



Thermal Infrared and Multiband Imaging to Investigate S-type Binary Asteroid Didymos and Dimorphos in Hera Mission

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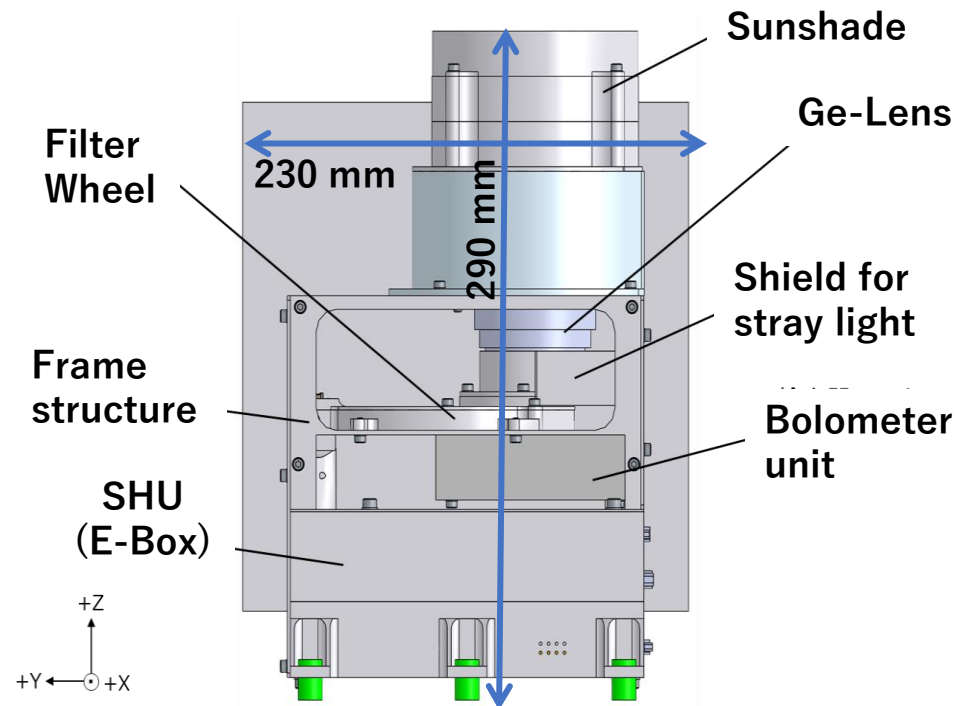
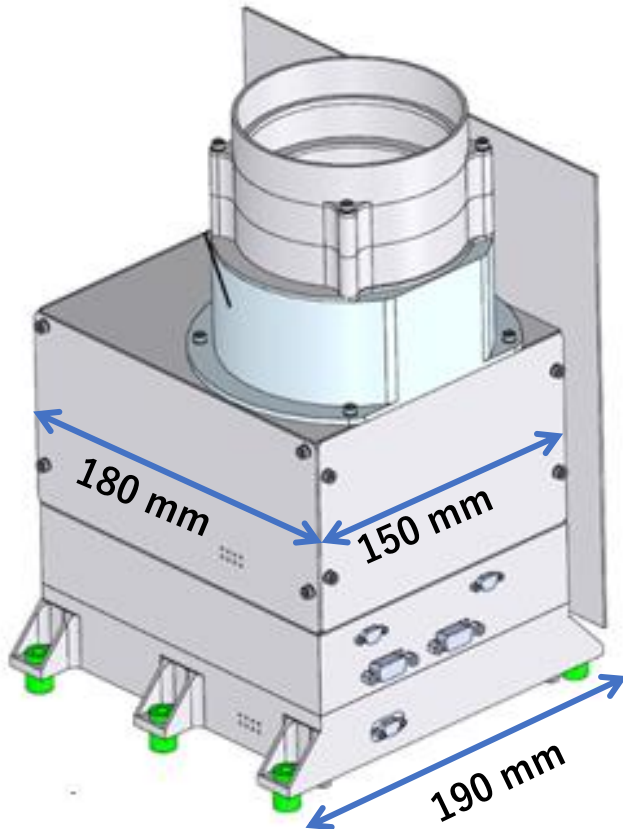
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6: Univ. Aizu, 7: Hokkaido Univ. Edu., 8: AIST*



Thermal Infrared Imager onboard Hera



- TIRI: A bolometer based thermal imager (Heritage from Hayabusa2 TIR)
 - ◆ Thermal imaging to investigate thermophysical properties of asteroid surface.
 - ◆ Multi-band thermal imaging to map the compositional difference.



Items	Descriptions
Detector	Lynred PICO1024 Gen2
Pixel size	1024 x 768 pixels
Image area	17.4 x 13.1 mm
Wavelength (wide)	7 to 4 μ m
Filter bands (narrow)	7.6, 8.6, 9.6, 10.6, 11.6, 13.1 μ m
Readout Freq.	30 Hz
NETD	< 0.1 K @300K
Temp. Accuracy	< 3 K @300K
Optics	F/1.0, f=75mm, AR coat
MTF	> 0.3 @300K
FOV	13.3 x 10.0 deg
IFOV	0.23 mrad (0.013 deg/pixel)
Avoidance Angle	45°
Max Integration	2 ^N , N=0, 1, 2, ..., 7
Consecutive Images	< 128
Filter exchange	< 10 sec
Total Mass	< 4.2 kg (<5.5kg with margin)
Total Power	17W (<30W with margin)



Observations by TIRI at Didymos binary system



Launch (2024)

- Commissioning
- Dark sky observations

Mars Flyby (2025)

- Mars observations
- Dark sky observations
- (possible asteroid flyby)

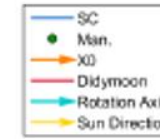
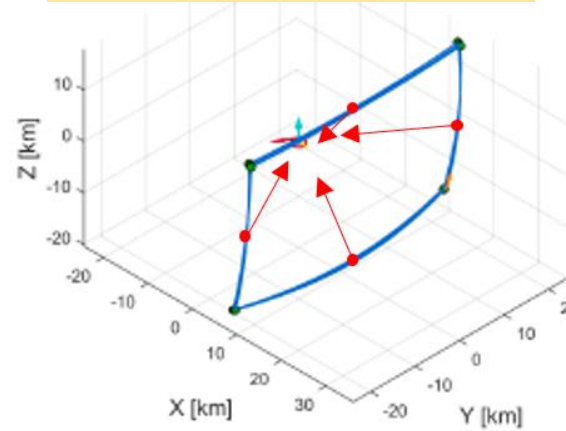
Approach (2026)

- Dark sky observations
- Optical (IR) navigation (test)

Rendezvous (2027)

- Dark sky observations
- Early Characterization (ECP, at 20-30km)
 - 30 thermal images for 1 rotation
 - 7 x Multi-band images for 1 rotation
 - From 4 directions for Didymos
 - From 4 directions for Dimorphos
- Payload Release (Cubesat, at 20km)
 - Tracking the cubesats
- Detailed Characterization (DCP, at 10-20km)
 - Same as ECP
- Close Operations (COP, at <5 -20km)
 - Consecutive thermal images
 - Multi-band images
 - At closest positions
- Extended Operations (EXT, <5km)

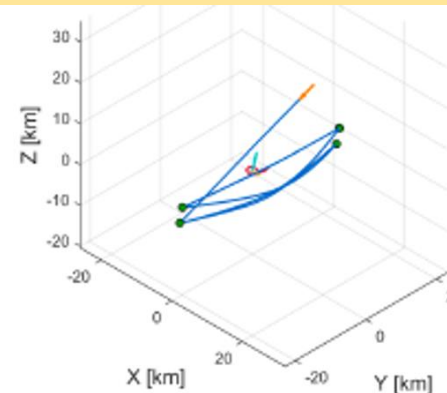
ECP from 20-30km at large solar angles



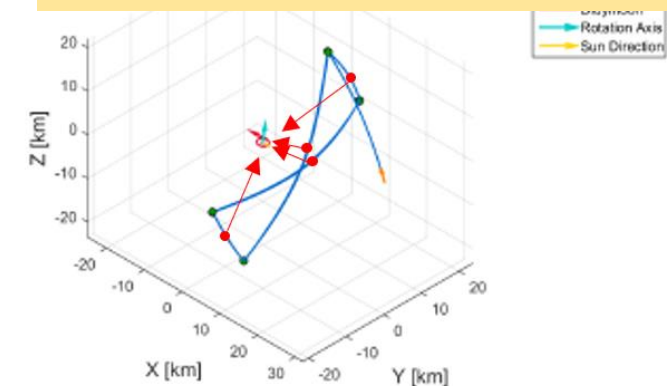
PRP for tracking CubeSats



COP from < 5 km at noon and ~20 km at large solar angles



DCP from 10-30km at noon and at large solar angles





Thermal Imaging of Asteroid



■ Global thermal images

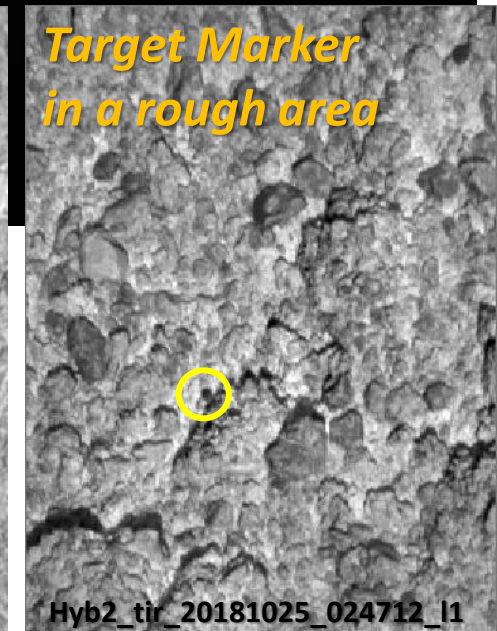
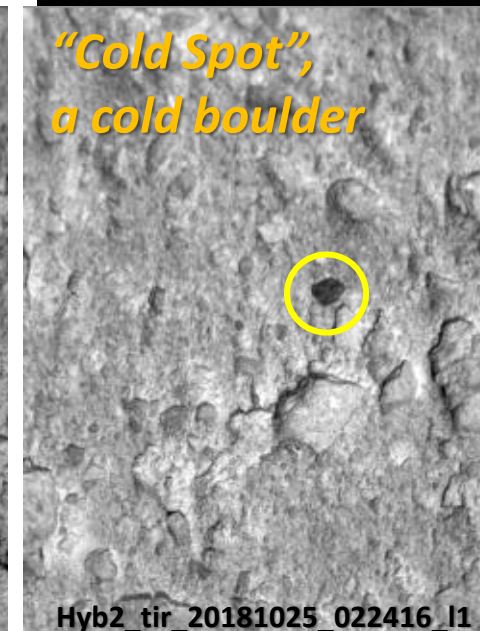
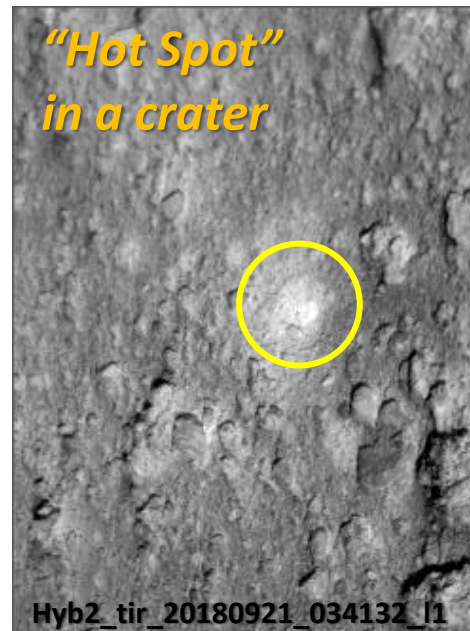
- ◆ Diurnal temperature profiles (landing site selection)
- ◆ Thermal inertia map, *to find Ryugu covered with low-TI boulders, indicating highly porous materials [Okada+, Nature 2020]*
- ◆ Images in the night side (for complete shape modeling)

■ Local thermal images

- ◆ Thermophysical properties of each of rocks and boulders
- ◆ Discovery of “cold” and “hot” spots [Okada+, Nature 2020; Sakatani+, Nature Astron. 2021]
- ◆ Detection of surface features, *incl. 10cm-dia. TM.*

Hayabusa2 TIR

23 June 2019, at Box-A: 20.2 km (~17.8 m/pixel):
Solar distance: 1.14 au, SPE angle (~phase angle) = 35.5°



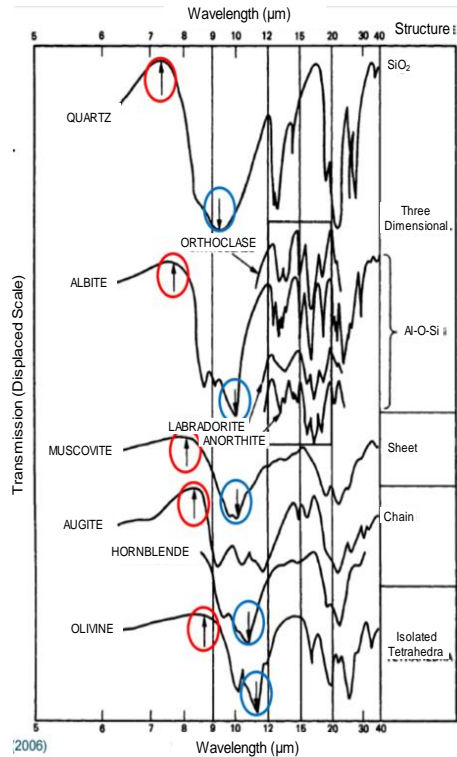
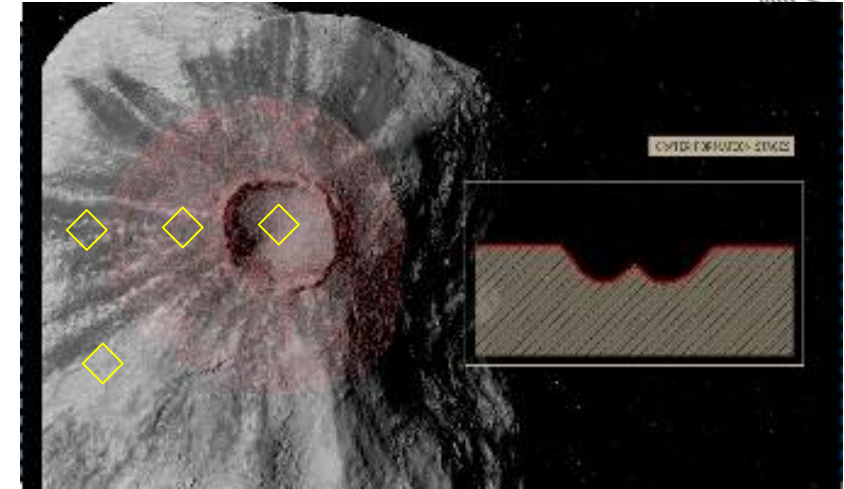


Multi-band Thermal Imaging of Asteroid

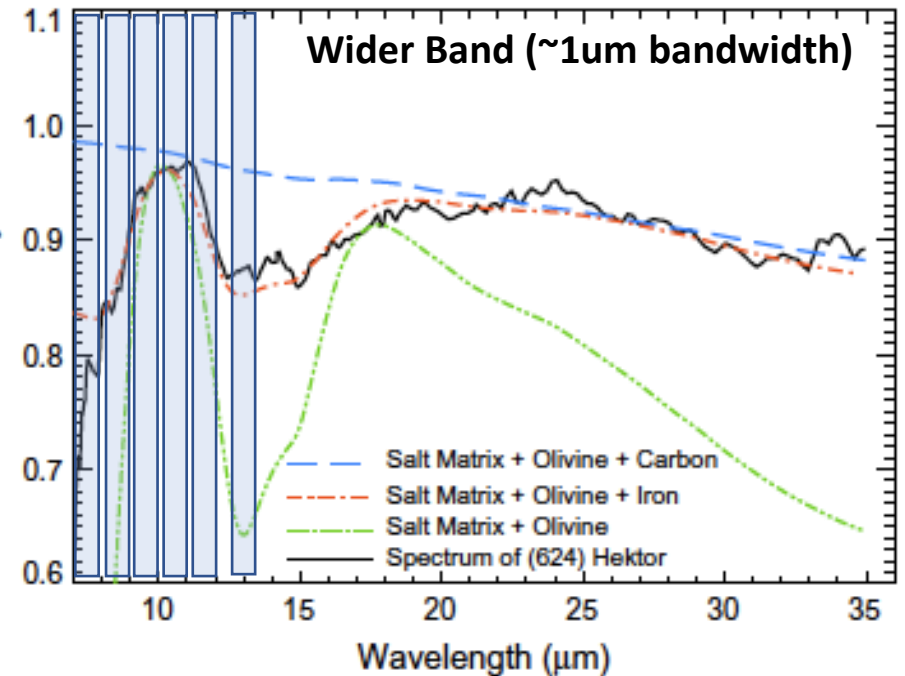
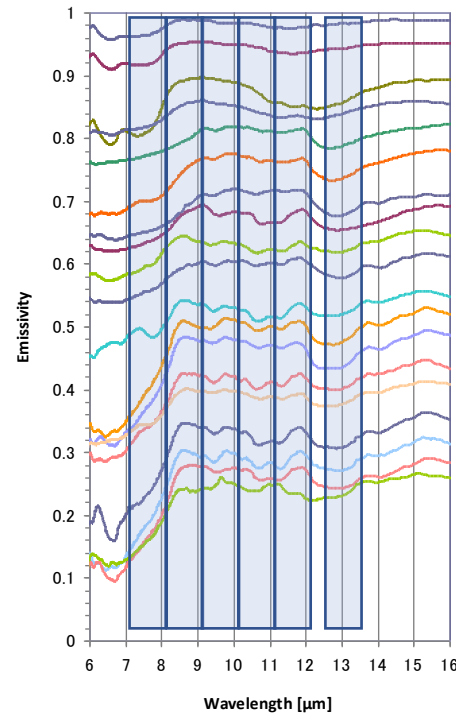


Comparison with

- ◆ Didymos / Dimorphos
- ◆ DART crater: interior / ejecta blanket / outside
- ◆ Flat area (sediments) / boulders



[Hunt+, 2015]





Summary



- TIRI is a bolometer based multi-band thermal imager onboard Hera.
- TIRI will contribute to understanding the nature of the Didymos asteroid binary system, especially in thermophysical properties and material distribution.
- TIRI will possibly contribute to constructing the complete shape model and spacecraft navigation, using thermal images.