# Back in style: Old names get new life in search for, well, new life

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In 1605, Johannes Kepler announced his first law of planetary motion, essentially stating that planets move around the sun with an elliptical, rather than circular, orbit.

Around the same time, the Age of Discovery was witness to countless European ocean voyages documenting the enormous, and sometimes falsely frightening, wider world. These forays into global exploration produced all sorts of skewed maps and mythical monsters, such as the Kraken, a giant sea creature somewhere between a squid and a dragon, depending on the account. It was greatly feared among sailors of the day to say the least.

More than 400 years later, two magnificent machines bearing the namesakes of Kepler and Kraken are making new waves into the next great frontier: deep space.

NASA's Kepler spacecraft is currently on the hunt for Earth-like planets throughout the Milky Way, and by extension, is surveying a multitude of stars to determine how many might support orbiting, Earth-like planets. It's a tall order, even for a mission named after one of history's most beloved astronomers.

Two things are required for a planetary body to be labeled "Earth-like": its orbit must reside within the habitable, or Goldilocks (not too hot, not too cold) zone of the host star, a distance suitable for water, and by extension possibly life, to exist; and it also must be roughly "Earthsized," meaning no more than 25 percent larger than the radius of the Earth.

Kepler recently grabbed headlines with the discovery of Kepler 22b, the first planet discovered by the spacecraft that resides in the Goldilocks zone. However, it failed the size test with a radius roughly 2.4 times that of Earth's.

Judging a planet's size can be tricky. The only method for doing so is by comparing it to the star it's orbiting. To know the planet you have to first know the star, a task currently being taken up by a team led by Travis Metcalfe of the Space Science Institute in Boulder, Colorado. Metcalfe was on the team that catalogued both Kepler 22b and its host star.

Much like the real Kepler worked with the legendary astronomer Tyco Brahe, the spacecraft, and Metcalfe, could use some help processing the mountains of data being produced by its far flung observations. Enter Kraken, a Cray XT5 supercomputer capable of more than a petaflop (a thousand trillion calculations per second) and managed by the University of Tennessee's National Institute for Computational Sciences (NICS) for the National Science Foundation (NSF). It's a monster alright, but instead of devouring sailors, it favors numbers.

Metcalfe's team is using Kraken to measure the properties of the stars being orbited by potential Earth-like planets, properties such as radius, mass, age, and bulk composition, or the proportions of individual gases throughout the star. But the ramifications of Metcalfe's project go far beyond that, far beyond the sea once thought to be wrought with all manner of monsters, and far beyond anything Johannes Kepler ever imagined.

## AMPed up

An astronomer by training, Metcalfe was attending a conference on seismology five years ago when he heard about Science Gateways for the first time. A concept promoted by the NSF's former TeraGrid program and currently supported by the NSF's Extreme Science and Engineering Discovery Environment (XSEDE), a network of supercomputers and high-end visualization and data analysis resources open to researchers across the country, Science Gateways provide easy-to-use, leading edge tools to researchers across the scientific spectrum.

Essentially, a Science Gateway is a community-developed set of tools, applications, and data that are integrated via a portal or a suite of applications, usually in a graphical user interface, that is further customized to meet the needs of a specific community, allowing researchers to focus on their scientific goals and less on assembling the computational tools they require. In Metcalfe's case, it's his Asteroseismic Modeling Portal (AMP) that features as its centerpiece an easy-to-use interface coupled with a low-level artificial intelligence algorithm that allows users, such as those managing the Kepler program, to quickly attain much-needed stellar data. For example, the data gathered by Kepler can be easily plugged into the AMP interface and the observed star modeled, thus giving researchers precious clues as to a star's true identity, such as its radius, mass, bulk composition, or gas mixture, and age, which is especially important because quantifying a star's age using traditional, observational methods presents unique difficulties.

This data gives astronomers a better idea of the qualities of any orbiting planets, a valuable tool in the quest to better understand the wider universe. Metcalfe estimates that roughly a hundred people around the world regularly use the AMP portal, which has come a long way since its humble beginnings.

The code was originally developed for a local computing cluster in

Colorado, in a larger set of mountains than those that surround Kraken in East Tennessee, when Metcalfe and his team received their data from ground-based telescopes that observed areas of the sky for weeks at a time. Back then, said Metcalfe, the team could observe and model twelve stars in a decade, compared to hundreds every few months with the one-two punch of Kepler and Kraken.

It's only in the last year that the team has been applying the AMP gateway to exoplanet host stars, or those that might support planets outside of our solar system. And Kepler keeps the work coming; the spacecraft is sending data for hundreds of stars every month. "We're analyzing five, ten stars at a time," said Metcalfe, adding that his team is trying to keep up: "Kepler is specifically built for this purpose, said Metcalfe. "We've never had this much data before."

And without Kraken, there would be no way the team could keep pace. Metcalfe's team has been utilizing Kraken for three years now, and the results speak for themselves. So far, the team has classified around 100 stars including several with planets (including Kepler 22b), said Metcalfe, and the team hopes to do 100 more this year alone. Interestingly, Kepler 22b, the latest planet the team classified, could harbor water, a quality widely regarded as essential if a far-flung planet is indeed capable of supporting any life forms similar to those on Earth, especially the mythical Kraken.

While the individual jobs themselves aren't especially large, only requiring 512 of Kraken's 100,000-plus cores, the team needs the somewhat small allocation for days at a time. And while doing five to ten stars at a time, the jobs can utilize more than 5,000 cores, a significant run by most measures.

"Little jobs like ours aren't given high priority by default," said Metcalfe. "It's been outstanding to have people there help push us through with minimal impact on the big users . . . We kind of got spoiled. Our jobs are episodic. The staff at NICS has been really helpful to make sure we get the priority we need to burn through the time we have." And who knows what discoveries lay ahead? Kepler has only been up for three years, and was recently extended by NASA by an additional four years. Even better, during the extended mission all of the data becomes public, benefitting the entire scientific community and leaving little doubt that Kepler, AMP, and Kraken will continue to be instrumental in getting to know our galactic stellar and planetary neighbors.

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