Column

Visualising Astronomy: Using Impact to Inform

Ryan Wyatt
California Academy of Sciences, USA
rwyatt@calacademy.org

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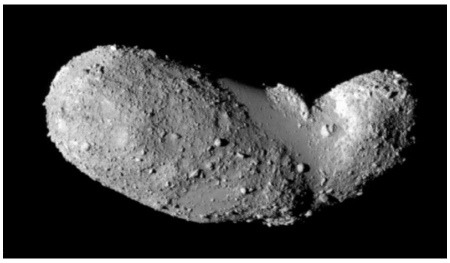

Figure 1. A Hayabusa image of asteroid 25143 Itokawa. Credit: Courtesy of JAXA

Pop culture has visualised asteroids in a way that has made a far greater impact in the public domain than the outreach community can ever hope to achieve. Films such as *Meteor* (1979), *Armageddon* (1997) and *Deep Impact* (1997) may score poorly on scientific accuracy, but they have influenced our collective consciousness. (Perhaps in a fit of pre-millennial anxiety, the late 1990s saw a host of films featuring an asteroid or comet on a collision course with Earth[1].) In addition to the destruction of Earth's cities, the *Millennium Falcon* dodging giant tumbling boulders in *The Empire Strikes Back* has probably influenced more people's mental image of an asteroid belt than any other single visual.

Insofar as "asteroid" simply means "rock from space" in the popular imagination, cinema has cemented images in many people's minds. This may have created some misconceptions, but it also has introduced people to a mental model that can provide a basis for further discussion and engagement. I think we have an opportunity right now in terms of visualising asteroids — both in terms of their appearance and of their dynamics — and their relevance to humanity as sources of raw materials and as potential threats to the survival of our species.

In the past decade, spacecraft have returned remarkable high quality images of asteroids. Most recently, the *Dawn* mission has given us a spectacular view of the asteroid Vesta, with similar results expected for the dwarf planet Ceres. Hayabusa's images of the more modestly sized Itokawa (Figure 1), coupled with its impressive story of landing on the asteroid and returning to Earth, make for a compelling story. Indeed, a Japanese production consortium created a lovely planetarium show about Hayabusa: a main character in the show is the asteroid itself, reconstructed from observed data[2].

A detailed model of Itokawa exists online in a variety of resolutions and file formats[3], and you can download freeware to view and interact with the models. A free Android application also exists that allows users to manipulate the model in three dimensions; unfortunately, the bare-bones implementation offers no interpretation in terms of science or even scale information, making it of limited interest[4]. The outreach community should work on a way of making three-dimensional data more accessible, since it's the non-spherical nature of asteroids that makes them more visually interesting than most planets.

The freeware programme Celestia[5] has a few asteroids in its database, including Itokawa, but the fairly low-resolution models (with low polygon counts that make them resemble computer-generated potatoes) don't inspire a positive aesthetic response. More models are available in the Celestia Motherlode[6] — an online repository for add-ons for objects in Celestia — but the data representing the asteroids' trajectories make for a more compelling message. For example, options exist in the Celestia Motherlode to add several thousand near-Earth asteroids, and there's even a collection of "potentially hazardous" objects. Unfortunately, illustrating the asteroid orbits creates a pixelated mess of digital spaghetti, and the software lacks a straightforward means of showing individual objects in a time-evolved depiction of the Solar System.

A less cluttered (but also less intuitive) interface appears when you elect to "show orbit diagram" in the JPL Small Body Database[7]. The Java applet allows you to view the orbits of individual asteroids and adjust time using sliders. You can't easily get a perspective on the sheer number of objects, but a little fiddling gives you a sense of how things evolve over time. The visualisation software WorldWide Telescope[8] probably gives the greatest flexibility in terms of depicting the sheer number of asteroids as

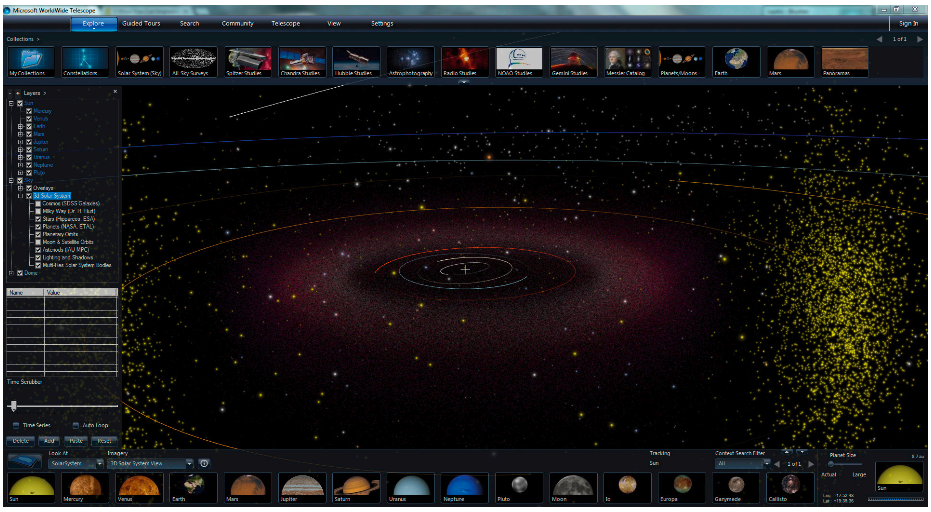

Figure 2. A screenshot showing the user interface for the visualisation software WorldWide Telescope. Credit: Microsoft Corporation

objects orbiting the Sun, but alas, you can't view the asteroids as anything other than points.

A critical component of mapping the Solar System is to understand its inherently dynamical nature. And as all those Hollywood productions suggest, the real story lies in the potential for catastrophe. In June 2012, the California Academy of Sciences had the pleasure of hosting a press conference for the B612 Foundation, announcing the proposal to launch Sentinel, the world's first privately funded space telescope, which will orbit the Sun at approximately the distance of Venus, scanning Earth's orbit to detect asteroids. Tuned to infrared wavelengths that reveal objects at Earth's approximate distance, the Sentinel mission should detect upwards of 900 000 asteroids 40 metres in diameter or larger. The foundation (named for the asteroid in *The Little Prince*[9]) has already supported research into the best ways to deflect or destroy potentially hazardous objects, so this mapping mission rounds off a programme whereby potential threats can be identified early, enabling humanity to take action.

I supervise a team at the Academy that has created two short videos in support of the press conference: one tells the story in a standard short form, with talking heads and other traditional video techniques[10], while the other captures an unbroken flight through a virtual space used to accompany a live presentation by former astronaut and B612 CEO Ed Lu[11]. (The latter video is available online as an HD crop of a fulldome video, originally designed to play in a modern digital planetarium). In both cases we used visuals created by the planetarium software *Uniview*[12] to depict asteroid orbits — and to convey the relative crowdedness of the inner Solar System.

Visualising the effects of an asteroid impact can help convey the reality of these events beyond Hollywood's fanciful depictions. Don Davis has painted several inspirational images for NASA[13] that capture an asteroid suspended in a surreal moment between impact and annihilation. Data-driven visualisations, however, are few and far between. I had a chance to work on a visualisation of the KT impact (responsible for the Cretaceous-Tertiary extinction) based on simulations by Galen Gisler and his collaborators at Los Alamos National Laboratories[14] for the American Museum of Natural History planetarium show *Cosmic Collisions* (2006). Gisler has posted at least one video of the simulation on his current research website[15], but the final animations, which integrate the impact into a global view of its effects, remain generally unavailable unless your local planetarium leases the show[16]. Alternatively, you may have lucked out and grabbed one of the many DVDs that NASA gave away a few years ago.

Figure 3. An artist's impression of an asteroid impact, created by Don Davis, that has left a persistent mental image in the minds of many. Credit: NASA

In the near future, asteroids will become a hot topic for public outreach, not only because of our interest in self-preservation, but also because they provide stepping stones to more distant destinations. Indeed, President Obama's administration has proposed a human trip to an asteroid by 2025[17]. On a commercial front, the newly formed company called Planetary Resources made headlines in April 2012 with its proposal to sample and eventually mine asteroids[18]. This was followed by a similar announcement by Deep Space Industries in January 2013[19], offering a positive spin on asteroid discoveries by Sentinel and other programmes.

In the last decade, many members of the public grappled with Pluto's loss of planetary status, but perhaps this has opened people's minds to our changing understanding of the Solar System. I think we have a real opportunity to describe the richness and diversity of our neighbourhood, with a focus on asteroids. Beautiful images of these tiny worlds make for a compelling aesthetic connection (in spite of their rather dreary greyness). More importantly, the visuals communicate the physicality of these places that could play a role in humanity's survival.

Notes

1. http://pan-starrs.ifa.hawaii.edu/public/asteroid-threat/movies.html
2. www.goto.co.jp/english/show_content/worldwide_distribution/wd_show_content_hayabusa.html
3. http://darts.isas.jaxa.jp/planet/project/hayabusa/shape.pl
4. https://sites.google.com/site/avelcoinfo/itokawa
5. www.shatters.net/celestia/
6. www.celestiamotherlode.net/
7. http://ssd.jpl.nasa.gov/sbdb.cgi
8. www.worldwidetelescope.org/
9. De Saint-Exupéry, A. 1943, Le Petit Prince, Gallimard
10. http://vimeo.com/44837633
11. http://vimeo.com/45276477
12. http://scalingtheuniverse.com/
13. http://impact.arc.nasa.gov/gallery_main.cfm
14. www.lanl.gov/quarterly/q_spring03/asteroid_text.shtml
15. http://folk.uio.no/galeng/research.html
16. www.amnh.org/traveling/planetarium/cosmic.php
17. www.nasa.gov/news/media/trans/obama_ksc_trans.html
18. www.planetaryresources.com/2012/04/asteroid-mining-plans-revealed-by-planetary-resources-inc/
19. http://deepspaceindustries.com/media/announcements/

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 blog, "Visualizing Science," available online at http://visualizingscience.ryanwyatt.net/.

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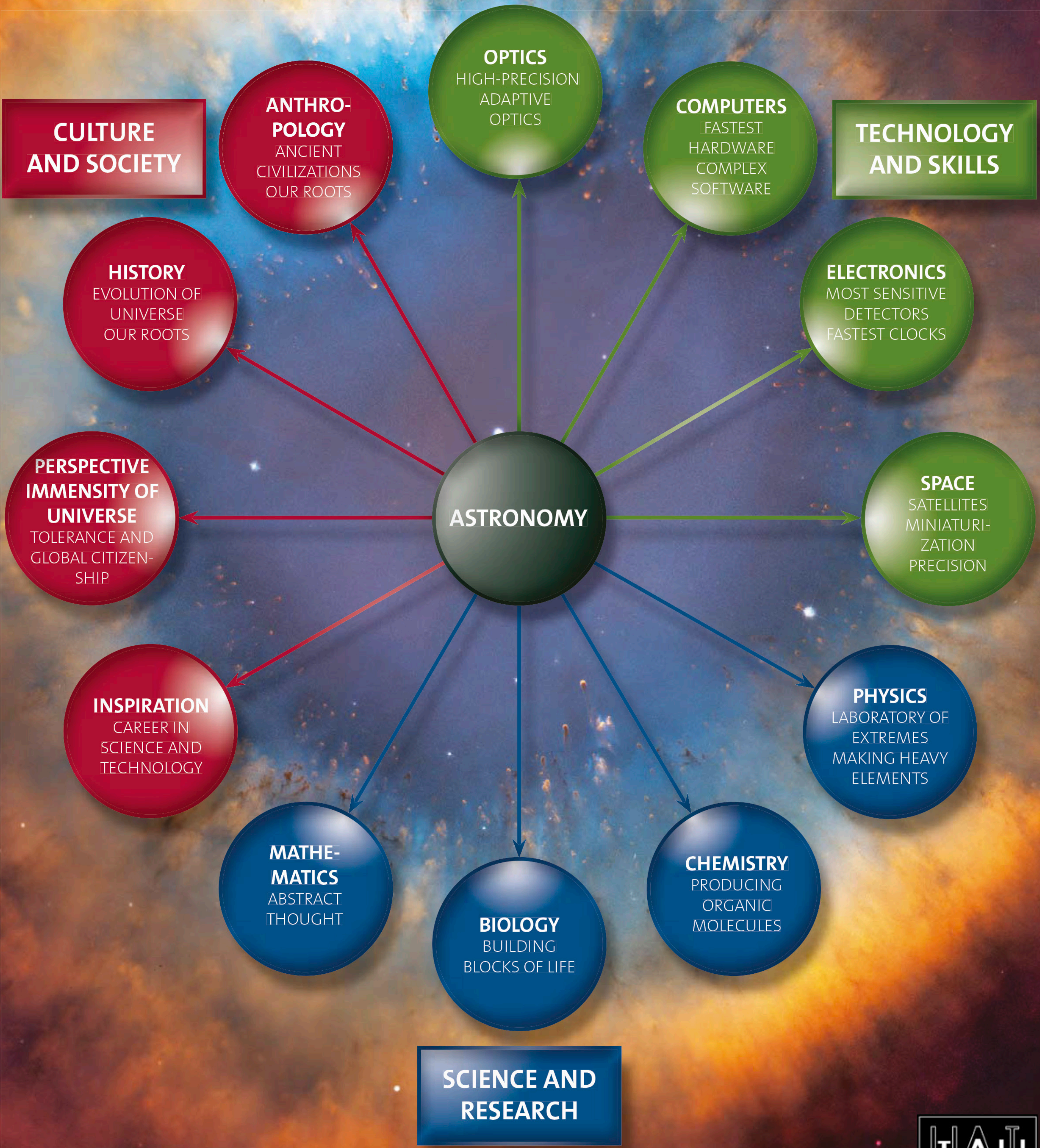

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