IO’S HOTSPOTS IN THE NEAR-INFRARED DETECTED BY LEISA DURING THE NEW HORIZONS FLYBY. C. C. C. Tsang¹, J.A. Rathbun², J.R. Spencer¹, B.E. Hesman³, A. Obramov⁴, ¹Southwest Research Institute, Department of Space Studies, 1050 Walnut Street, Suite 300, Boulder, 80302, USA, ²Department of Physics, University of Redlands, 1200 East Colton Avenue, Redlands, CA, 92373, USA, ³Department of Astronomy, University of Maryland, College Park, MD 20742, USA, ⁴United States Geological Survey, Astrogeology Science Center, 2255 North Gemini Drive, Flagstaff, AZ 86001 USA

Introduction:

The New Horizons spacecraft flew past Jupiter and its moons in February 2007 on its way to Pluto. The flyby provided one of the most comprehensive observations in longitude of Io’s active plumes and hotspots yet taken, including the large 350 km high eruption of Tvashtar. Among the suite of instruments active during the flyby was the Linear Etalon Infrared Spectral Array (LEISA), a near-infrared imaging spectrometer covering the spectral range 1.25 to 2.5 µm. We have identified 36 distinctive hotspots on Io in the nine spectral image cubes taken during the flyby. We present the thermal emissions from these volcanoes, and fit single component blackbody curves to these hotspot spectra to derive eruption temperatures, areas and power output for the hotspots with sufficient signal-to-noise. Of these, 11 hotspots were seen by LEISA more than once, and East Girru showed short-term variability on the order of a few days, also seen by other New Horizons instruments.

Background:

Since the discovery of active volcanism on Io in 1979 by the Voyager 1 spacecraft, Io has been extensively observed and studied in an attempt to understand the source and the driving mechanisms of its widespread volcanism. The Galileo spacecraft most notable provided the most detailed snapshot of these volcanoes over 20 orbits between 1996 and 2001. Continuing long-term ground-based observations of Io’s volcanism, at ever improving spatial resolutions, especially in the near-infrared, can provide the ability to study the temporal variability of hotspots over decadal timescales. However, as Io is tidally locked to Jupiter, the Galileo spacecraft was limited to observing the same longitudes as viewed from Earth. This made estimating the instantaneous total emitted power by all of Io’s volcanoes difficult. In this study, we present estimates of temperatures, emitting areas and powers of some 17 volcanoes, from a total of some 36 detected volcanoes, from the LEISA instrument on New Horizons during the flyby of Io in 2007. By doing so, we provide one of the most global, instantaneous estimates of the total emitted power of Ionian volcanoes, as the flyby covered all longitude ranges on Io.

Observations:

LEISA is the Linear Etalon Infrared Spectral Array, a near-infrared spectrometer. It covers the wavelength region between 1.25 and 2.5 µm, at spectral resolving powers of ~240, with a higher resolving power segment (R~540) covering 2.1 to 2.25 µm. Both segments share the same detector array, resulting in a 256 x 256 x N (spatial, spatial + spectral, temporal) pixel image cube with a 62 µrad per pixel field-of-view. Each row on the detector is sensitive to a particular wavelength. The target is scanned across the rows to construct a spectral image. In this work, we only use the lower resolution 1.25 to 2.5 µm segment due to the wider spectral sample.

The closest approach occurring on February 28 at a range of 2.26 million kms, with LEISA observations ranging from this closest approach to a distance of 3.04 million kms. Other remote sensing observations of Io were taken including monochromatic and color images and ultraviolet spectra. Initial analysis of the detected hotspots and temperatures from LEISA were presented in a previous publication [1]. LEISA took a total of nine spectral image cubes in the near-infrared. Io was observed under a number of phase angles, including being in the gibbous, crescent and eclipse phases (Figure 1 & 2).

Results:

The LEISA spectral observations of Io revealed a total of 36 hotspots, 11 of them seen more than once. We will show the hotspots identified, their locations and retrieved temperatures, emitting areas, 2.2 µm radiant fluxes, and total powers. Of those 36 hotspots found, we were able to fit single temperature blackbody curves to 17 hotspots, four of which was measured more than once at different times during the flyby. Most hotspots are long-lived hotspots and allow some comparison with ground-based and spacecraft observations, although some hotspots have retrieved temperatures and areas with significant errors.

Most of the hotspot temperatures range from 500 K to 900 K, with Pele, East Girru and Tvashtar at approximately 1000, 1150 and 1240 K respectively.

Of the 11 hotspots seen more than once with LEISA, those of Ukko Patera, NIMS I32D, East Girru, Reiden, Pele, Ulgen, North Lerna, Dazhbog, Loki and...
an unidentified hotspot at longitude 335°, only East Girru, seen in three observations, showed temporal variations. Pele was also observed on three separate occasions, but the power output remained constant in the short period of time it was observed. North Lerna and Dazhbog were each observed twice and whose power also remained constant over the few days of observations. There were four potential new hotspots identified in the images that have not been seen in previous observations. All four of these hotspots do not have sufficient SNR to retrieve their blackbody emissions, and are only weakly seen in the co-added spectral images.

The total power output of Io observed from these LEISA observations is $7.62 \times 10^{12}$ W, with Tvashtar contributing $4.95 \times 10^{12}$ W to this total. The total observed is well below the observed total thermal output from other studies [3], and significantly below the theoretical limit predicted [4] of $\sim 1.25 \times 10^{14}$ W, although this is to be expected given we are insensitive to low temperature hotspots that have blackbody emissions which peak at much longer wavelengths, that is expected to make up a significant portion of the thermal emission from Io, or hotspots with low emitting areas given the high noise in our data.

**Conclusions:**

A total of 36 distinct hotspots were identified, 11 of which were imaged more than once. Four of the 36 hotspots are possible new eruptions, but are at too low an intensity to fit with blackbody curves. The majority of the observed hotspots are long-lived, seen during the Galileo era and from ground-based observations in the late 1990’s and mid-2000s, respectively. Tvashtar was the most powerful emission in the New Horizons dataset, at 1239 (± 19) K and an area of 37 (+4/-3) km², values that are slightly different found previously [1]. We find the emitted power of East Girru fell during the 48 hours LEISA observed the hotspot, decreasing in power by a factor of 2.5 in this period, an effect also identified in LORRI and MVIC data [2]. This work represents one of the most complete surveys in longitude of Io’s volcanic activity, and provides a snapshot of the total power emitted by Io’s hotspots, which is estimated at 7.62 TW from LEISA observations.

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**References:**