JWST OBSERVATIONS OF THE DIDYMOS-DIMORPHOS SYSTEM

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OVERVIEW

NASA's DART (Double Asteroid Redirection Test) impacted Dimorphos, the secondary of the near-Earth binary asteroid (65803) Didymos, on September 26, 2022 in the first test of kinetic impact for asteroid deflection (Daly et al. 2023). Telescopes around the world and in space monitored the Didymos-Dimorphos system before, during, and following the impact to study the change in orbital period, the evolution of the ejecta, and the physical properties of the target bodies.

DART
Double Asteroid Redirection Test

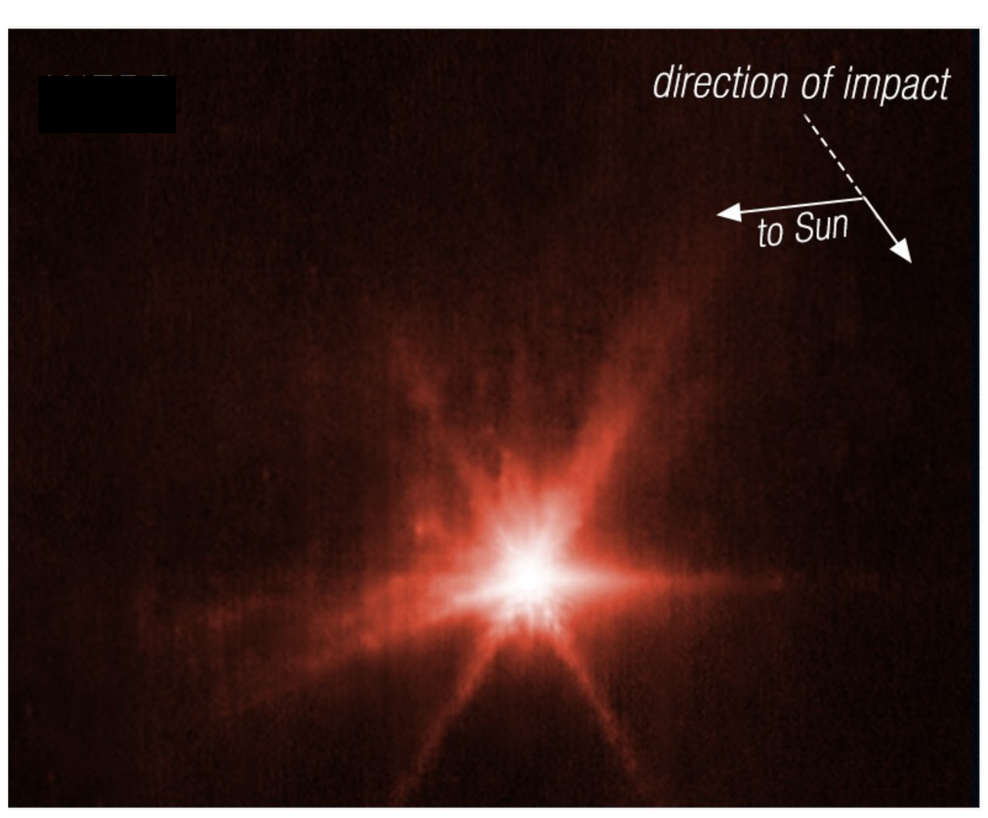
Our JWST observations are part of a Guaranteed Time Observation program. At the time of impact, the non-sidereal rate of motion for Didymos (~110 mas/sec) was far beyond the nominal JWST tracking limit (30 mas/sec at the time). Following a series of test observations in early September 2022, we were able to observe Didymos at the full tracking rate with NIRCam immediately before and in the hours after impact. We obtained follow-up NIRCam imaging as well as spectra with NIRSpec and MIRI a couple of months after impact once the non-sidereal rate had fallen below 30 mas/sec. At this time, a large fraction of the ejecta had moved to the tail so our data are dominated by light from Didymos. Our spectra are the first measurements of Didymos taken in these wavelengths.

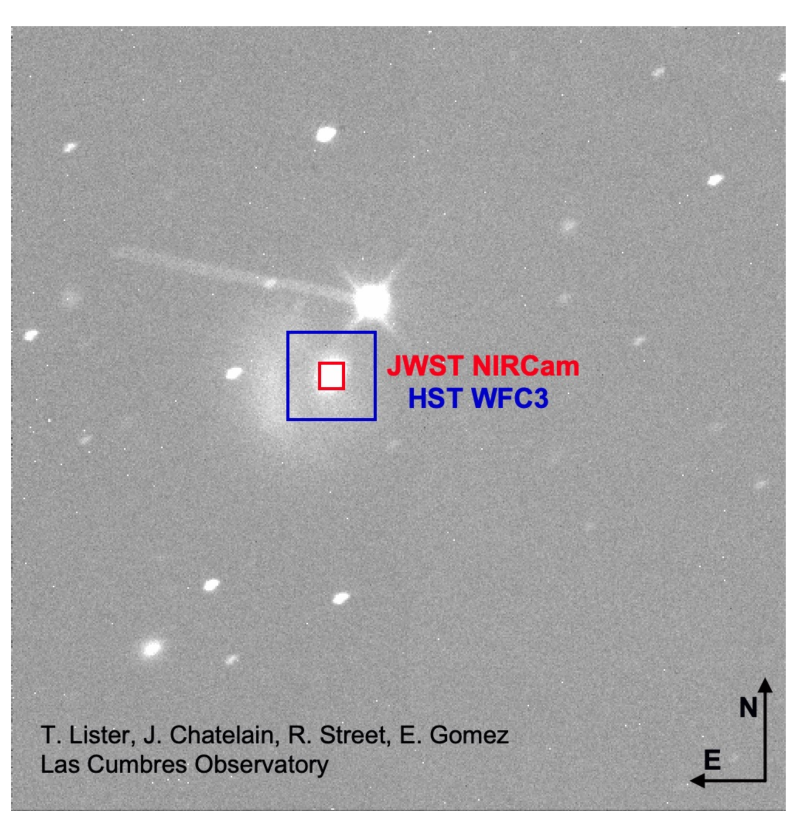
Instrument	Mode & Wavelengths	UT Date
NIRCam	F090W & F430M	26-27 September 2022
NIRSpec	Fixed Slit, Prism (0.6– 5.3 µm)	27 November 2022
MIRI	Medium Resolution Spectroscopy (4.9-27.9 µm)	4 December 2022
NIRCam	F090W & F430M	9 December 2022

NIRCAM AT IMPACT

JWST observed the Didymos system with NIRCam over a period of approximately 5 hours beginning shortly before impact. The successful Didymos impact observations used non-sidereal tracking at a rate greater than three times the then-nominal JWST tracking rate. The cadence of the images was determined by the availability of guide stars and the amount of time the star remained in the Fine Guidance Sensor aperture. The impact observations include 9 visits of approximately 5 minutes.

These observations show the evolution of the ejecta near the asteroids in the hours after impact with a resolution of ~1.7 km/pixel on the short wavelength detector. A second set of NIRCam observations were taken on 9 December to show the state of the ejecta closest to Didymos and Dimorphos at that time (short wavelength resolution ~4.1km/pix). These images cover the smallest field of view and highest spatial resolution of our telescopic observations.





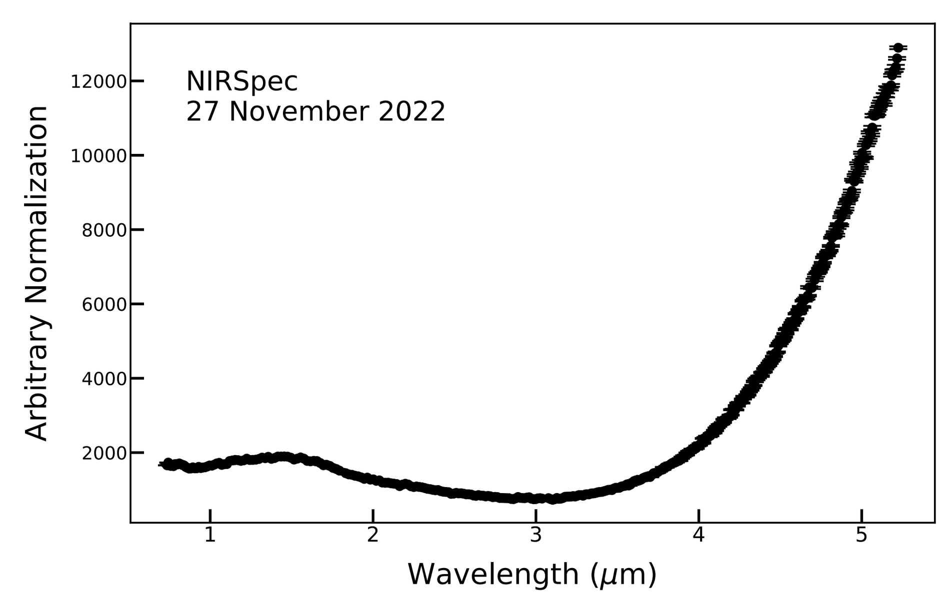
ACKNOWLEDGEMENTS

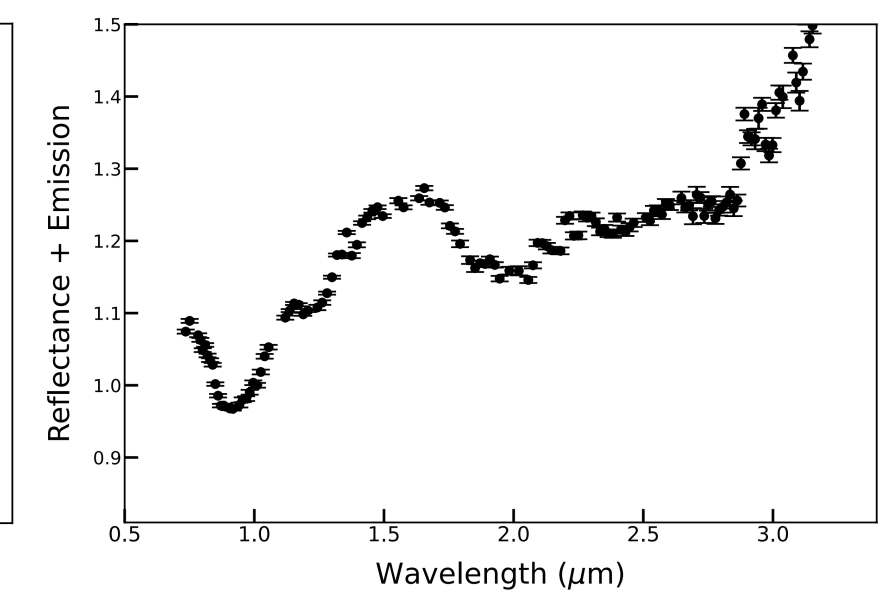
We are enormously grateful to the support provided by the Space Telescope Science institute to make our impact observations possible. This work was supported by the DART mission, NASA Contract No. 80MSFC20D0004.

NIRSPEC (0.6-5.3 µm)

The NIRSpec data show an S-type spectrum and significant thermal excess. There is no clear absorption feature at 3 µm, which implies no abundant hydrated minerals. A weak feature in this wavelength region is still possible and will be investigated. Ground-based observations of nominally anhydrous near-Earth objects have shown that 3 µm features with band depths of a few percent are present on some S-types (Rivkin et al. 2018, McGraw et al. 2022).

We used the thermal contribution to perform independent assessments of Didymos' thermal properties. Using the Harris & Drube (2016) method, we estimate the thermal inertia to be ~350 $Jm^{-2}K^{-1}s^{-1/2}$. A more rigorous assessment of thermal inertia (Rozitis, personal communication) finds a thermal inertia of 370 ± 20 $Jm^{-2}K^{-1}s^{-1/2}$. The calculated thermal inertia for Didymos is similar to Bennu (350 ± 20 $Jm^{-2}K^{-1}s^{-1/2}$, DellaGuistina et al. 2019) and other asteroids of similar size (MacLennan & Emery 2021). MIRI data will provide another assessment of thermal inertia once the data can be fully calibrated.

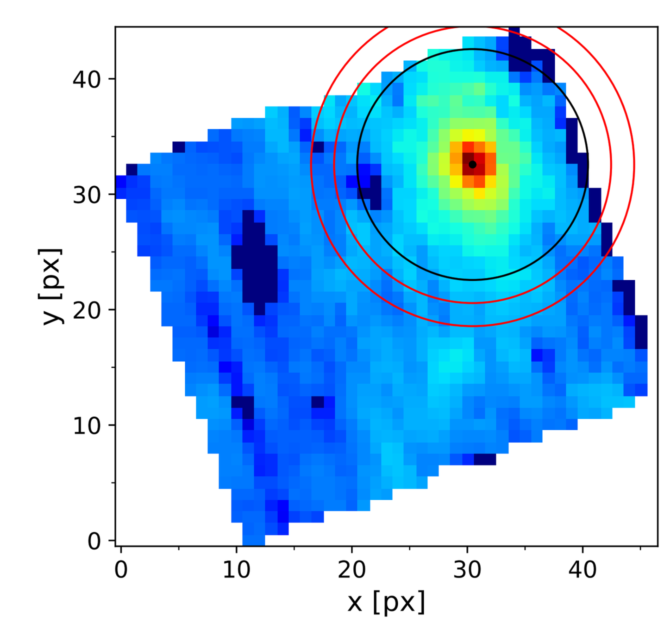




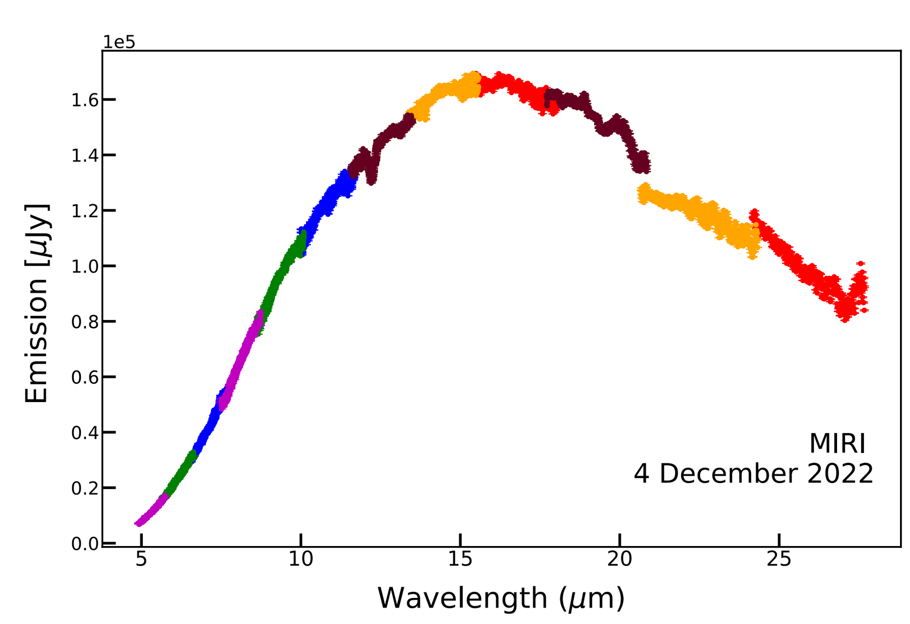
MIRI (4.9-27.9 µm)

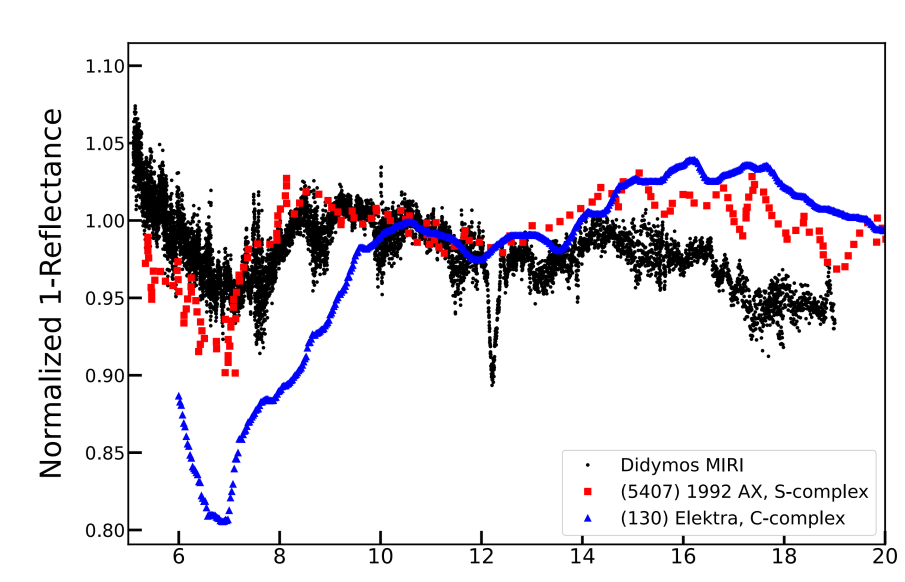
The MIRI medium resolution spectrometer (MRS) observes a set of three simultaneous exposures of the 4 integral field units (IFUs). A complete spectral analysis is dependent on upcoming flux calibrations (specifically at λ > 20 µm, see figure below) that will enable more accurate joining of the spectral segments.

The Didymos spectrum has emissivity features consistent with LL ordinary chondrites and S-type asteroids, but is different from other asteroid spectral types (e.g., Marchis et al. 2012).



MIRI IFU frame





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