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High resolution LBT imaging of Io and Jupiter

A. Conrad (1), K. de Kleer (2), J. Leisenring (3), A. La Camera (4), C. Arcidiacono (5), M. Bertero (4), P. Boccacci (4), D. Defrère (3), I. de Pater (2), P. Hinz (3), K.-H. Hofmann (6), M. Kürster (7), J. Rathbun (8), D. Schertl (6), A. Skemer (3), M. Skrutskie (9), J. Spencer (10), C. Veillet (1), G. Weigelt (6), and C. E. Woodward (11)
(1) LBTO, University of Arizona, Tucson Arizona, USA (aconrad@lbto.org / Fax: 1-520-626-9333), (2) University of Califronia at Berkeley, California, USA, (3) University of Arizona, Arizona, USA, (4) University of Genoa, Genoa, Italy, (5) Observatory of Bologna, Bologna, Italy, (6) Max Planck Institute for Radio Astronomy, Bonn, Germnay, (7) Max Planck Institute for Astronomy, Heidelberg, Germany, (8) Planetary Science Institute, Arizona, USA, (9) University of Virginia, Virginia,USA, (10) Southwest Research Institute, Colorado, USA, (11) Minnesota Institute for Astrophysics, Minnesota,USA

Abstract

We report here results from observing Io at high angular resolution, ~32 mas at 4.8 µm, with LBT at two favorable oppositions as described in our report given at the 2011 EPSC [1]. Analysis of datasets acquired during the last two oppositions has yielded spatially resolved M-band emission at Loki Patera [2], L-band fringes at an eruption site, an occultation of Loki and Pele by Europa, and sufficient sub-earth longitude (SEL) and parallactic angle coverage to produce a full disk map. We summarize completed results for the first of these, and give brief progress reports for the latter three. Finally, we provide plans for imaging the full disk of Jupiter using the MCAO system which is in its commissioning phase at LBT.

1. Loki Patera

Using the Large Binocular Telescope Interferometer (LBTI) [3] mid-infrared camera, LMIRcam, we imaged Io on the night of 24 Dec 2013 UT and detected strong M-band (4.8 µm) thermal emission arising from Loki Patera [1]. In this Fizeau imaging mode, the 22.8 m baseline of the Large Binocular Telescope (LBT) provides angular resolution of ~32 mas (~100 km at Io). In Fig. 1 we show the two distinct emission features detected in this observation, overlaid on a Voyager image of the lava lake on which they are located. These observations also revealed 15 other emission sites, including two previously unidentified hot spots [1].

2. L-band fringes on eruption site

The majority of the LBTI data have been taken at M-band; however, an extremely bright eruption occurred during our 5 Feb 2015 UT observing run which was visible on the limb. The brightness enabled us to obtain L-band fringes (Fig. 2) in Fizeau imaging mode using the 22.8 m baseline.

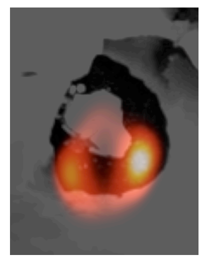

Figure 1: Location of the two hotspots detected within Loki patera. The grey portion of the figure is a Voyager image. We resolve approximately 3 resolutions elements across the lake. The overlaid image of our 4.8 µm LBTI data (in orange) has been smoothed to better indicate the location of the two distinct emission features.

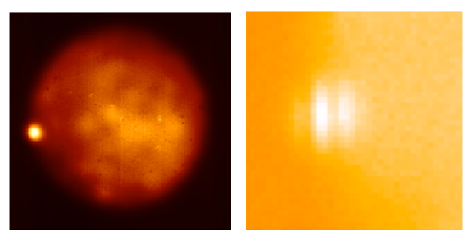

Figure 2: L-band images of an eruption taken with LBTI on 5 Feb 2015.

3. Io/Europa Occultation

On 8 Mar 2015 UT, we observed an occultation of the two Io volcanoes Loki and Pele (see Fig. 3) by Europa. The knife-edge effect of the occultation could provide additional data for measuring features at high angular resolution. Note for example in Fig. 3 that as occulting Europa approaches Loki, that volcano is still resolved (whereas Pele is unresolved). However as Loki becomes clipped by Europa, we briefly see only a portion of Loki and its image is therefore unresolved.

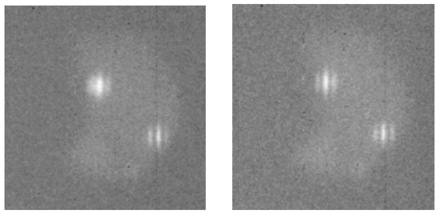

Figure 3: Two raw frames at 4.8 µm of Io's 8 Mar 2015 UT occultation by Europa. Pele (unresolved in both frames) is in the lower right and Loki (resolved in the left hand frame) is in the upper left. Europa appears dark because the water ice on its surface absorbs the incident sunlight at this wavelength.

4. Complete Surface

Production of a complete map of Io at the LBT 22.8 meter resolution requires coverage in both parallactic angle and sub-earth longitude (SEL). Data obtained during the last two Io oppositions provides sufficient coverage for producing a full disk map (Fig. 4).

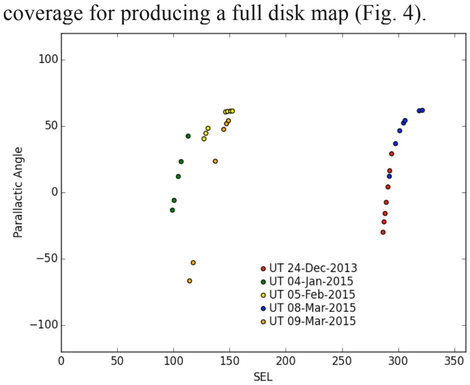

Figure 4. SEL versus parallactic angle coverage of data collected during last two oppositions.

5. Jupiter Full Disk

Solar system objects, since the late 1990's, have been well-studied from ground-based telescopes with adaptive optics (AO). However, a few objects have eluded this technology due to their wide angular extent. Most notably, Venus, Mars at most viewing opportunities, and Jupiter, because their size exceeds the 2-4 arc-second limit for self-reference imposed by most AO systems, are rarely viewed at high angular resolution from the ground. At 40 arc-seconds, Jupiter cannot be used for self-reference and the anisoplanatic effect of single conjugate AO (SCAO) systems limits field of view [4]. Jupiter is therefore a perfect target for exploiting the capabilities of emerging multi-conjugate AO (MCAO) systems. With 12 pyramid wave front sensors (PMWFS) patrolling an annulus with 6-arcminute diameter in its ground-layer AO (GLAO) subsystem, and 8 PMWFS patrolling a circular 2 arc-minute field in its high layer AO subsystem, LINC-NIRVANA (L-N) [5] will be capable of providing homogenous AO correction at 1.1-2.2 µm across the full disk of Jupiter for the first time since observations taken with the MCAO demonstrator (MAD) system in 2008 [6]. At the meeting, we will provide simulations that quantify the correction expected with L-N, in both single-mirror (8.4 meter) MCAO mode, planned for 2017, and in Fizeau (22.8 meter) mode, under consideration as a possible upgrade.

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