THE ROAD TO 10 MAS IMAGING AT LBT. A. R. Conrad[1], C. Veillet[1], Ellen S. Howell[2]
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Introduction: Although often designed for higher contrast ratios, the surge of interest in exo-planets has resulted in imaging technologies that benefit the search for small satellites in the Solar System as well. At the Large Binocular Telescope (LBT) we have conducted three observations that demonstrate the use of unique methods to detect binaries. We show here how each of these observations provides a proof of concept for a technology that could enable us to be spotting asteroid satellites at 10 mas separation by the middle of the next decade.

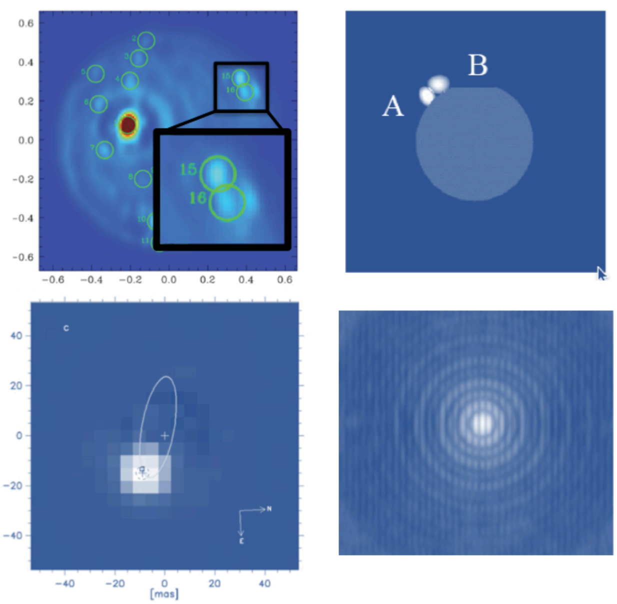

Figure 1. Representative figures from 3 observations taken with LBT are shown (volcanoes on Io [1] upper left, close companion of asteroid 2003 YT1 [2] upper right, the binary star system Alpha Andromeda [3] lower left), together with the theoretical point spread function (PSF) for a new instrument planned for LBT in the next decade [4]. See text for details. Each figure was taken directly from the reference given, however the color map was altered to ease in viewing in this single family portrait.

2013 – 100 mas @4.8μm: In 2013 Jupiter's volcanic moon Io was observed using the Fizeau, 23-meter mode of LBT at M-band [1]. Two new hot spots were identified at a separation of about 14° of Ionian latitude, about 200 km on the surface of Io (see figure 1 upper left). This proof of concept in the observation of a moving solar system object using the 23-meter mode stands as one of the 3 ingredients given here toward 10-mas resolution for observing solar system binaries.

2016 – 60 mas @2.2μm: In 2016 LBT was used to observe the binary near-Earth asteroid 164121 (2003 YT1) at K-band (see figure 1 upper right). This work is reported on separately, at this workshop [2]. The angular difference imaging (ADI) analysis of LBT images that was applied to make this detection stands as the second of the 3 ingredients given here toward 10-mas resolution for observing solar system binaries.

2019 – 20 mas @0.6μm: In 2019, as part of the LBT SHARK-VIS Pathfinder Experiment, speckle-free-imaging (SFI) observations were taken of binary system Alpha Andromeda at R-band. To better reveal the secondary star, a careful subtraction of the primary was performed (see figure 1 lower left; two plus signs indicate the respective locations of the two stars, with the flux from the brighter primary removed by subtracting a fitted PSF). The two stars were seen clearly distinguished at a separation of about 20 mas [3]. The SHARK-VIS instrument stands as the third of 3 ingredients given here toward 10-mas resolution for observing solar system binaries.

2025? – 10 mas @0.6μm: By combining the 3 ingredients above, distinguishing a parent asteroid from its satellite at a distance of 10 mas could be possible. The LBT Interferometer Visible Extension (LIVE) project is now under consideration [4]. The theoretical PSF for LIVE is shown in figure 1, lower right. This system would take advantage of the LBT 23-meter baseline, as was done for the Io observations described above. Combining this technique with AO at visible wavelengths, as was done for the Alpha Andromeda observations described above, yields 10 mas resolution. Adding the ADI method, used for the YT1 observation described above, completes the picture.

Conclusions: We have shown, through past observations made at LBT, that the potential to image asteroid satellites at 10 mas separation from their parent body could become a reality at LBT by the middle of the next decade.

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References: [1] Conrad, A., de Kleer, K., Leisenring, J., et al (2015) *AJ*, **149** 175, [2] Howell, E., Conrad, A., et al (2019) *Binaries 5,* to appear, [3] Mattioli, M., Pedichini, P., et al (2019) *AAS,* **3** 1, [4] Hinz, P., Esposito, S., et al (2014) SPIE **9146** 5