Here goes the title

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1. INTRODUCTION

LaTeX was written in 1985 by Leslie Lamport who based it on the TeX typesetting language which itself was created by Donald E. Knuth in 1978. In 1988 a suite of LaTeX macros were developed to investigate electronic submission and publication of AAS Journal articles (Hanisch & Biemesderfer 1989). Shortly afterwards, Chris Biemesdefer merged these macros and more into a LaTeX 2.08 style file called AASTeX. These early AASTeX versions introduced many common commands and practices that authors take for granted today. Substantial revisions were made by Lee Brotzman and Pierre Landau when the package was updated to v4.0. AASTeX v5.0, written in 1995 by Arthur Ogawa, upgraded to LaTeX 2e which uses the document class in lieu of a style file. Other improvements to version 5 included hypertext support, landscape deluxetables and improved figure support to facilitate electronic submission. AASTeX v5.2 was released in 2005 and introduced additional graphics support plus new mark up to identifier astronomical objects, datasets and facilities.

2. FLOATS

Floats are non-text items that generally can not be split over a page. They also have captions and can be numbered for reference. Primarily these are figures and tables but authors can define their own. LaTeX tries to place a float where indicated in the manuscript but will move it later if there is not enough room at that location, hence the term "float".

Authors are encouraged to embed their tables and figures within the text as they are mentioned. Please do not place the figures and text at the end of the article as was the old practice. Editors and the vast majority of referees find it much easier to read a manuscript with embedded figures and tables.

Depending on the number of floats and the particular amount of text and equations present in a manuscript the ultimate location of any specific float can be hard to predict prior to compilation. It is recommended that authors textbfnot spend significant time trying to get float placement perfect for peer review. The AAS Journal's publisher has sophisticated typesetting software that will produce the optimal layout during production.

Note that authors of Research Notes are only allowed one float, either one table or one figure.

For authors that do want to take the time to optimize the locations of their floats there are some techniques that can be used. The simplest solution is to placing a float earlier in the text to get the position right but this option will break down if the manuscript is altered. A better method is to force LaTeX to place a float in a general area with the use of the optional `[placement specifier]` parameter for figures and tables. This parameter goes after `\begin{figure}`, `\begin{table}`, and `\begin{deluxetable}`. The main arguments the specifier takes are "h", "t", "b", and "!". These tell LaTeX to place the float here (or as close as possible to this location as possible), at the top of the page, and at the bottom of the page. The last argument, "!", tells LaTeX to override its internal method of calculating the float position. A sequence of rules can be created by using multiple arguments. For example, `\begin{figure}[htb!]` tells LaTeX to try the current location first, then

the top of the page and finally the bottom of the page without regard to what it thinks the proper position should be. Many of the tables and figures in this article use a placement specifier to set their positions.

Note that the LaTeX `tabular` environment is not a float. Only when a `tabular` is surrounded by `\begin{table}` ... `\end{table}` is it a true float and the rules and suggestions above apply.

In AASTeX v6.3 all deluxetables are float tables and thus if they are longer than a page will spill off the bottom. Long deluxetables should begin with the `\startlongtable` command. This initiates a longtable environment. Authors might have to use `\clearpage` to isolate a long table or optimally place it within the surrounding text.

2.1. *Tables*

Tables can be constructed with LaTeX's standard table environment or the AASTeX's deluxetable environment. The deluxetable construct handles long tables better but has a larger overhead due to the greater amount of defined mark up used set up and manipulate the table structure. The choice of which to use is up to the author. Examples of both environments are used in this manuscript.

Tables longer than 200 data lines and complex tables should only have a short example table with the full data set available in the machine readable format. The machine readable table will be available in the HTML version of the article with just a short example in the PDF. Authors are required to indicate in the table comments that the data in machine readable format in the full article. Authors are encouraged to create their own machine readable tables using the online tool at http://authortools.aas.org/MRT/upload.html.

AASTeX v6 introduced five new table features that were designed to make table construction easier and the resulting display better for AAS Journal authors. The items are:

1. Declaring math mode in specific columns,
2. Column decimal alignment,
3. Automatic column header numbering,
4. Hiding columns, and
5. Splitting wide tables into two or three parts.

Full details on how to create each type are given in the following sections. Additional details are available in the AASTeX guidelines at http://journals.aas.org/authors/aastex.html

2.1.1. *Column math mode*

Both the LaTeX tabular and AASTeX deluxetable require an argument to define the alignment and number of columns. The most common values are "c", "l" and "r" for center, left, and right justification. If these values are capitalized, e.g. "C", "L", or "R", then that specific column will automatically be in math mode meaning that $s are not required. Note that having embedded dollar signs in the table does not affect the output.

2.1.2. *Decimal alignment*

Aligning a column by the decimal point can be difficult with only center, left, and right justification options. It is possible to use phantom calls in the data, e.g. `\phn`, to align columns by hand but

this can be tedious in long or complex tables. To address this AASTEX introduces the `\decimals` command and a new column justification option, "D", to align data in that column on the decimal. In deluxetable the `\decimals` command is invoked before the `\startdata` call but can be anywhere in LaTEX's tabular environment.

Two other important thing to note when using decimal alignment is that each decimal column *must end with a space before the ampersand*, e.g. "&&" is not allowed. Empty decimal columns are indicated with a decimal, e.g. ".". Do not use deluxetable's `\nodata` command.

The "D" alignment token works by splitting the column into two parts on the decimal. While this is invisible to the user one must be aware of how it works so that the headers are accounted for correctly. All decimal column headers need to span two columns to get the alignment correct. This can be done with a multicolumn call, e.g `\multicolumn2c{}` or `\multicolumn{2}{c}{}`, or use the new `\twocolhead{}` command in deluxetable. Since LaTEX is splitting these columns into two it is important to get the table width right so that they appear joined on the page. You may have to run the LaTEX compiler twice to get it right.

2.1.3. *Automatic column header numbering*

The command `\colnumbers` can be included to automatically number each column as the last row in the header. Per the AAS Journal table format standards, each column index numbers will be surrounded by parentheses. In a LaTEX tabular environment the `\colnumbers` should be invoked at the location where the author wants the numbers to appear, e.g. after the last line of specified table header rows. In deluxetable this command has to come before `\startdata`. `\colnumbers` will not increment for columns hidden by the "h" command, see Section 2.1.4.

Note that when using decimal alignment in a table the command `\decimalcolnumbers` must be used instead of `\colnumbers` and `\decimals`.

2.1.4. *Hiding columns*

Entire columns can be hidden from display simply by changing the specified column identifier to "h". In the LaTEX tabular environment this column identifier conceals the entire column including the header columns. In AASTEX's deluxetables the header row is specifically declared with the `\tablehead` call and each header column is marked with `\colhead` call. In order to make a specific header disappear with the "h" column identifier in deluxetable use `\nocolhead` instead to suppress that particular column header.

Authors can use this option in many different ways. Since column data can be easily suppressed authors can include extra information and hid it based on the comments of co-authors or referees. For wide tables that will have a machine readable version, authors could put all the information in the LaTEX table but use this option to hid as many columns as needed until it fits on a page. This concealed column table would serve as the example table for the full machine readable version. Regardless of how columns are obscured, authors are responsible for removing any unneeded column data or alerting the editorial office about how to treat these columns during production for the final typeset article.

Table 1 provides some basic information about the first ten Messier Objects and illustrates how many of these new features can be used together. It has automatic column numbering, decimal alignment of the distances, and one concealed column. The Common name column is the third in the LaTEX deluxetable but does not appear when the article is compiled. This hidden column can

Table 1. Fun facts about the first 10 messier objects

Messier Number	NGC/IC Number	Object Type	Distance (kpc)	Constellation	V (mag)
(1)	(2)	(3)	(4)	(5)	(6)
M1	NGC 1952	Supernova remnant	2	Taurus	8.4
M2	NGC 7089	Cluster, globular	11.5	Aquarius	6.3
M3	NGC 5272	Cluster, globular	10.4	Canes Venatici	6.2
M4	NGC 6121	Cluster, globular	2.2	Scorpius	5.9
M5	NGC 5904	Cluster, globular	24.5	Serpens	5.9
M6	NGC 6405	Cluster, open	0.31	Scorpius	4.2
M7	NGC 6475	Cluster, open	0.3	Scorpius	3.3
M8	NGC 6523	Nebula with cluster	1.25	Sagittarius	6.0
M9	NGC 6333	Cluster, globular	7.91	Ophiuchus	8.4
M10	NGC 6254	Cluster, globular	4.42	Ophiuchus	6.4

NOTE—This table "hides" the third column in the LaTeX when compiled. The Distance is also centered on the decimals. Note that when using decimal alignment you need to include the `\decimals` command before `\startdata` and all of the values in that column have to have a space before the next ampersand.

be shown simply by changing the "h" in the column identifier preamble to another valid value. This table also uses `\tablenum` to renumber the table because a LaTeX tabular table was inserted before it.

2.1.5. *Splitting a table into multiple horizontal components*

Since the AAS Journals are now all electronic with no print version there is no reason why tables can not be as wide as authors need them to be. However, there are some artificial limitations based on the width of a print page. The old way around this limitation was to rotate into landscape mode and use the smallest available table font sizes, e.g. `\tablewidth`, to get the table to fit. Unfortunately, this was not always enough but now along with the hide column option outlined in Section 2.1.4 there is a new way to break a table into two or three components so that it flows down a page by invoking a new table type, splittabular or splitdeluxetable. Within these tables a new "B" column separator is introduced. Much like the vertical bar option, "|", that produces a vertical table lines the new "B" separator indicates where to Break a table. Up to two "B"s may be included.

Table 2 shows how to split a wide deluxetable into three parts with the `\splitdeluxetable` command. The `\colnumbers` option is on to show how the automatic column numbering carries through the second table component, see Section 2.1.3.

2.2. *Figures*

Authors can include a wide number of different graphics with their articles but encapsulated postscript (EPS) or portable document format (PDF) are encouraged. These range from general

Table 5. Measurements of Emission Lines: two breaks

Model	Component	Shift	FWHM	Flux	N V	Si IV	C IV	Mg II	Hγ	Hβ	Hα	He I	Paγ
		(km s^{-1})	(km s^{-1})	(10^{-17} erg s^{-1} cm^{-2})									
				Lyα									
(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)	(10)	(11)	(12)	(13)	(14)
Model 1	BELs	-97.13	9117±38	1033±33	< 35	< 166	637±31	1951±26	991±30	3502±42	20285±80	2025±116	1289±107
	IELs	-4049.123	1974±22	2495±30	< 42	< 109	995±186	83±30	75±23	130±25	357±94	194±64	36±23
	NELs	···	641±4	449±23	< 6	< 9	–	275±18	150±11	313±12	958±43	318±34	151±17
Model 2	BELs	-85	8991±41	988±29	< 24	< 173	623±28	1945±29	989±27	3498±37	20288±73	2047±143	1376±167
	IELs	-51000	2025±26	2494±32	< 37	< 124	1005±190	72±28	72±21	113±18	271±85	205±72	34±21
	NELs	52	637±10	477±17	< 4	< 8	–	278±17	153±10	317±15	969±40	325±37	147±22

Note—This is an example of how to split a deluxetable. You can split any table with this command into two or three parts. The location of the split is given by the author based on the placement of the "B" indicators in the column identifier preamble. For more information please look at the new AASTEX instructions.

figures all authors are familiar with to new enhanced graphics that can only be fully experienced in HTML. The later include figure sets, animations and interactive figures. All enhanced graphics require a static two dimensional representation in the manuscript to serve as the example for the reader. All figures should include detailed and descriptive captions. These captions are absolutely critical for readers for whom the enhanced figure is inaccessible either due to a disability or offline access. This portion of the article provides examples for setting up all these types in with the latest version of AASTEX.

2.3. *General figures*

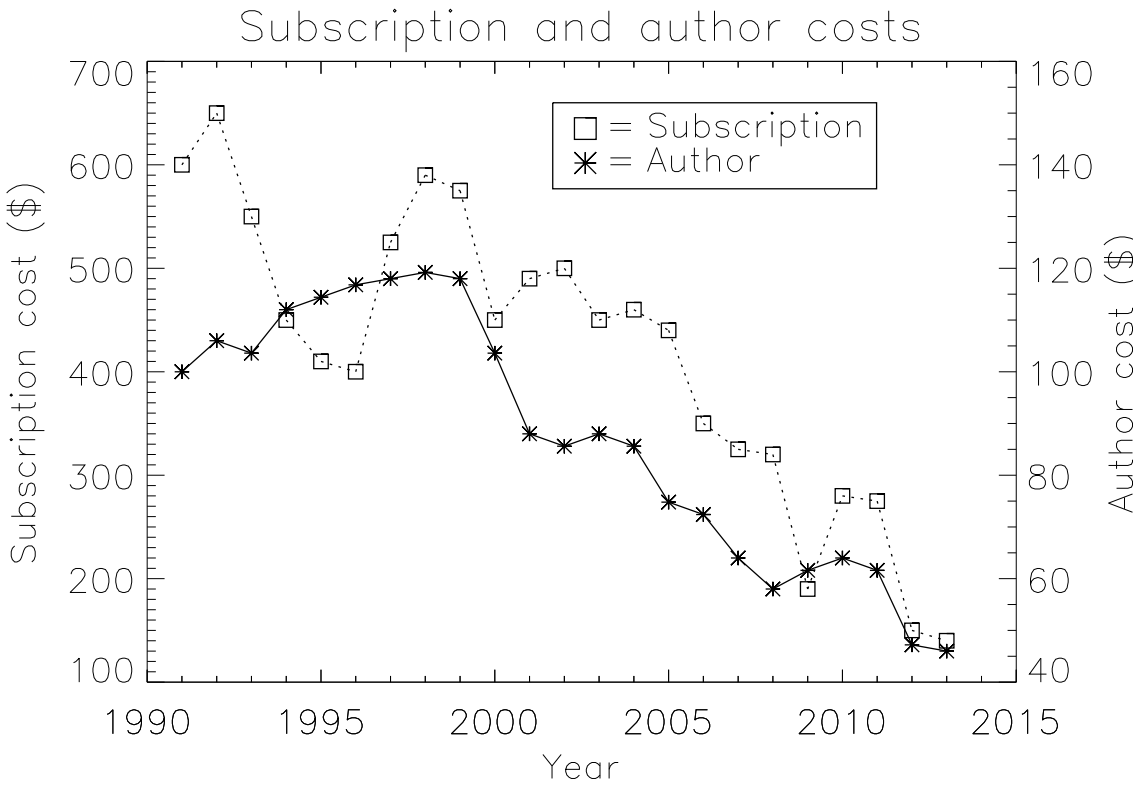

Figure 1. The subscription (squares) and author publication (asterisks) costs from 1991 to 2013. Subscription cost are on the left Y axis while the author costs are on the right Y axis. All numbers in US dollars and adjusted for inflation. The author charges also account for the change from page charges to digital quanta in April 2011.

AASTEX has a `\plotone` command to display a figure consisting of one EPS/PDF file. Figure 1 is an example which shows the approximate changes in the subscription costs and author publication charges from 1991 to 2013 in the AAS Journals. For a general figure consisting of two EPS/PDF files the `\plottwo` command can be used to position the two image files side by side.

Both `\plotone` and `\plottwo` take a `\caption` and an optional `\figurenum` command to specify the figure number[1]. Each is based on the `graphicx` package command, `\includegraphics`. Authors are welcome to use `\includegraphics` along with its optional arguments that control the height, width, scale, and position angle of a file within the figure. More information on the full usage of `\includegraphics` can be found at https://en.wikibooks.org/wiki/LaTeX/Importing_Graphics#Including_graphics.

2.4. *Grid figures*

Including more than two EPS/PDF files in a single figure call can be tricky to easily format. To make the process easier for authors AASTEX v6 offers `\gridline` which allows any number of individual EPS/PDF file calls within a single figure. Each file cited in a `\gridline` will be displayed

[1] It is better to not use `\figurenum` and let LaTeX auto-increment all the figures. If you do use this command you need to mark all of them accordingly.

in a row. By adding more `\gridline` calls an author can easily construct a matrix X by Y individual files as a single general figure.

For each `\gridline` command a EPS/PDF file is called by one of four different commands. These are `\fig`, `\rightfig`, `\leftfig`, and `\boxedfig`. The first file call specifies no image position justification while the next two will right and left justify the image, respectively. The `\boxedfig` is similar to `\fig` except that a box is drawn around the figure file when displayed. Each of these commands takes three arguments. The first is the file name. The second is the width that file should be displayed at. While any natural LaTeX unit is allowed, it is recommended that author use fractional units with the `\textwidth`. The last argument is text for a subcaption.

2.5. *Enhanced graphics*

Enhanced graphics have an example figure to serve as an example for the reader and the full graphical item available in the published HTML article. This includes Figure sets, animations, and interactive figures. The Astronomy Image Explorer (http://www.astroexplorer.org/) provides access to all the figures published in the AAS Journals since they offered an electronic version which was in the mid 1990s. You can filter image searches by specific terms, year, journal, or type. The type filter is particularly useful for finding all published enhanced graphics. As of June 2019 there are over 3000 videos, 1000 figure sets, and 65 interactive figures. The next sections describe how to include these types of graphics in your own manuscripts.

2.5.1. *Figure sets*

The grid commands given above works great for a limited set of individual figure files but what do you do if you have many 10s or 100s or even 1000s of individual figure files? Figure sets represents a virtual flip book of a large group of similar style figures. The derived PDF article will only shows an example figure while the enhanced content is available in the figure set in the HTML edition. The advantage of a figure set gives the reader the ability to easily sort through a large collection to find individual component figures. The advantage to the author is that grouping similar figures into a figure set can result in significant cost savings in terms of reduced publication charges, see Appendix B. All of the figure set components, along with their html framework, are also available to the reader for download in a single .tar.gz package.

Special LaTeX mark up is required to create a figure set. Prior to AASTeX v6 the underlying mark up commands had to be inserted by hand but is now included. Note that when an article with figure set is compiled in LaTeX none of the component figures are shown and a floating Figure Set caption will appear in the resulting PDF.

Authors are encouraged to use an online tool at http://authortools.aas.org/FIGSETS/make-figset.html to generate their own specific figure set mark up to incorporate into their LaTeX articles.

2.5.2. *Animations*

Authors may, and are in fact encouraged, to include animations in their manuscripts. The video will stream inline with the published article and also be available for download. When writing the manuscript, a stand alone figure is necessary to serve as an example for the reader. Ideally, this is a single still frame from the animation but in some case the animation may only represent a small portion of the example figure, say one many panels as shown in Figure 2. Regardless, it is very important that the author provide descriptive text in the figure caption including start and stop

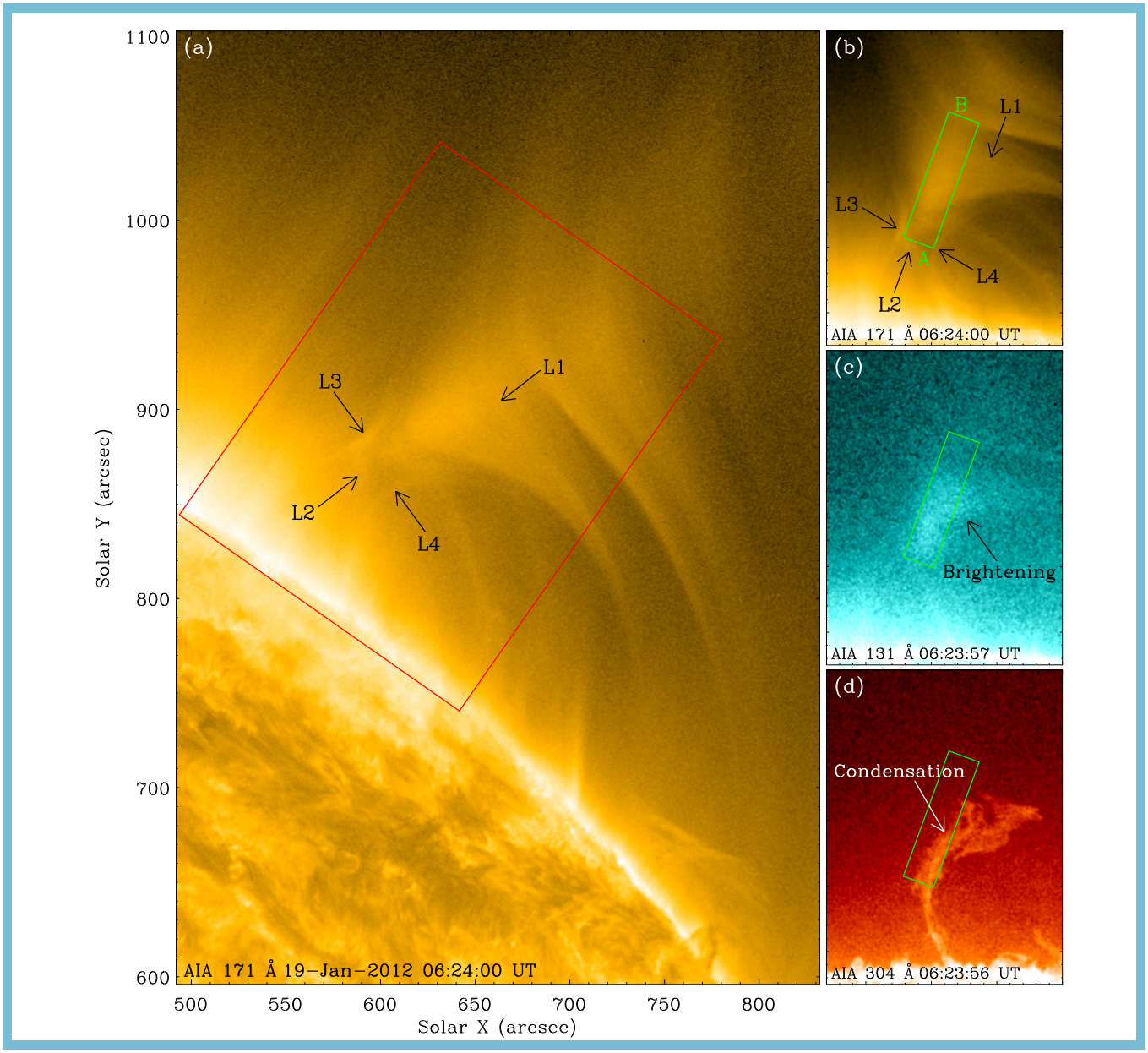

Figure 2. Figure 1 from Li et al. (2018). AIA 171Å(a,b), AIA 131Å(c), and AIA 304Åimages are shown. The red rectangle in (a) shows the field of view of the other panels. An animation of panels (b-d) is available. It covers 8 hours of observing beginning at 01:00 UT on 2012 January 19. The video duration is 20 seconds.

times and the video duration. Authors should review the AAS animation guidelines in the graphics guide at https://journals.aas.org/graphics-guide/#animations.

Animations and interactive figures (Section 2.5.3) should use the `\begininteractive` environment in the figure call. This environment places a blue border around the figure to indicate that the figure is enhanced in the published HTML article. The command also serves to alert the publisher what files are used to generate the dynamic HTML content. `\interactive` takes two arguments. The first details the type and currently only three are allowed. The types are `js` for generic javascript interactive figures, `animation` for inline videos, and `timeseries` for interactive light curves produced

by astropy Astropy Collaboration et al. (2013)[2]. If these types are not provide the compiler will issue an error and quit. The second argument is the file that produces the enhanced feature in the HTML article.

2.5.3. *Interactive figures*

Interactive figures give the reader the ability to manipulate the information contained in an image which can add clarity or help further the author's narrative. These figures consist of two parts, a static representative figure for the manuscript and the dynamic javascript plus HTML framework that allows for interactive control.

An example of an interactive figure is a 3D model. The underlying figure is a X3D file while x3dom.js is the javascript driver that displays it. An author created interface is added via a html wrapper. The first 3D model published by the AAS Journals using this technique was Vogt et al. (2014).

run locally to demonstrate how a simple javascript plus html interface allows a reader to switch between figures. The necessary files for this particular interactive figure are in the `interactive.tar.gz` file included with this package. Unpack the file and point the browser to the local html file. In this case, the javascript that runs the interactive buttons is embedded in the html file but it could just as easily be calls to external javascript libraries. Ideally, the javascript should be included with the submitted package of interactive files to minimize external dependencies within the published article.

3. DISPLAYING MATHEMATICS

The most common mathematical symbols and formulas are in the amsmath package. AASTEX requires this package so there is no need to specifically call for it in the document preamble. Most modern LaTEX distributions already contain this package. If you do not have this package or the other required packages, revtex4-1, latexsym, graphicx, amssymb, longtable, and epsf, they can be obtained from http://www.ctan.org

Mathematics can be displayed either within the text, e.g. $E = mc^2$, or separate from in an equation. In order to be properly rendered, all inline math text has to be declared by surrounding the math by dollar signs ($).

A complex equation example with inline math as part of the explanation follows.

$$\bar{v}(p_2, \sigma_2) P_{-\tau} \hat{a}_1 \hat{a}_2 \cdots \hat{a}_n u(p_1, \sigma_1), \tag{1}$$

where p and σ label the initial $e^{\pm}$ four-momenta and helicities ($\sigma = \pm 1$), $\hat{a}_i = a_i^{\mu} \gamma_{\nu}$ and $P_{\tau} = \frac{1}{2}(1+\tau\gamma_5)$ is a chirality projection operator ($\tau = \pm 1$). This produces a single line formula. LaTEX will auto-number this and any subsequent equations. If no number is desired then the `equation` call should be replaced with `displaymath`.

LaTEX can also handle a a multi-line equation. Use `eqnarray` for more than one line and end each line with a \\. Each line will be numbered unless the \\ is preceded by a `\nonumber` command. Alignment points can be added with ampersands (&). There should be two ampersands per line. In the examples they are centered on the equal symbol.

[2] To be release in the summer of 2019

APPENDIX

A. SAMPLE APPENDIX SECTION

This is appendix

REFERENCES

Astropy Collaboration, Robitaille, T. P., Tollerud, E. J., et al. 2013, A&A, 558, A33, doi: 10.1051/0004-6361/201322068

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