

#### Meteoroid Impact Detection for Exploration of Asteroids (MIDEA): A concept for asteroid prospecting

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#### **Motivation**



#### Solar system science

- Meteoroid and dust dynamics
- Geology and chemistry of primitive bodies

#### In situ resource characterization/utilization

- Candidate asteroid selection for retrieval
- Target surface regions for exploitation



#### **Concept overview**



- Use natural meteoroid population to probe asteroid surface through impacts
- Measure impact plasma to characterize surface



# **Concept overview**



- Meteoroid Impact Detection for Exploration of Asteroids: MIDEA
- Targeting 100–300 m asteroids
- Nanogram-sized meteoroid impactors
- Single small (6–12U) parent spacecraft to asteroid
- 5–10 deployable free-flying sensors orbiting at 100–300 m altitude

# Hypervelocity impact



- Impact at speed greater than sound speed in the material
- Results in vaporization and ionization of the impactor and target



### Impact ionization



- Charge production based on power law  $Q = Cm^{\alpha}v^{\beta}$
- Wide range of experimental values obtained for C and  $\beta$



#### **Plasma expansion**



- Nearly hemispherical plume expanding at 20 km/s
- Density falls off with distance (inverse cubic)
- Expected detection threshold at about 300–500 m
- Determine composition through ion time-of-flight



# **Grun interplanetary flux model**



- Applicable near 1 AU, 10<sup>-18</sup> to 100 g
- Based on lunar craters, zodiacal light, in situ measurements



# **Meteoroid Engineering Model**



- Based on meteor radar, calibrated to Grun model near 1 AU
- Applicable from 0.2 to 2 AU, 10<sup>-6</sup> to 10 g
- Would like to compare with IMEM

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# **Reference asteroid: Itokawa**



- Discovered in 1998, visited by Hayabusa in 2005
- S-type asteroid, possibly contact binary
- 535 x 294 x 209 m
- 0.95 to 1.7 AU orbit





Generated from Gaskell Itokawa Shape Model

#### Itokawa meteoroid environment



Stanford

University

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Stanford University

- Sun-facing flux
- Scale from MEM microgram limit to nanogram (~5–10 µm) using Grun model



#### Itokawa meteoroid environment

Stanford University

- Sun-facing flux
- Scale from MEM microgram limit to nanogram (~5–10 µm) using Grun model
- Apply velocity threshold of 20 km/s



#### **Mission parameters**



- 0.1–0.3 impacts per square meter per day
- One impact detection every few seconds
- Every square meter covered in 3–10 days



# Potential meteoroid research



- Identification of new meteoroid streams intersecting asteroid path
- Determination of background flux
- Selection of asteroid targets corresponding to intersection with known meteoroid streams

# Conclusions



- Meteoroids, typically treated as a threat, can serve as useful probes into composition of asteroids
- Nanogram-sized meteoroids impact at reasonably frequent rate
- Impact plasma sensors provide a low-mass/cost alternative to spectroscopy for preliminary exploration