolute magnitude. From the absolute magnitude, the mass of the galaxy will be estimated. If the query does not turn up information, you can enter it by hand. Once the primary galaxy has been identified, click on the Secondary tab and repeat the "Select" and "Query" steps. The redshifts should be similar. Click "Save" to save your work.

Disk Orientation

On this tab you will be able to remove the background of the image and set the size and shape of the initial disks for the simulation. Begin by clicking and dragging the "Background" slider up slowly. This will raise the threshold for the image floor. As the slider goes up, the less bright pixels are set to 0 brightness. Once you feel that most of the background directly around the galaxies has been removed, you can stop dragging the slider. Stars and other objects in the image that are not touching the galaxies will be removed later.

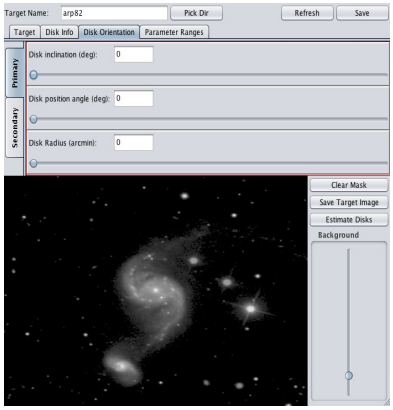

Figure 4: Disk Orientation with background level raised

If there is a star or other object in the image that is touching your galaxies, you can click and hold down the mouse while over the image to activate the eraser mode. The cursor will turn into an eraser, and you can use it to erase pixels from the image by moving your mouse while holding down the button. The figure below shows where the nearby star has been erased.

Figure 5: Image after the star to the right of the primary has been erased

If you are satisfied that the background is correctly removed and other objects have been separated from the galaxies, you can save this target image by clicking "Save Target Image". This saves only the pixels connected to the primary and secondary galaxies you defined.

Next click "Estimate Disks" to get the software to estimate disk shape and size for you.

You can adjust the orientation angles and disk size by using the sliders at the top. Generally the disk should be set to be a little bit smaller than the outer tidal features, like the tails in this image.

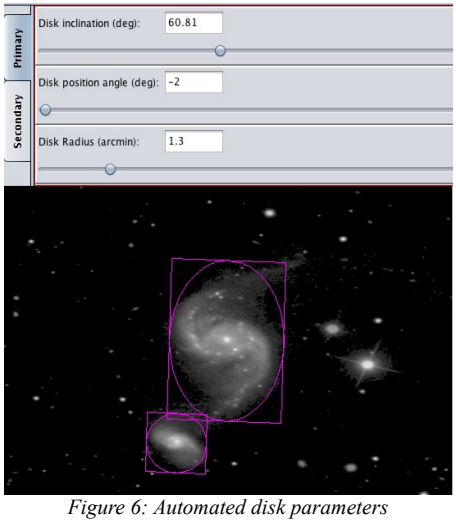

Figure 6: Automated disk parameters

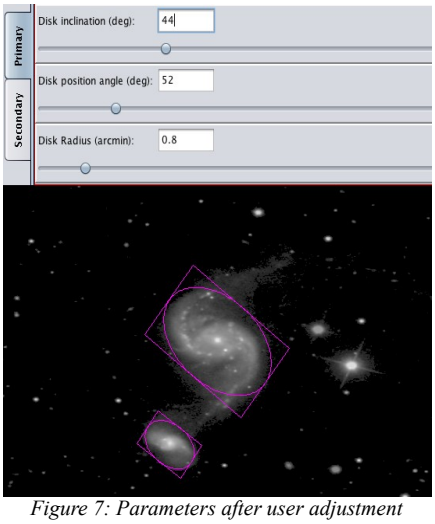

Figure 7: Parameters after user adjustment

Once you have the disk shape and size as you like it, click "Save" at the top right.

Parameter Ranges

The parameter range values are initially 0. The software will estimate ranges for you if you click "Calculate Simulation Ranges" at the bottom. Advanced users may wish to edit the ranges here. Once done, click "Save" again.

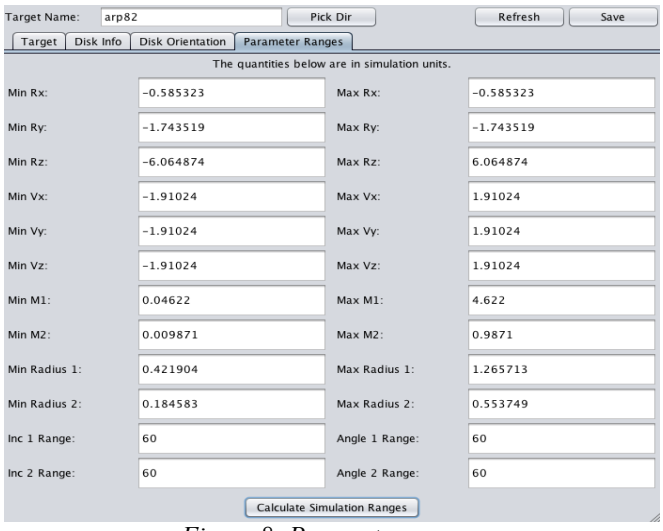

Figure 8: Parameter ranges

With the parameter ranges set, you are now ready to begin running simulations of this pair of galaxies. If you would like to redo a previous step, go back to the desired tab and make changes. If you are unsatisfied with the results after a few tries, consider starting over by exiting and relaunching the application.

Simulation Search

Using the initial conditions and parameter ranges you set up during target preparation, you can generate simulations in an attempt to match the shape of the galaxies in your target image. The process begins on the "Simulate" tab. Here you can view 8 simulations per batch and select candidate matches. There is a "Review" tab to allow you to see which simulations you have selected. The next tab is "Enhance" where you can try to improve upon the simulations that were randomly generated. On the "Evaluate" tab you will rank the simulations to determine which is the best. There is also a "Statistics" tab to let you view information about your progress.

Simulate

To begin running simulations, open the "File" menu and click on "Select Target". From this dialog browse to the directory where you saved the tgt file in the previous activity and open it. You should see your target image loaded in the center square.

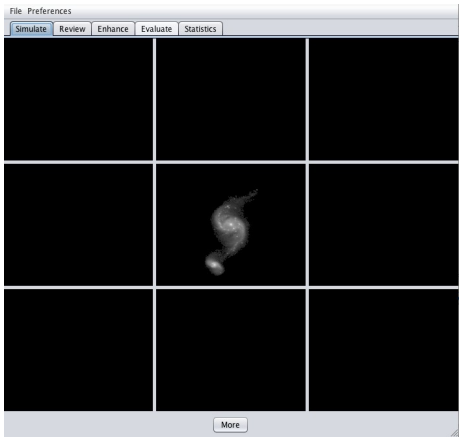

Figure 9: Simulate tab with target loaded

To have the software randomly select sets of simulation parameters and run them for you, click "More". As interesting simulations appear, you can click on them. They will be highlighted with a red box and will be added to your list of selected simulations. If you change your mind about a simulation before you click "More" again, you can click the image a second time to turn off the red highlighting and remove it from your list. The goal at this stage is not perfection. Look for simulations that have at least a hint of having the proper shape, such as a tail that is too short or in the wrong position. Maybe you can find a simulation where the primary is correct, but the secondary is not. Add it to your selected list. You will need to review about 1000 simulations to develop several dozen candidate matches.

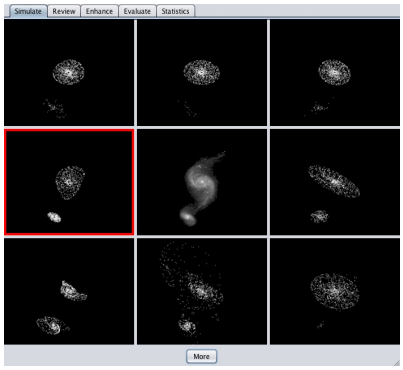

Figure 10: Simulate screen with selected simulations

Preferences

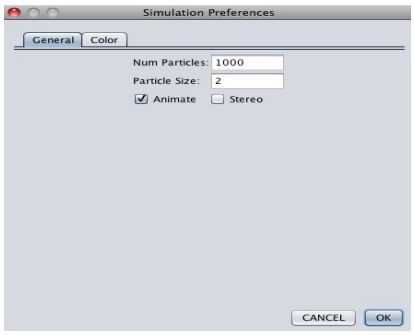

Figure 11: Preferences

The Preferences menu will let you edit simulation preferences. You can set the number of particles in each simulation and the size of the particles. There is an option to turn the animation on and off. You can also view the simulations in red/blue stereo if you have red/blue 3D glasses available. The "Color" tab will let you set the color for the simulation particles.

Review

The "Review" tab allows you to see the list of selected simulations. As you progress through the "Evaluate" activity, the order of simulations in the list will change so that the best simulations are at the top. To select a simulation for use on the "Enhance" tab, click on it and a yellow highlight box will appear around it.

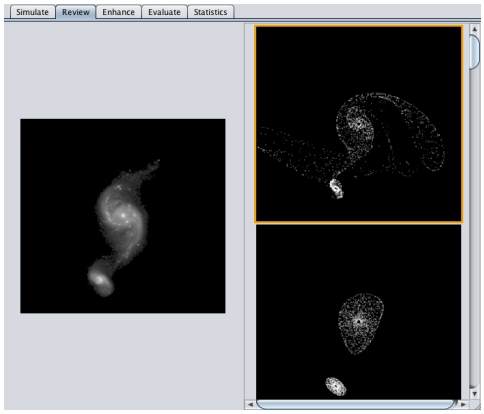

Figure 12: Review Tab

Enhance

The "Enhance" tab allows you to alter the simulation parameters in an attempt to improve the match with the target image. On the interactive simulation screens like this one and on the "Simulate" tab, if you click and hold down the mouse you can rotate the simulation in 3D to see if from different angles. The "Reset View" button under the simulation will return it to its default position. Clicking "More 'Stars'" will rerun the simulation using more particles. Clicking "Fewer 'Stars'" will do the opposite. The increase in particle number is only temporary to provide an enhanced view of the simulation.

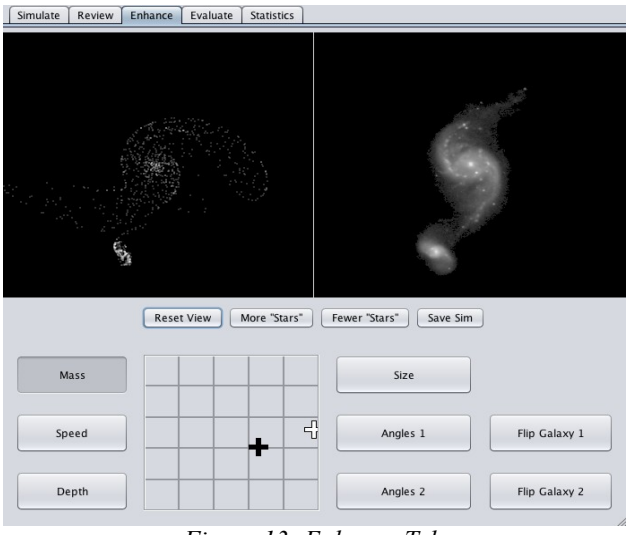

Figure 13: Enhance Tab

Simulation parameters are available to alter two at a time. Clicking on the various toggle buttons: Mass, Speed, Depth, Size, Angles 1, and Angles 2, will allow you to edit their values. There are tooltips available to explain which parameters are active. To adjust the values, click on the black cross symbol, hold the mouse down, and then drag it around the gridded area. The tool tips will indicate which values are edited by moving up and down or left and right. Depending on the speed of your computer, the simulations will update immediately while you move the cursor around. Sometimes you may have to wait a few seconds after you stop moving the cursor for the simulation to catch up. The flip buttons allow you to reverse the rotation direction of galaxy 1 and 2 independently. If you think you've improved the simulation, click "Save Sim" to add it to the list of selected simulations.

Evaluate

After you've selected at least 8 simulations, you can use the "Evaluate" tab to sort them by quality or fitness. This is accomplished by judging a series of head-to-head comparisons. Two simulations are displayed at a time. If you think the simulation on the left is better, click on it. If you think the one n the right is better, click on it. If you think neither simulation is particularly good, you can click on "Neither is a Good Match". Through a series of these competitions a fitness score is accumulated for each simulation. The ones that are more often judged to be the best will rise to the top.

The scoring algorithm does not have a termination condition. As you add more simulations, you will need to come back to this activity to properly evaluate them. For a given set of simulations, the more competitions you judge, the more accurate your score for them will be.

Figure 14: Evaluate Screen with Merger Wars

Statistics

The "Statistics" tab provides information on your progress. The number of random sims rejected refers to simulations that were evaluated by the system to have too small of an impulse to generate an interesting simulation and were never shown to you. The number of simulations run is how many you have seen on the "Simulate" tab. The number selected refers to how many you have clicked on. The number enhanced refers to how many you have added from the "Enhance" tab. The number evaluated refers to how many have had a score assigned. The number of merger wars competitions refers to the number of clicks you done on the "Evaluate" tab.

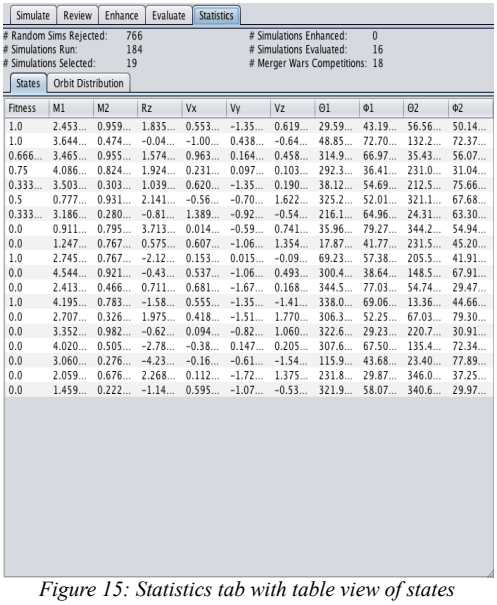

Figure 15: Statistics tab with table view of states

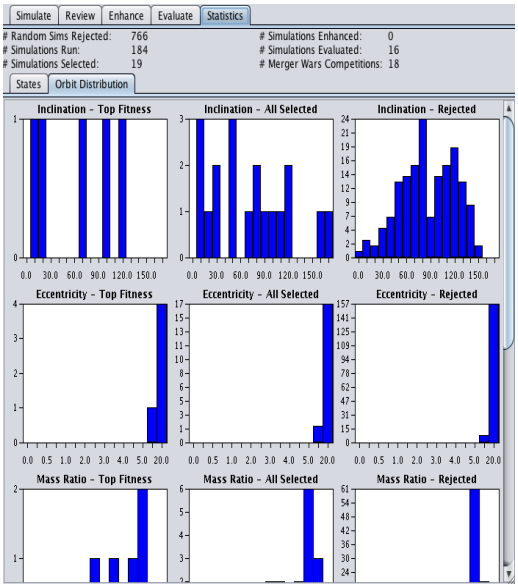

Figure 16: Statistics tab with histogram view

Saving

Once you are satisfied with your results, you can save the set of simulation parameters in a text file. Each row will have a comma separated list of simulation parameters that you can use with the SPAM simulation software to recreate your target galaxy. The order of simulation parameters in the file is by fitness, with the best ones on top.

About the Software

The software was developed by Anthony Holincheck. You can contact him via email at aholinch@masonlive.gmu.edu. It is based on the tools and interfaces he created for the Galaxy Zoo Mergers[1] project of the Zooniverse[2]. The software for computing the simulations is known as SPAM. It is described in the first two references below. The goals of the Galaxy Zoo Mergers project are discussed in the other reference. The SPAM code is available on the Astrophysics Source Code Library[3]. The author plans to soon make the Target Preparation and Simulation Search software available there as well.

References

Holincheck, A. J., Wallin, J. F., 2013. SPAM: A restricted three-body code for simulating interacting galaxies. In preparation.

Wallin, J. F.,1990. Dynamical and photometric models of star formation in tidal tails. Astrophysical Journal. 100, 1477-1488.

Wallin, J.F., et al., 2010. Tasking Citizen Scientists from Galaxy Zoo to Model Galaxy Collisions. In: Smith, B., Bastian, N., Higdon, S., and Higdon, J. (Eds.), Galaxy Wars: Stellar Populations and Star Formation in Interacting Galaxies, ASP. 423, 217-222.

1 http://mergers.galaxyzoo.org
2 http://www.zooniverse.org
3 http://asterisk.apod.com/viewforum.php?f=35