Appreciating Hubble At Hyper-speed ($AHaH$) User Manual v. 1.0

Mira R. Mechtley[1], Liam J. Nolan[1], Rogier A. Windhorst[1], Karen Knierman[1], Teresa A. Ashcraft[1], Seth H. Cohen [1], Scott Tompkins [1], and Lisa M. Will[2]

ljnolan@asu.edu

1. $AHaH$ User Manual

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1 * System Requirements


The following are the minimum system requirements to run the Appreciating
Hubble at Hyper-speed application:


* Microsoft Windows, Mac OS, or *nix operating system with Sun Java
run time version 1.4.3 or later
* 1.0 GHz processor
* 256 MB RAM
* Mouse and Keyboard


We recommend the following for optimal system performance:


* 2.0 GHz dual-core processor
* 1.0 GB RAM
* Graphics accelerator card with 64 MB video RAM


In addition, an internet connection is required if the user wishes to view
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[1]School of Earth and Space Exploration, Arizona State University, Tempe, AZ 85287-1404

[2]San Diego City College, San Diego, CA 92101

extended information about selected galaxies.

2 * Installing and Running the Application

The Appreciating Hubble at Hyper-speed application is distributed as an
archive containing a standard executable Java resource file. To install the
application, simply download the archive file for the user's operating
system and save it wherever preferred. Extract the archive wherever desired,
and then double-click the ahah.jar file to run the program. If the user
prefers to run from the command line, then simply use: java -jar ahah.jar
For further details on the installation, see subsection 9 below.

Also provided is a configuration file, ahah.conf, that provides several
options that the user may modify if the user wants to use custom settings
every time they run the program. See the Configuration File section for more
information.

3 * Main Screen and User Interface

The main screen represents the user's primary interface with the application.
Besides holding the actual visualization, the screen also provides various
forms of information about the simulation and methods to interact with and
gain more information about specific galaxies.

The numbered user interface elements are as follows:

1. Position Indicator, showing the camera's x and y position within the
coordinate system, as well as the camera's redshift.
2. Active Geometry Indicator, showing whether the Universe's real
geometry is active or a non-physical geometry, in which angular
sizes are unaffected by the Universe's expansion.
3. Info Box that shows more information about the selected galaxy,
including its HUDF ID, redshift, and comoving radial distance.
4. Jump Dialog, where the user may enter an Object ID or redshift on
  which to center the camera.
5. Speed Indicator. Used to remind the user that the speeds represented
in the application (when moving) are not physically attainable.

4 * Moving the Camera

The user may move the camera using either the mouse or keyboard, or with a combination of both. We recommend that most users navigate with the mouse, though advanced users may find the precision movement afforded by the keyboard useful in some situations.

To navigate using the mouse, simply click and hold the left mouse button anywhere within the Main Screen. Moving the mouse will then move the camera left, right, up, and down. To move forward and backward, either scroll the mouse wheel up and down, or click and hold the mouse wheel or middle mouse button, then move the mouse forward and backward. The user may also move forward and backward by holding shift while clicking and holding the left mouse button.

To navigate using the keyboard, simply use the arrow keys to move left, right, up, and down. To move forward and backward, hold shift and use the up and down arrow keys. Holding control while using keyboard navigation will move the camera at 10x the normal speed.

In addition to direct navigation, the user may double left-click on any galaxy to initiate an automatic move to it. This will move the camera at a moderate pace along the line (geodesic) between the camera and the galaxy. The automatic move can be canceled at any time by performing most other actions, such as attempting to move the camera or selecting a galaxy. Note that toggling the spatial geometry mode will not cancel an automatic movement.

5 * Hot keys and Special Functions

The application contains a number of additional features besides moving the camera, most of which are accessed using hot keys. The following table contains an overview of these additional features and their hot keys:

Program Feature:	Hot keys
Select a galaxy and open its Info Box:	Left-click galaxy
Toggle spatial geometry mode:	G
Open Jump Dialog to travel to a specific galaxy/redshift:	J
Reset the simulation and move the camera to the origin:	R or F5
Open the Help and Options Dialog:	H or F1

Info Box

The Info Box contains various information about the selected galaxy:

* The Object ID is a number uniquely identifying each galaxy and can be used in conjunction with the Jump Dialog to direct another user to a specific galaxy.
* The Redshift represents the factor by which a galaxy's observed spectrum is shifted from what we would observe if it were nearby. It is this measurement that allows us to calculate distances to galaxies using Hubble's law.
* The Comoving Radial Distance represents the spatial separation of the galaxy from the origin at the present epoch, assuming zero peculiar velocity with respect to our own galaxy. It is calculated using the currently active cosmology constants.
* The Stamp Size is the length of one side of the black box surrounding the galaxy's picture. Thus if a galaxy takes up roughly half the width of the box and has a stamp size of 30 kpc, its proper transverse diameter should be about 15 kpc.
* The More Information Link links to a web page containing additional data for the selected galaxy. This includes its position (J2000 RA and Dec coordinates) and spectral fitting data. Note that not all galaxies have this additional information available. Specifically, it is available only for those galaxies that were included in the GRAPES survey, which are most of the brighter, larger galaxies.
* The Jump Button moves the camera to a view centered on the selected galaxy, exactly as if the galaxy's ID number had been entered into the Jump Dialog.

Spatial Geometry Mode

Toggling the spatial geometry mode changes between the Universe's actual geometry and a geometry where angular sizes are unaffected by the expansion of the Universe. This second geometry does not have a physical analogue -- it does not represent what the Universe would look like if it were not expanding, or any other such set of circumstances. Instead, it is provided simply to convey visually that observed angular sizes have been affected by the scale factor.

Jump Dialog

The Jump Dialog is a way to quickly move to a specific location. If the user enters an Object ID number, then the simulation will move the camera to a position centered on that object. This is useful for labs that require students to examine a number of specific galaxies. If no Object ID is entered then the simulation will move the camera to the specified redshift, leaving the x and y coordinates fixed.

Resetting

Using the reset function will reset the simulation, exactly as if the application had been newly opened. This includes reloading all galaxies -- both images and position data -- as well as recalculating all distances and moving the camera to the origin. It also resets the graphics rendering thread, so may be used in the event that images fail to update.

Help and Options Dialog

The Help and Options Dialog gives the user basic information about running the application, such as movement controls, as well as allowing the user to modify some of the simulation's configuration parameters at run time. It is discussed in detail in the next section. In addition, the license for the software is also provided in this dialog.

6 * Changing Options and Settings

There are two primary ways of changing options and settings for the application. These are the Configuration File, which will be covered in the next section, and the options pane of the Help and Options Dialog. The options pane contains two primary sections, Cosmology Parameters and Program Performance.

Cosmology Parameters

The Cosmology Parameters section allows the user to modify certain constants of the displayed cosmology. There are currently four parameters that may be modified at run time:

* H0 is the Hubble Constant, which goes into Hubble's Law v = H0*D relating recessional velocity v and distance D. It is also used when obtaining proper distances from coordinate distances within the application.

Its units are km/s/Mpc.
* OmegaM is the matter density parameter of the Universe. It represents what
fraction of the total energy density of the Universe is attributable
to matter, both baryonic and dark. The Planck (2018) value is
OmegaM = 0.32.
* OmegaLambda is the so-called vacuum energy density parameter of the
Universe. It represents what fraction of the total energy density of the
Universe is attributable to dark energy, ie. expansion energy
associated with the Cosmological Constant, Lambda. The Planck (2018) value
is OmegaLambda = 0.68.
* OmegaR is the radiation density parameter of the Universe. It represents
what fraction of the total energy density of the Universe is
attributable to radiation.

The curvature parameter, OmegaK is derived from these supplied parameters
internally as OmegaK = 1 - (OmegaM + OmegaLambda + OmegaR). Most changes to these
parameters will result in rather subtle visual effects -- they will manifest
primarily as changes to the comoving radial distance in a galaxy's Info Box.
Curvatures that are very large in magnitude (|OmegaK| >> 1) may result in more
marked visual differences.

Program Performance

The Program Performance section contains one value that may be changed at
run time -- the Cull Size. It sets the smallest size in pixels for which a
galaxy's image will be displayed -- if a galaxy's size is smaller than the
Cull Size, the galaxy will be displayed as a single pixel of its averaged
color. Modification of this value is provided as a way to adjust the speed
at which the application runs. The most CPU-intensive task is resizing and
displaying images, so by increasing the Cull Size the user may decrease the
number of displayed images and thus increase the speed of the simulation.
Note that decreasing the Cull Size will provide better visuals but could
potentially slow the application down significantly.

7 * Configuration File and Advanced Options

In addition to run time options in the Help and Options Dialog, the user
may create or download an optional configuration file to modify the
application's default behavior. This file is simply a specially formatted
text file called ahah.conf that must be placed in the same directory as

ahah.jar. The options are placed in the file as Key : Value pairs separated
by a colon. For example the line OmegaM : 0.32 sets OmegaM to 0.32, the
currently accepted Planck (2018) value. Comments within the file are preceded by
and section headings (optional) are placed in brackets, such as [Cosmology
Constants]. Keys other than those below will simply be ignored, and giving a
key an improper value (such as a floating point number where an integer is
required) will cause the application to print an error and then use the
default value. The available options are as follows:

Application Operation Options

Options in this section change the default behaviors of how the application
runs, including performance tweaks. If AHaH is to be shown to students that
are taught over the internet via a Zoom-like application, this parameter has
to be chosen judiciously, as the demonstrated performance of AHaH will now
be limited by the local internet speed, and not the host's computer speed.

* FrameSleepTime is an integer that specifies the time in milliseconds
to wait between redraws of the main simulation window. A shorter
time will update the viewport more often, but be more taxing on the
CPU. Modifying the default value may affect performance drastically.
* MacroStepDelay is an integer that specifies the time in milliseconds
to wait between steps of an automatic move (when double-clicking on
a galaxy). A shorter time will result in smoother, faster movement.
* CullSize is an integer that specifies the default Cull Size, as
discussed in the Options and Settings section above. This way if the
user has a particularly fast computer, they can force the
application to use a smaller Cull Size every time they run it. Thus
the user would not have to open the Help and Options Dialog to
change it every time. Note that modifying the value at run time
using the Help and Options Dialog will always override any value in
the configuration file.
* DefaultBrowser is a string representing the user's preferred browser
command on any Unix or Linux systems. If the user does not change
this setting themselves, the application will try, in order the
following browsers: firefox, mozilla, opera, konqueror, epiphany,
netscape. The value set in the configuration file is simply any
shell command, so may be something in $PATH like firefox, or the
full path such as: /usr/local/share/firefox/firefox. On Windows
and Mac OS, the operating system's default browser is always used,

so modifying this setting will have no effect.

Cosmology Constants

Options in this section set the defaults for various cosmology constants.
For more detailed explanations, see the descriptions for the parameters in
the Options and Settings section above. Like the Cull Size, changing the
values at run time using the Help and Options Dialog will override settings
in the configuration file. The default Planck (2018) parameters are: H0 = 68
km/sec/Mpc, Omega_M = 0.32, Omega_Lambda = 0.68, and Omega_R = 9 x 10^-5.

* HNought is a floating point number that specifies the default value of
the Hubble Constant, H0.
* OmegaM is a floating point number that specifies the default value of
the matter density parameter, OmegaM.
* OmegaV is a floating point number that specifies the default value of
the vacuum energy density parameter, OmegaLambda.
* OmegaR is a floating point number that specifies the default value of
the radiation density parameter, OmegaR.

Dataset Information

Options in this section give the application information about the original
image that the individual stamps come from, as well as specifying where to
find the object database. Options from this section should generally not be
changed by users -- they are provided for future use of the application with
different data.

* DBFile is a string representing the path of the database file within
the jar file. This should only be modified if the application is
repackaged with different data. The file should be specified with
the root of the path being the root of the jar file, not of the
computer's file system.
* ImageSizePx is an integer specifying the height and width of the
original image in pixels. If for some reason the image is not
square, use whichever dimension is larger.
* ImageArcsecPerPx is a floating point number that specifies the
arcsec/pix scale of the original image. This is used internally for
changing pixel sizes to angular sizes and vice versa.
* MaxRedshift in an integer that specifies the maximum redshift for the

distance tables. This need only be sufficiently large such that no
object in the database has a higher redshift (as the program may
then crash since it would not be able to correctly interpolate the
object's distance).

Application Configuration Constants

Options in this section change aspects of the application that users
generally do not need to modify, such as the locations of external resources
like this documentation. These options are provided primarily as a
convenience to website administrators in the event that URLs change, etc.

* StampURLBase is a string that specifies the directory containing the
More Information html files for galaxies. The provided string must
contain the trailing /. The application expects the html files
within this directory to be named n.html, where n is the HUDF ID
number of the object.
* HelpURL is a string that indicates the url of the application's online
documentation, i.e. this page.
* TextColor is a hex code that defines the color of the text on the Main
Screen. The value is standard RGB hex encoding (like in HTML and
CSS), i.e. RRGGBB. For instance a deep purple would be encoded as
TextColor : 6633aa.

8 * License, Source Code, and Modifications

The Appreciating Hubble at Hyper-speed (AHaH) application is provided under a
BSD-like license. In simple terms, this means that virtually any
modification or redistribution of the application is permitted, with the
following caveats:

* Any redistribution must retain the original copyright notice and
license file, either with the source code or with the documentation
in the case of binary distributions.
* The names of the copyright holders, contributors, and associated
institutions may not be used to endorse or promote any derivative
works without prior permission.

Note that there is no requirement that source code be provided with any

derivative work or redistribution. We encourage any derivative works to
provide source code as well so that others may learn from the user's
modifications, but we leave such decisions to the user's discretion.

9.a Application Source Code (All OS, Mac Terminal Users)

The application's source code is provided with the standard distribution.
Java archives are simply standard ZIP (DEFLATE) archives with a special
internal directory structure. Thus, the user only needs to extract the contents
of the archive using their favorite ZIP extractor. (Using jar, the user would
simply run: jar -xf ahah.jar). The application source code is contained
in the src/ directory.

Warning: The ahah.jar file exhibits "tarbomb" behavior, extracting to the
current directory instead of its own subdirectory. This is mostly a
limitation of the jar format, since the META-INF/ directory must always be
in the archive root. We strongly recommend the user moves the archive to its own
directory before extracting it.

To compile the source the user simply needs to run in terminal mode:
javac *.java. The compiled binaries will automatically be placed within the
directory edu/asu/Ahah/. To run the modified application, the user then needs to
create a new jar including the directories edu/, images/, and data/, as well as
the files defaults.conf and license.txt, and any source code if the user desires.
The user also needs to specify a Manifest file, which must contain at least
the line Main-Class: edu.asu.Ahah.Ahah -- this tells the Java interpreter
where to find the main class when a user runs the jar. An example jar
creation command is:

jar -cvfm ahah.jar MANIFEST.MF edu images data src defaults.conf license.txt

9.b Application Source Code (Mac GUI Users)

Some users have reported some issues with launching AHaH from modern Mac
operating systems. We include here detailed instructions (as of OS 10.14.6)
for use of the tool. Note: the user must have administrative access to the
Mac in question -- with full download rights.

* Download the ahah_Mac_iOS.zip file from the AHaH website (use the lower
   download button)

* Double-click on the file, opening a new window with AHaH and the user's Applications folder
* Drag AHaH to the Applications folder, close this window
* Navigate to the Applications folder and double-click AHaH
* If the user gets an error that the user needs the legacy version of Java, close the error, navigate to java.com, and install Java
* Double-click again on AHaH in the Applications folder
* If a similar error occurs as before, click the now available more information option
* This should bring the user to the legacy Java installation, which the user should complete
* Double-click on AHaH again, and close the permissions error
* Navigate to the user's System Preferences menu
* Navigate to the Security & Privacy submenu
* Where the page says AHaH was blocked from running, and click "Open Anyway"