Investigating the DART Impact Event with the Lucy LOng Range Reconnaissance Imager

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Introduction

The Lucy Mission

NASA's Lucy mission is the first to provide flyby reconnaissance of the Jovian trojan asteroids, which are thought to be primordial small bodies that formed at a variety of heliocentric distances during the early stages of the solar system's formation and were subsequently captured into Jupiter's L4 and L5 Lagrange stability zones. More Lucy mission information can be found near the bottom of this panel.

Lucy Supports DART

Three weeks before the Lucy spacecraft conducted its first Earth Gravity Assist (EGA1) on 2022-Oct-16, the Lucy LOng Range Reconnaissance Imager (L'LORRI) obtained a comprehensive series of images of the Didymos-Dimorphos binary asteroid system bracketing the DART kinetic impact of Dimorphos on 2022-Sep-26.

L'LORRI captured 1548 images of the Didymos system, starting 12 hr before the DART impact event and ending 24 hr after it.

The Lucy imaging campaign provided pre-impact monitoring of the baseline brightness of the Didymos system over a full orbital rotation period, intensive one second cadence imaging starting three minutes prior to impact and extending until four minutes after impact, and then continued monitoring at varying cadences and image exposure times to monitor the Didymos system brightness changes due to the development of the ejecta cloud produced by the impact.

The time-resolved photometry and ejecta morphology derived from the L'LORRI images help to characterize the consequences of the kinetic impact.

Meet L'LORRI

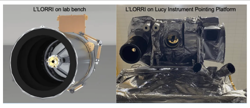
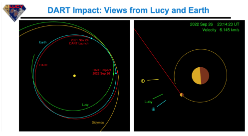
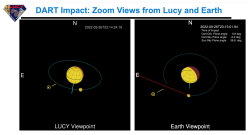


Image to left shows the Optical Telescope Assembly (OTA) mounted on

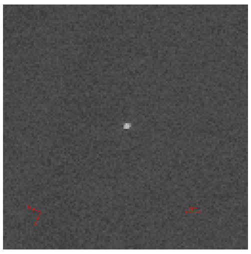
Geometry and Observing Plan



The figure to the left shows the trajectories for the Lucy and DART spacecraft, and for the Earth and Didymos. The locations at specific times are indicated by solid circles. The figure to the right is a magnified view near the time of the DART impact and shows the directions to the Sun, Lucy, and the Earth. The view from Lucy is at a smaller solar phase angle than the Earth view. (Both figures were made by T. Farnham)



Lucy Results



Composite of 280 pre-impact L'LORRI images of the Didymos system, each taken with an exposure time of 9.9 sec. ASINH intensity stretch ranging from -1 to 180 DN. Flux in 5 pixel radius aperture is 315.98 +/- 4.14 DN in 9.9 sec, which implies V=15.16

Summary and Path Forward

- **The Lucy DART program executed flawlessly and produced excellent results**
  - Lucy LORRI was the only non-DART space-based asset to observe the impact event itself at high cadence
- **Key findings from the Lucy DART investigation include:**
  1. Lucy LORRI successfully observed the Didymos system starting 12 hr before the DART impact and ending 24 hr after impact
  2. Lucy LORRI documented the early evolution of the DART impact ejecta at 1 sec cadence and detected both fast-moving and slow-moving material
  3. Lucy LORRI did *not* detect the DART impact flash (i.e., self-luminous material produced immediately after impact)
  4. Lucy LORRI and complementary Earth-based data taken at different phase angles constrain the scattering phase law of the DART/Dimorphos ejecta, thereby constraining the particle size and/or composition
  5. Lucy LORRI and Earth-based data can be used to elucidate the nature of the fast-moving dust and how much it contributes to the system brightness and mass loss
- **Working on a paper summarizing the Lucy results for submission to a refereed publication**
  - Expect further progress on data analysis during the next two months, which will likely result in new findings

Thanks for your attention!

ABSTRACT

NASA's Lucy mission is the first to provide flyby reconnaissance of the Jovian trojan asteroids, which are thought to be primordial small bodies that formed at a variety of heliocentric distances during the early stages of the solar system's formation and were subsequently captured into Jupiter's L4 and L5 Lagrange stability zones. Since its successful launch on 2021-Oct-16, the Lucy spacecraft has been orbiting the sun within the inner solar system. On 2022-Oct-16, Lucy executes the first of three Earth Gravity Assists (EGAs) that put the spacecraft on the correct trajectory to achieve its encounters with the Jovian trojans. The DART kinetic impact on the secondary body of the Didymos-Dimorphos binary system occurs 20 days prior to EGA1, at a time when the Lucy spacecraft is well-placed to observe it. Lucy carries a sensitive panchromatic camera, the Lucy LOng Range Reconnaissance Imager (L'LORRI), which is capable of detecting the binary system with high signal-to-noise ratio (SNR) and with temporal cadences as fast as once per second.

The observing geometry from Lucy is similar to that from the Earth: the range to the Didymos system is 0.126 au from Lucy vs 0.0757 au from Earth, and the solar phase angle is 31.9 deg vs 53.2 deg. The L'LORRI investigation of the DART impact event is divided into eight separate observational phases, starting 12 hr before the impact and ending 24 hr afterwards. L'LORRI cannot resolve the binary, but instead records the total brightness, which is expected to increase after the DART impact due to reflected sunlight from the ejecta. The first two phases are designed to obtain baseline photometry of the Didymos system covering both the Didymos-Dimorphos mutual orbit period (11.92 hr) and the rotational period of Didymos (2.26 hr). Phase 3 covers the impact event itself at one second cadence, starting 3 minutes before impact and ending 4 minutes afterwards. Lucy has a clear view of the predicted DART impact site, theoretically enabling L'LORRI to detect an optical flash in the unlikely event it is brighter than Didymos itself. L'LORRI observations during phases 4 through 8 are designed to monitor the temporal and spatial evolution of ejecta associated with the impact event, but ejecta don't leave the central pixel during Lucy's observing period unless their speed is greater than about 2 m/s.