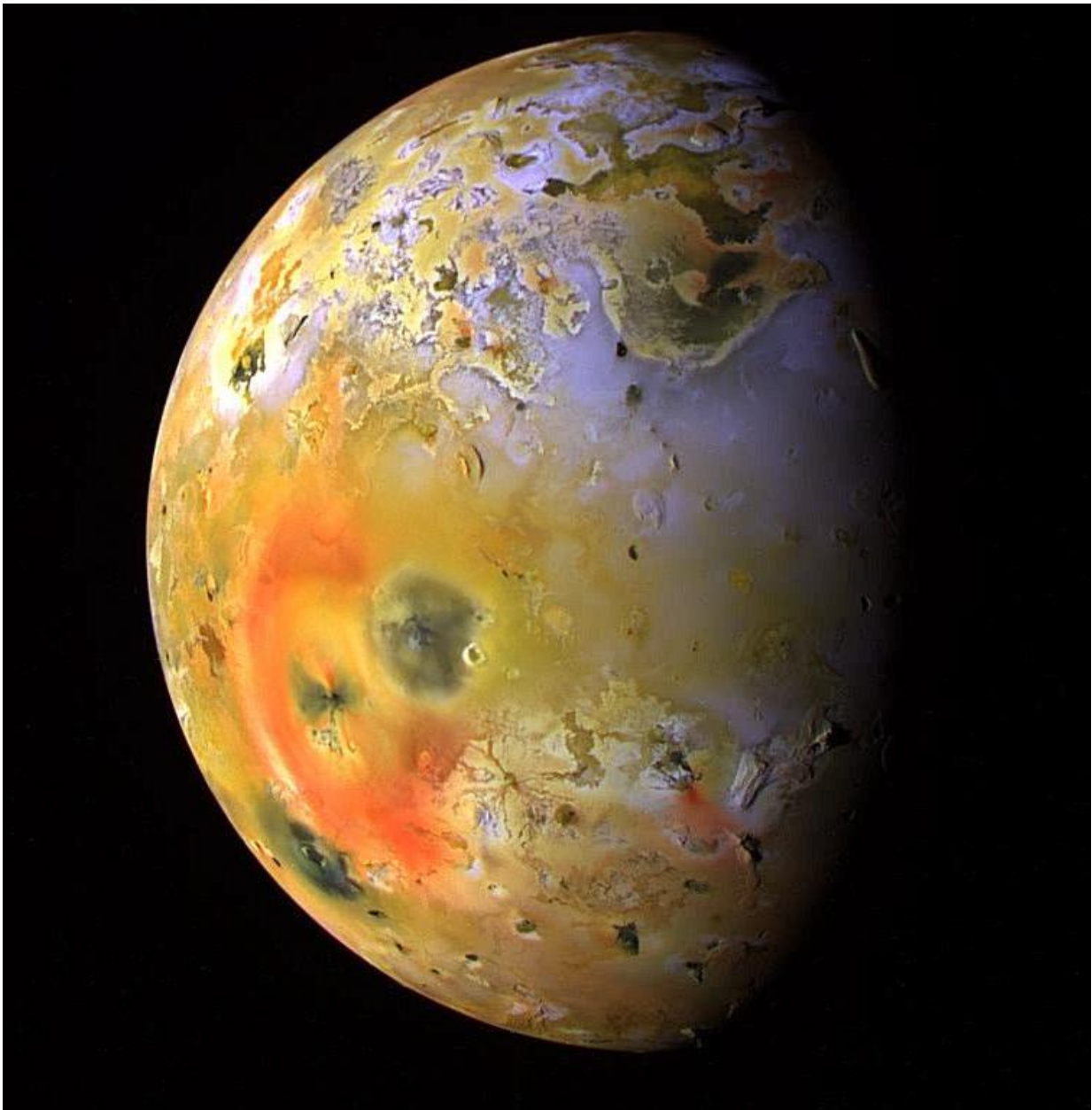


Giant telescope takes close look at Jupiter's moon Io

May 1 2015, by Daniel Stolte



Io as imaged by NASA's Galileo spacecraft. Credit: NASA/JPL-CALTECH

With the first detailed observations through imaging interferometry of a lava lake on a moon of Jupiter, the Large Binocular Telescope Observatory places itself as the forerunner of the next generation of Extremely Large Telescopes.

Io, the innermost of the four moons of Jupiter discovered by Galileo Galilei in 1610 and only slightly bigger than our own moon, is the most geologically active body in our solar system. Hundreds of volcanic areas dot its surface, which is mostly covered with sulfur and sulfur dioxide.

The largest of these volcanic features, named Loki after the Norse god often associated with fire and chaos, is a volcanic depression called patera in which the denser lava crust solidifying on top of a lava lake episodically sinks in the lake, yielding a raise in the thermal emission that has been regularly observed from Earth. Loki, only 124 miles in diameter and at least 373 million miles from Earth, was, up until recently, too small to be looked at in detail from any ground-based optical/infrared telescope.

With its two mirrors, each 8.4 meters (about 27 feet) across, set on the same mount 20 feet apart, the Large Binocular Telescope, or LBT, produces images at the same level of detail that a telescope with a single, 22.8-meter (75-foot) mirror would achieve by combining the light through interferometry. Thanks to the Large Binocular Telescope Interferometer, or LBTI, an international team of researchers was able to look at Loki Patera, revealing details as never before seen from Earth. Their study is published in the *Astronomical Journal*.

"We combine the light from two very large mirrors coherently so that they become a single, extremely large mirror," said Al Conrad, the lead of the study and a scientist at the Large Binocular Telescope Observatory, or LBTO. "In this way, for the first time we can measure the brightness coming from different regions within the lake."

For Phil Hinz, who leads the LBTI project at the University of Arizona's Department of Astronomy and Steward Observatory, this result is the outcome of a nearly 15-year development.

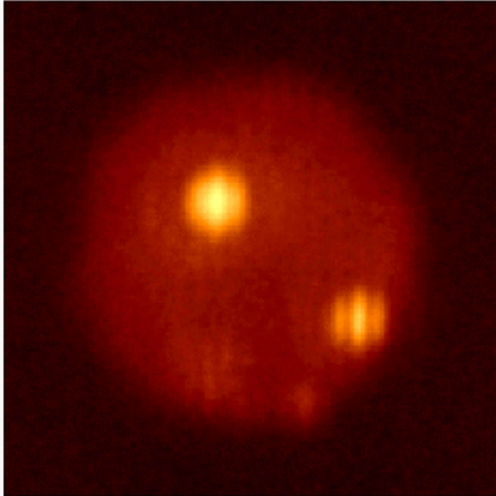


The Large Binocular Telescope

"We built LBTI to form extremely sharp images. It is gratifying to see the system work so well," Hinz said. He noted that this is only one of the unique aspects of LBTI. "We built the system both to form sharp images and to detect dust and planets around nearby stars at extremely high dynamic range. Recent results from LBTI on eta Crv and HR 8799 are great examples of its potential," he said.

Sharp images are important to look at small features on an object (such as the volcanoes on Io). As with any telescope, the bigger the mirror, the smaller the features astronomers can see on their target.

"Interferometry is the way to combine the light coming from each of the two main mirrors of the telescope in a way which allows us to make it look like coming from a single mirror as big as the most distant points of the LBT's two mirrors: 22.8 meters instead of the 8.4 meters of each main mirror," explained Christian Veillet, director of the LBTO. "If we want to look in the vicinity of a star to find dust or planets, we use the information coming from both mirrors in a way that will 'erase' the bright star and allow us to look at faint objects around the star such as planets or a disk of dust."

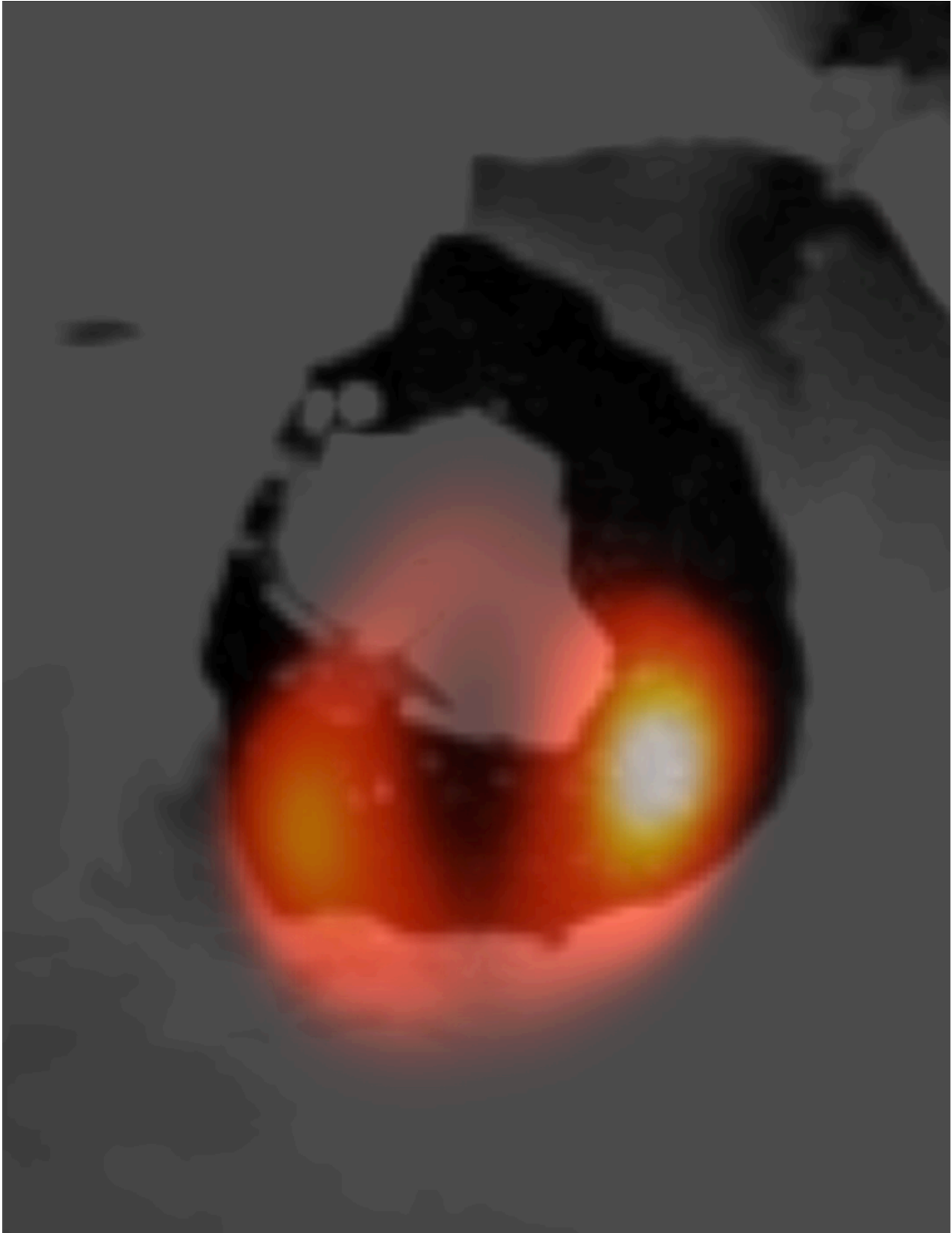


A serendipitous movie of an occultation of Io by its neighboring moon Europa when the team re-observed Io on the night of March 7, 2015, for a follow-up to the work done for the published study. Europa happened to pass in front of Io as observed from Earth. Loki is the bright volcano on the left and Pele the other one on the lower right. Europa appears dark because the water ice on its surface absorbs the incident sunlight at the wavelength used. Credit: LBTO

LMIRcam, the camera recording the images at the very heart of LBTI in the 3 to 5 micrometers near-infrared band, was the thesis work of Jarron Leisenring as graduate student at the University of Virginia. For Jarron, now an instrument scientist for NIRCcam (the Near InfraRed Camera for NASA's James Webb Space Telescope) at Steward Observatory, these observations mark "a major milestone for me and the instrument team. LMIRcam has already been very productive these past few years. Now interferometric combination provides the last step in harnessing LBTI's full potential and enabling a whole host of new scientific opportunities."

"While we have seen bright emissions—always one unresolved spot—'pop up' at different locations in Loki Patera over the years," said Imke de Pater, a professor at the University of California, Berkeley, "these exquisite images from the LBTI show for the first time in ground-

based images that emissions arise simultaneously from different sites in Loki Patera. This strongly suggests that the horseshoe-shaped feature is most likely an active overturning [lava lake](#), as hypothesized in the past."

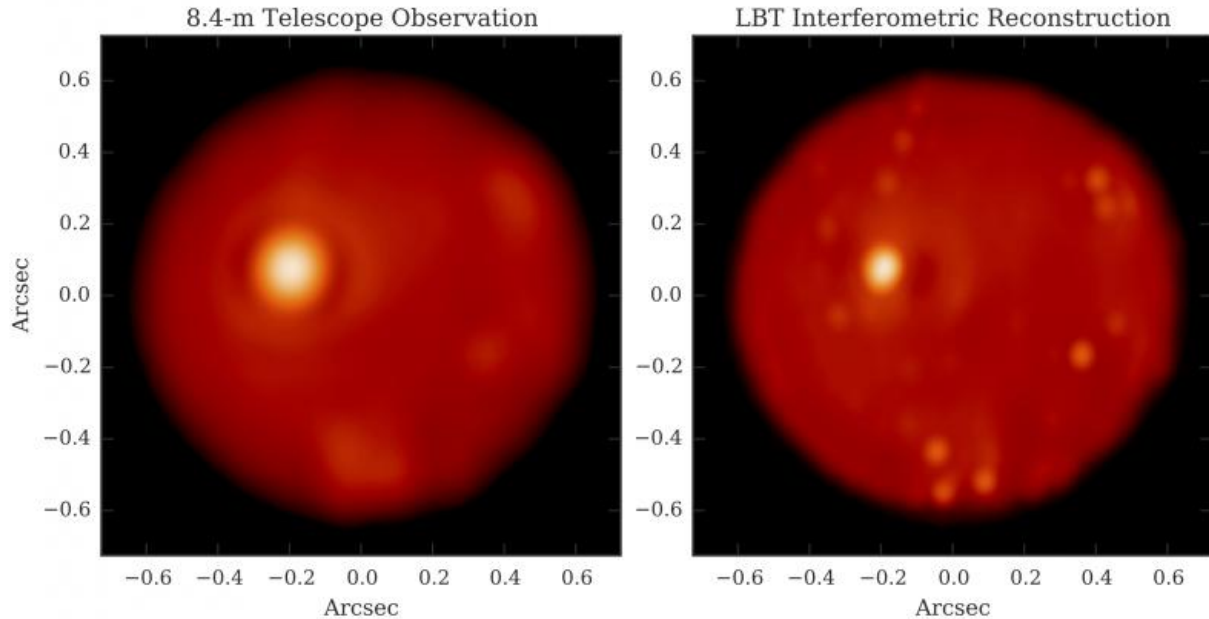


The LBT image of Loki Patera (orange) laid over a Voyager image of the

volcanic depression. The emission (in orange color) appears spread out in the north-south direction due to the telescope point-spread function; it is mainly localized to the southern corners of the lake. Credit: LBTO- NASA

"Two of the [volcanic features](#) are at newly active locations," explains Katherine de Kleer, a graduate student at the University of California, Berkeley. "They are located in a region called the Colchis Regio, where an enormous eruption took place just a few months earlier, and may represent the aftermath of that eruption. The high resolution of the LBTI allows us to resolve the residual activity in this region into specific active sites, which could be lava flows or nearby eruptions."

"Studying the very dynamic volcanic activity on Io, which is constantly reshaping the moon 's surface, provides clues to the interior structure and plumbing of this moon," remarked team member Chick Woodward of the University of Minnesota, "helping to pave the way for future NASA missions such as the Io Volcano Observer. Io's highly elliptical orbit close to Jupiter is constantly tidally stressing the moon, like the squeezing of a ripe orange, where the juice can escape through cracks in the peel."



Comparison between a simulated view of Io through an 8-meter telescope (left) and the final real LBTI reconstruction (right). Credit: LBTO

For Veillet, this study marks "a very important milestone for the observatory. The unique feature of the binocular design of the telescope, originally proposed more than 25 years ago, is its ability to provide images with the level of detail (resolution) only a single-aperture telescope at least 22.7m in diameter could reach. The spectacular observations of Io published today are a tribute to the many who believed in the LBT concept and worked very hard over more than two decades to reach this milestone."

Added Veillet: "While there is still much work ahead to make the LBT/LBTI combination a fully operational instrument, we can safely state that the Large Binocular Telescope is truly a forerunner of the next generation of Extremely Large Telescopes slated to see first light in a decade (or more) from now."

More information: "Spatially Resolved M-band Emission from Io's Loki Patera–Fizeau Imaging at the 22.8 m LBT." 2015, *The Astronomical Journal* 149 175. [DOI: 10.1088/0004-6256/149/5/175](https://doi.org/10.1088/0004-6256/149/5/175)

Provided by University of Arizona

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