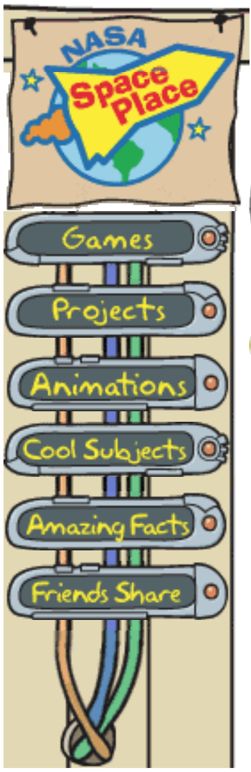


Scientists and engineers on NASA missions share their experiences and findings.

Checking the Pulse of Spacetime Itself

February 2010

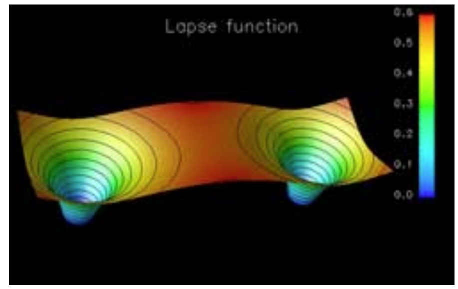
Michele Vallisneri
Deputy Mission Scientist
Laser Interferometry Space Antenna Mission

Michele Vallisneri with Galileo impersonator. Behind them is a model of a LISA spacecraft.

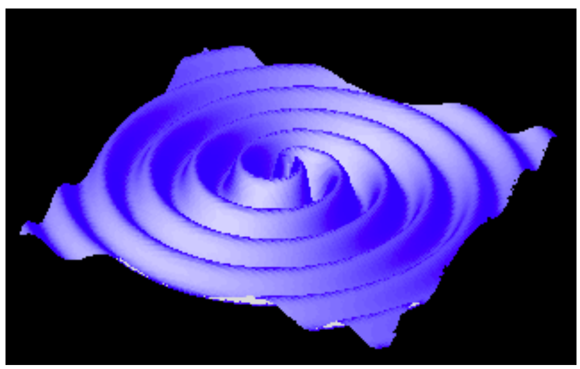
My name is Michele (pronounced mi-KAY-leh) Vallisneri, and I am a scientist at the Jet Propulsion Laboratory. I am part of a team working on a space mission called LISA, the Laser Interferometer Space Antenna. If we work really hard and we are very successful, the mission will be ready for launch ten years from now.

Why would I work on something that takes so long to bear fruit? Well, all good things take time. But I must say it is all Albert Einstein's fault. You see, in 1915 Einstein came up with a new explanation for the way gravity works--yes, that old question of why apples fall to the ground and why the planets orbit the Sun. Newton had solved this already in the seventeenth century, but there remained a few discrepancies with observations. More important, Newton's universal law of gravitation could not be squared with Einstein's special relativity, which explains how space and time are really a single entity ("spacetime"), and how different "observers" in motion with respect to each other can have different ideas of times and distances. It's fascinating stuff, but it needs more space than I have here. (**Einstein Online is a web portal explaining more.**)

All the Universe a Stage?



Anyway, in 1915 Einstein pointed out that spacetime is not just a big stage where "physics" happens, but it is an active player itself; it can bend and warp and undulate! Masses, especially big ones like the Sun, bend spacetime ever so slightly, and gravitational forces occur naturally because the planets and the apple try to move as straight as possible in spacetime--but have to curve, because spacetime itself is curved! (The fall of the apple can still be seen as a curve, not in space, but in spacetime.) And what about the undulations? When masses move around rapidly, like for instance two stars in a close binary system, they create outwardly propagating waves in spacetime-gravitational waves. You can imagine them as the waves created in a pond when you throw in a stone; except gravitational waves do not move out in circles, but in spheres, and they do not affect the surface of water, but the very fabric of spacetime.

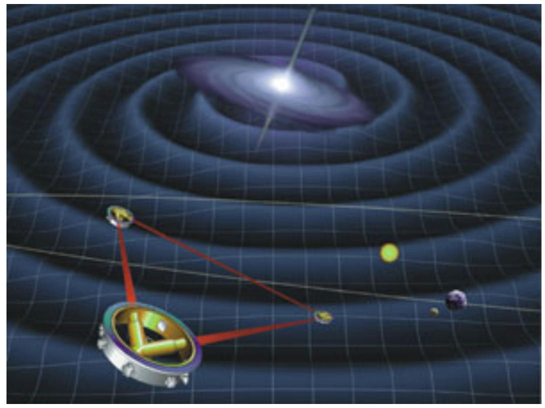


Listening to the Dark

If we could **listen to these waves**, we would learn a lot about the Universe, especially about its dark side, which we cannot observe with telescopes. This dark side is populated by heavy objects that nevertheless do not emit much light, such as the huge black holes at the centers of galaxies, millions to billions of times heavier than our Sun.

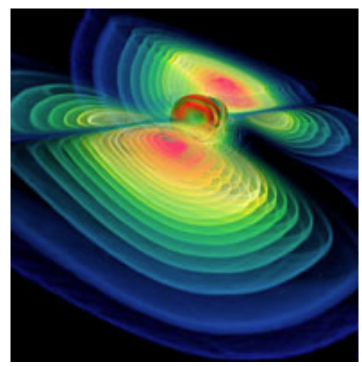
Since the 1960s, scientists have been trying to detect gravitational waves, but it's very hard, because when they cross the Earth, the waves create only minute perturbations. The best attempt so far is with the giant **interferometric** detectors such as **LIGO** (Laser Interferometer Gravitational Wave Observatory), which have "arms" of 2.5 miles to magnify these minute signals.

With LISA, we want to bring this quest to space, and create a gravitational-wave antenna consisting of three spacecraft positioned in a triangle, with arms of 3.1 million miles (thirteen times the distance from the Earth to the Moon). We want to go to space because it is so quiet and because you could not do something so big on the ground; also, a big antenna can measure the waves with the largest wavelengths (the distance between two peaks in the oscillations). There are many systems in the Universe that can emit such waves, so once LISA is up, we're sure to hear and learn a lot.



The Nuts and Bolts

So what's it like in our day-to-day work getting LISA ready? It takes many people with different talents, from the engineers who plan the spacecraft launch and trajectories, to the experimental physicists who are testing the optics, lasers, mirrors, and all the widgets that will make the instrument work. I am a theorist, so I am happier with pen, paper (and a computer) than around a lab. I work to prepare mathematical techniques and computer programs to analyze the LISA data, so that once it's in the sky and it starts making measurements, we'll know what we see. Is it a binary of **black holes** or **neutron stars**? How heavy are the components?



One aspect of this preparation can be especially fun. Together with many other LISA physicists around the world, we just finished playing a "mock data challenge." A group of us made a set of measurements, just like what we'd get from the real mission, and "hid" some gravitational waves in it. Another group then took the data and tried to get the waves out. There were many surprises! Some of us thought they had found a (fake) binary emitting on one side of the sky, but it was really on the opposite side. It's hard to do science in space, and that's why we must start so many years in advance; but the payoff will be great, and physicists always like a challenge.

See the LISA mission website at **http://lisa.jpl.nasa.gov**.

Watching Sea Level Rise from Space

October 2009

Annie Richardson
Outreach Specialist
Ocean Surface Topography Missions

Hi, Annie Richardson here, and I'm an outreach specialist with the ocean surface topography missions at NASA's Jet Propulsion Laboratory (JPL).

Today, all around the world, people are talking about climate change and global warming. We hear about the rise of greenhouse gases in our atmosphere, about glaciers and ice sheets melting, and about global sea level getting higher and higher.

For now, let's just talk about sea level rise. Did you know that global sea level has risen more than 3 millimeters (about one-tenth of an inch) per year since 1992? That's a little bit more than two inches in seventeen years.

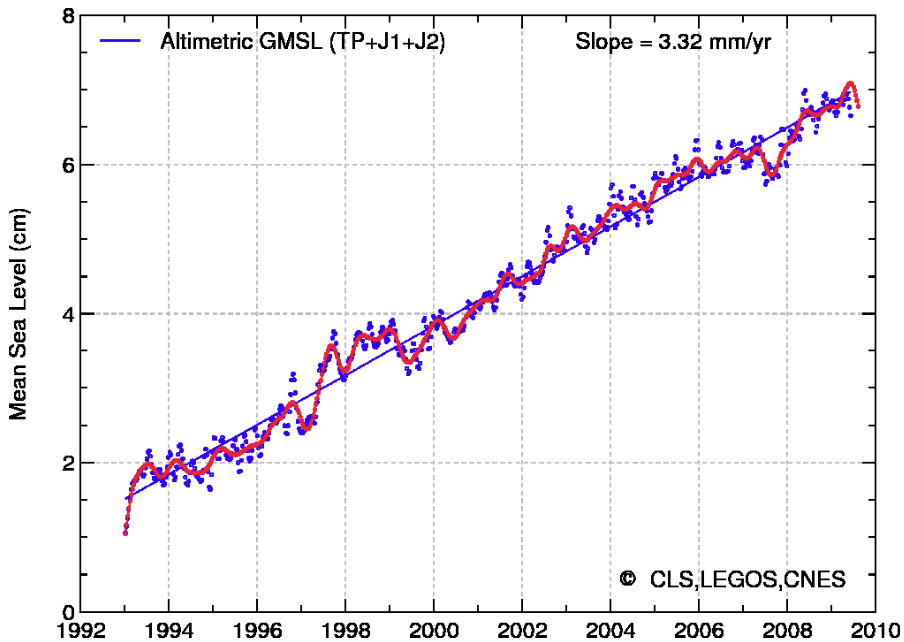
How do we know this? Well, since 1992, to measure sea surface height, NASA and the French Space

Agency, CNES have been using radar altimeters on a series of satellites called Topex/Poseidon; Jason-1; and the Ocean Surface Topography Mission/Jason-2. These three satellites are the ocean surface topography missions that I'm fortunate enough to work for.

Faucet Left Running?

We know that there are two things that cause sea level to rise: First, the ocean is warming, and as it warms the water expands. This is called thermal expansion and it makes the sea level higher. Second, more water is being added to the ocean because glaciers and ice sheets are melting. That melt water flows into the ocean, increasing the mass of water in the ocean and raising the sea level. The ocean surface topography missions measure all the sea level rise regardless of cause, while another satellite mission called the Gravity Recovery and Climate Experiment or "GRACE," measures the change in mass due to new water. The difference between these two measurements tells us what part of the total rise in sea level is due to thermal expansion only.

This graph shows sea level rise as measured by the Topex/Poseidon, Jason-1, and OSTM/Jason-2 satellites from 1992-2009.



The Incredible Shrinking Beach

But, you might be saying, "So what's the big deal about sea level rise? Two inches in 17 years doesn't seem like very much at all."

Well, here's the big deal. Dr. Bill Patzert, an oceanographer at JPL, says that every inch of sea level rise will cover 50 to 100 inches of beach with water. Bill says that the actual amount of beach loss will depend on the slope of the beach, with flatter beaches being lost more quickly than steep ones.

Why is it a big deal? In less than 100 years, sea level could rise 10 or more inches, and we would lose 500 to 1000 more inches of beach. That's 41 to 83 fewer feet of sand between your dream beach house and the surf.

Nurture a Scientist

Scientists are using the information from satellites not only to measure sea level rise, but to understand how the entire Earth reacts to a warming climate. Satellite observations have really helped improve our understanding of all this, but new questions arise every day, such as "How do we slow down sea level rise?" That's where the next generation comes in. We need many more new scientists to help answer the questions about our changing planet. Who knows? It just might be your kids or your students who can protect that beach house and save the sand castles for the kids to come.

Check out this **classroom activity that demonstrates how the sea-level-measuring satellites use the Global Positioning System**.

Here is an explanation of El Niño, along with a yummy dessert recipe for "El Niño Pudding".

For more information about the satellites and global climate, visit the following websites:

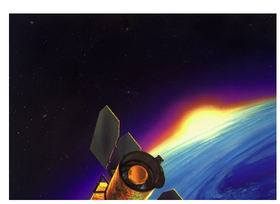
- **Topex/Poseidon, Jason-1, and OSTM/Jason-2**
- **The NASA GRACE website**
- **University of Texas GRACE website**
- **NASA's new Global Climate Change website**
- **Ocean Literacy Network site**

New Surprises from an Old Friend

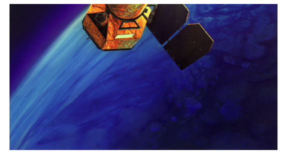
September 2009

Don Neill
Science Analyst
Galaxy Evolution Explorer (GALEX) Project

Hi. My name is Don Neill, and I am a post doc at Caltech. I am part of the GALEX team and we all get to look at the images taken by the GALEX ultraviolet imager of faraway galaxies.

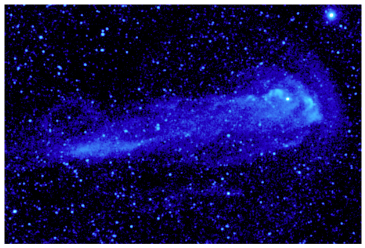


One day, I got an e-mail from my colleague, Karl Forster. When I opened the image attached to his message, several thoughts went through my mind. First, this must be some kind of artifact--an error introduced by the limits of the instrument. Second, what object is this? Third, if this isn't an artifact, this is something new. After checking the coordinates and discovering that the object in question



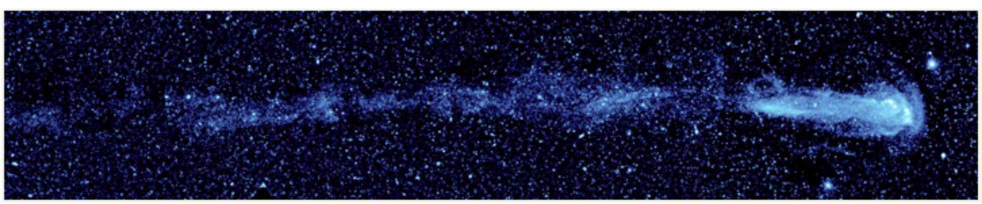
was the venerable variable star Mira, I starting considering that this was indeed something new. What the image showed was a glowing flow of ultra-violet emission surrounding a star that was not quite bright enough, to my eye, to produce the kind of artifacts that sometimes surround the very brightest stars when their light exceeds the camera's capacity to record an image accurately. Mira is a very old, red star and should not produce that much light in the ultra-violet part of the spectrum (which scientists refer to as UV).

Seeing an Old Friend in a New Light



After several exchanges of e-mail between a few of us on the GALEX team, we gradually accepted that this glowing halo around Mira was a genuine new UV phenomenon. We agreed that we needed to trace the extent of this UV glow, which appeared to extend beyond the edge of the original image. Over the next few weeks, Karl added the required observations to the schedule. As these new images arrived, it became clear that this new feature of Mira included a long straight tail over two degrees long, or four times larger than the width of the full moon, making Mira appear like the nucleus of a comet. We began to discuss ways to explain this amazing tail on the old star.

The clues were already in the original image. Looking more closely at them, we saw that the southern edge of the feature looked like the wave that appears in front of a fast-moving boat--what physicists call a "bow-shock." Such a feature combined with the two-degree "wake" would make sense only if Mira were a fast-moving boat with respect to the thin gas between the stars of our Milky Way. So we looked up any and all measurements of Mira's motion. After accounting for the published motions of Mira and the motion of our own Sun, we found that Mira is indeed moving fast through the Milky Way "waters." More like a bullet, this shooting star is moving at well over 800 miles per second through our galaxy. This fast motion, combined with the fact that Mira is literally shedding its atmosphere, as many old stars do, produces the bow-shock and tail that had gone undetected through over 400 years of observing this well-known star.



A different Kind of Stardom

As we wrote up our results and released our story and the new UV images of Mira to the world, I felt a deep satisfaction at having participated in a true discovery. I was not prepared, however, for the reaction to our results. People all over the world were captivated by this shooting star. We started finding our images popping up in popular science web sites in Russia, Japan and Europe. Several members of our team were interviewed on television and by numerous journalists. The National Geographic Channel based an entire episode of their show "Naked Science" around our Mira discovery. I learned from this experience that discovery leads to adventures of all kinds. I keep scanning our GALEX images hoping to have another chance to participate in the thrill of discovery and the adventures that this discovery will lead to.

The Space Place has a kid-friendly description of **Mira, a "real shooting star,"**

The **GALEX website** has lots of other amazing discoveries and images.