Visualising Astronomy: Visualising Exoplanet Data

Ryan Wyatt
California Academy of Sciences
E-mail: rwyatt@calacademy.org

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Without a doubt, exoplanets represent one of the most engaging and compelling astronomical discoveries of the last two decades. How do we help our public visualise these intriguing objects — these intriguing *locations*? Earlier in this space[1], I have ruminated on the changing nature of visual evidence related to exoplanets, but this time around, I would like to consider how visualisation can help fire people's imaginations, from the perspective of both data and data-driven visuals.

First off, we have the data. The images of Fomalhaut and HR 8799 represent the most straightforward visual depiction of exoplanet data, namely light collected from a telescope. Recent images of the latter system reveal a fourth exoplanet, and the new images have improved sharpness and clarity (Figure 1)[2]. But we have a fundamental issue here: the direct images will never resolve exoplanets in a way that our Hubble-influenced aesthetic will find compelling. Telescope images of exoplanets will remain dots of light, not much more.

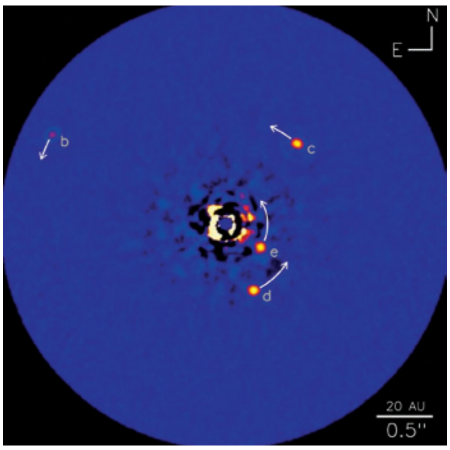

Figure 1. *Infrared adaptive optics image of the HR8799 planetary system, with four observed planets and arrows showing their predicted motion over the next ten years. Credit: NRC-HIA/C. Marois/W.M. Keck Observatory.*

Of course, Carl Sagan waxed eloquent about life on a particular "pale blue dot", namely Earth as seen by Voyager 1 from a vantage point 6.1 billion kilometres distant, revealing our home planet as a mere pixel in the image: "*On it everyone you love, everyone you know, everyone you ever heard of, every human being who ever was, lived out their lives.*"[3] That perspective, so at odds with our daily experience, dramatically recontextualises Earth[4]. But what of other worlds? No image we ever retrieve of an exoplanet will resolve it as anything more substantial than a lone pixel. How can we help people imagine these abstract data as actual places?

One step in this direction takes more esoteric data than the direct images and shows the Kepler mission's 1235 stars with planetary candidates. In Jason Rowe's depiction of the data (Figure 2), candidate transiting companions are shown silhouetted in front of their host stars, with all the objects properly scaled and the correct colours for each star[5]. Moreover, Rowe displays each planet at its appropriate latitude on the star, deduced from the specifics of the light curve. (Added bonus: Rowe also shows limb darkening, which influences the shape of the light curve and allows the impact parameter to be estimated, giving what I referred to as the "latitude" above.) And an image of the Sun, with Earth and Jupiter seen in shadow, provides context. Pretty spiffy. This single image allows the viewer to contemplate the sheer number and variety of systems (potentially) out there, and I admire it for its simplicity, self-consistency and accessibility.

Jer Thorpe's animated visualisation of the same data also received a lot of buzz back in February[6]. It layers a different collection of data, depicting the planetary candidates as a swarm of coloured spots orbiting an imaginary single parent star (not shown), which then splay out into a Cartesian plot, first of planet size versus distance, then temperature versus distance. The size of each spot corresponds to the planet size, and the colour to its temperature: note that "*the colour scale is calibrated so that Earth is a pale blue dot*"[7].

I have some real issues with Thorpe's choices. First off, animation of the data adds nothing except deceptive visual interest. Why deceptive? Because the absolute distance between a planet and its parent star only tells part of the story of the planet's habitability, since the stars in the Kepler dataset (as beautifully and simply illustrated in Rowe's visualisation) vary widely in size, temperature, and brightness. Thus, the little spots swirling around an imaginary central star have no intrinsically interesting meaning. Then, Thorpe's graphing exercise simply shows in a Cartesian context what the size and colour of the data already represent! Totally redundant. Rowe's more staid still image dramatically outshines the gloss of Thorpe's video exercise.

Of course, with online tools, people now have an opportunity to interact with the data, and a number of sites and at least one iPhone app offer a variety of user experiences. I'll touch on a few of my favourites.

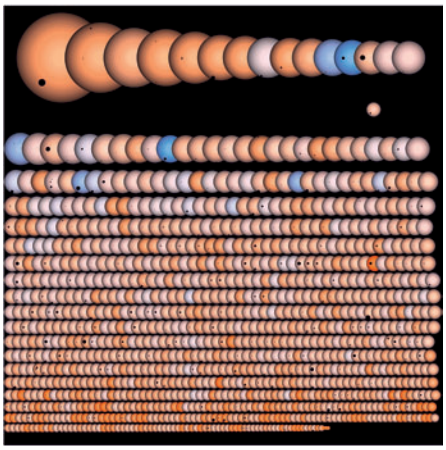

Figure 2. Jason Rowe's jam-packed illustration of the 1235 Kepler planetary candidates with their host stars, featuring accurate sizes of all objects, appropriate star colours with limb darkening, and even impact parameters for each exoplanet candidate! Credit: J. Rowe.

For some time, Exoplanets.org has offered the Exoplanets Plotter as part of their Data Explorer[8]. A slick interface allows the user to select from preset views of the data or to customise a plot in a number of ways; and the views can be saved or the graphs exported to a variety of formats. I'd call it a paraprofessional experience: a complete novice would probably have difficulties with the interface, but its intuitive design will feel comfortable to slightly savvier users.

NASA's PlanetQuest hosts the New Worlds Atlas[9], a more accessible, but less powerful data interface that gives a top-level view of planetary systems and their characteristics, so that the user can select, for example, stars visible to the unaided eye or stars with multiple planets, and so on. The site also sports a Shockwave viewer that allows the user to see the three-dimensional distribution of exoplanetary systems around the Sun; but unfortunately, the locations lack context or scale, and even worse, the data seem not to have been updated in quite some time (only 247 planets showed up when I tried it recently).

On the smartphone front, Hanno Rein has created an iPhone app[10] that offers a truly impressive user experience; in fact, he has replicated much of the functionality of the sites I described above. The app's graphing capabilities don't match the Exoplanets Plotter, but the user can create basic "correlation diagrams" that give illuminating perspectives on the data. A Milky Way tab reveals the three-dimensional distribution of exoplanetary systems through (a somewhat awkwardly-rendered model of) the Milky Way. And each exoplanet gets its own page (Figure 3), showing the discovery method, the size of the planet relative to planets in the Solar System, the location of the parent star in the night sky, and a representation of the planet's orbit relative to orbits in the Solar System — along with a table of relevant data and links to scientific publications!

Rein has also introduced a Kepler candidate app[11] that offers an (effectively) identical interaction for each object. It'd be neat if the app incorporated the actual light curves (true for the transiting planets in the general app as well), and maybe tackled a visual for the star and planet more along the lines of Rowe's approach, but I find the lack of such data-driven details easy to forgive.

Interacting with the data can, for more expert audiences, provide a much deeper connection to the research. In the informal education world, we need to consider how to expose our audiences to astronomy's rich and swiftly growing collection of data. But we also need more immediate and accessible visuals for people to comprehend the scope, the breadth and the impact of these spectacular exoplanet observations. In my next column, I want to consider a different approach to the same topic... How can space art and data-driven visual representations help people envision these alien worlds?

Notes

1 Wyatt, R. 2009, *Visualising Astronomy: Other Worlds*, CAPjournal, 5, 33

2 Stark, A. 2010, *New pictures show fourth planet in giant version of our solar system*, online at https://www.llnl.gov/news/newsreleases/2010/Dec/NR-10-12-02.html (retrieved on 17/5/2011)

3 Sagan, C. 1994, *Pale Blue Dot: A Vision of the Human Future in Space*, New York: Random House, 8

4 If you haven't read the passage lately (or ever), I'd encourage you to take a look; you can find the relevant, touching handful of paragraphs online at http://planetary.org/explore/topics/voyager/pale_blue_dot.html (retrieved on 17/5/2011)

5 Rowe, J. 2011, *Kepler Transiting Planet Candidates (Saturated Colours),* online at http://www.flickr.com/photos/astroguy/5552363328 (retrieved on 17/5/2011)

6 Thorpe, J. 2011, *Kepler Exoplanet Candidates*, online at http://vimeo.com/19642643 (retrieved on 17/5/2011)

7 Billings, L. 2011, *A new view of the galaxy: Exclusive Kepler data Visualisation by Jer Thorp*, online at http://www.boingboing.net/2011/02/08/a-new-view-of-the-ga.html (retrieved on 17/5/2011)

8 Exoplanets.org Exoplanets Plotter online at http://exoplanets.org/plot/ (retrieved on 17/5/2011)

9 Online at http://planetquest.jpl.nasa.gov/atlas/atlas_index.cfm (retrieved on 17/5/2011)

10 The Visual Exoplanet Catalogue features a link to the iPhone app, online at http://exoplanet.hanno-rein.de/

11 Online at http://itunes.apple.com/us/app/kepler/id430616551 (retrieved on 17/5/2011)

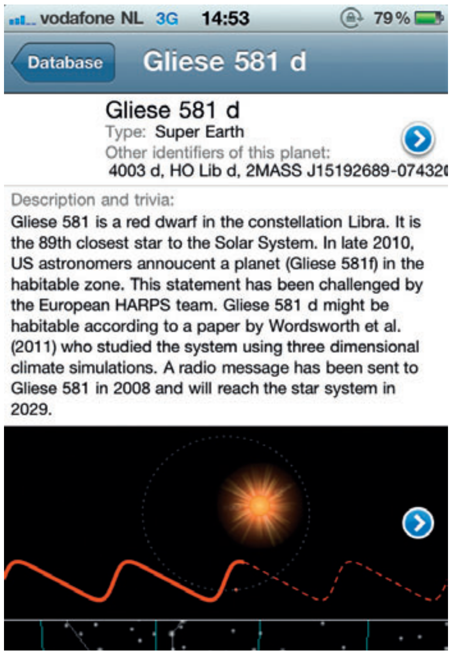

Figure 3. A snapshot of the Gliese 581d page in Hanno Rein's exquisite iPhone exoplanet app. Credit: H. Rein.

Biography

Ryan Wyatt is the Director of Morrison Planetarium and Science Visualization at the California Academy of Sciences in San Francisco, California, USA. He writes a sadly irregular blog, Visualizing Science, available online at http://Visualizingscience.ryanwyatt.net/.