ASPECT

Asteroid spectral imaging mission

Antti Kestilä & ASPECT Team

VTT Technical Research Centre of Finland
Aalto University
Department of Physics, University of Helsinki
Background - AIDA

Launch 2020 – Mission 2022
The ASPECT team

Prime contractor: VTT Technical Research Centre of Finland Ltd

Main responsibility: the Fabry-Perot interferometer (i.e., the Vis-NIR spectral imager)

- Dr. Heikki Saari (principal scientist)
- Antti Näsilä (project manager)
- Dr. Kai Viherkanto (instrument concept design)

University of Helsinki, Finland

Main responsibility: scientific mission planning and analysis of the spectral images

- Prof. Karri Muinonen (senior research fellow)
- Dr. Tomas Kohout (research fellow)
- Dr. Antti Penttilä (supporting scientist)
- Dr. Mikael Granvik (supporting scientist)

Aalto University Foundation, Finland

Main responsibility: mission operations and platform design

- Prof. Esa Kallio (platform supervisor)
- Tuomas Tikka (platform manager)
- Antti Kestilä (system engineer)
- Dr. Jaan Praks (project management)
ASPECT

- 3U CubeSat
  - Aalto-1 and 2 heritage
- Special "slow" deployer
- 1 Gbit limit to data transfer
- Largely autonomous operations
  - Combined with navigation, a challenge!
- Spectral imager/spectrometer
Didymos

- NEO
- During mission ~0.06-1 AU distance from Earth.
- Didymos I 775 m, 2.14 g/cm³, Didymos II 163 m
- 1.18 km distance between D1 and D2 a\textsubscript{orb} centers & D2 orbital period bit less than 12 hours
Payload

- Based on Aalto-1 spectral imager
- Three main channels:
  - VIS 500 – 900 nm and NIR 900 – 1600 nm spectral imagers
  - SWIR (1600 – 2500 nm) spectrometer
- Fits into a compact 1U size in the satellite
Orbit

Ecliptic Didymain-centric coordinates for a prograde Didymoon and ASPECT without radiation pressure

Ecliptic Didymain-centric coordinates for a retrograde Didymoon and ASPECT without radiation pressure

Ecliptic Didymain-centric coordinates for a retrograde Didymoon and ASPECT with radiation pressure
Orbit
## ASPECT scientific objectives

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Reflectance spectra of silicate minerals

LL ordinary chondrite (meteorite)

- Position of the bands shifts to lower wavelengths with decreasing Fe/Mg ratio.
Reflectance spectra of silicate minerals

- 1 and 2 µm absorption bands due to Fe$^{2+}$ ions.
- Position of the bands shifts to lower wavelengths with decreasing Fe/Mg ratio.
Hydrated features

Bus et al. 1999
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Photometric observations

- E: (44) Nysa
- V: (4) Vesta
- S: (6) Hebe, (20) Massalia
- M: (22) Kalliope, (69) Hesperio
- C: (24) Themis

Magnitude vs. Phase Angle (°)
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Space weathering

Binzel et al. 2010
Space weathering

- Material damage/response to interplanetary environment (solar wind, microimpacts, space radiation)
- Spectral changes associated with presence of reduced iron nanoparticles
- Confirmed on the Moon and Itokawa
- Vesta may have distinct space weathering mechanism

Itokawa - Noguchi et al. 2011
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Shock effects

Kohout et al. 2014
Shock-darkened or melted material has spectra similar to C/X-complex asteroids. Can these be related?
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DART impact, crater and ejecta distribution

[Images: ESA for impact visualization, Gaffey 2010 for crater and ejecta distribution]
Platform

- COTS subsystems
  - Aalto nanosatellite heritage ADCS
- Radiation hardened EPS
- Separate radhard PDHU for the payload
- Inter-satellite link by ESA
- Cold gas propulsion
  - ~10 m/s deltaV
Conclusions

- AIDA is a novel technology demonstrator mission.
- CubeSats will be deployed for a first time in asteroid vicinity.
- Spacecraft – CubeSat tandem activities.
- ASPECT is a CubeSat mission with VIS-NIR imaging spectrometer.
- Main science objectives are to characterize Didymos surface composition and its changes as a result of the DART impact.
- Potential to provide significant improvement of our understanding of space weathering and shock processes.
Conclusions

• Autonomous operations due to limited communications combined with navigation will be challenging.

• Extended mission: if imposed data transfer (1Gb) is lifted, more images can be downlinked.