New Research Areas enabled by a Redirected Asteroid

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Asteroid Science

- Now primarily Origin of Solar System
- with a dash of Origin of Life
- Pretty good, but a small audience
- Are there scientific communities being missed?
- 3 examples…

1. Granular Physics

- Tricky to attach, dig rubble pile asteroids
- Rubble piles in micro-g are unknown physics
- Field is *Granular Physics*
  - New: ~20 years old
  - Physics of material piles
  - Grain elevators, avalanches,
- New phenomena
  - Jamming
    - why bunker-busting bombs pretty ineffective
  - Bulk rearrangement from shock waves
- Use drop towers, vomit comet for μg
- Returned asteroid provides:
  - long times (anything >5 minutes)
  - large samples (anything > grams)
  - novel arrangements

See: Daniels, K.E., 2014, Chapter 11 in "Asteroids: Prospective Energy and Material Resources", ed. V. Badescu [Springer]

Condensed Matter Physics

- Even simple crystals (e.g. Fe-Ti, *K. Rabe*) have a
- ***vast theoretical landscape of low energy stable states***
- Literally incalculable. i.e. too large to investigate numerically.
- Novel conditions in the Solar Nebula and in asteroids
- → discovery of new physically realizable minima *(K. Rabe)*
- Can guide condensed matter research into new areas.
- Measurements on samples would yield otherwise unknowable behavior
  - Meteorites provide samples, but…
  - Need large samples to make measurements
- Physical properties of these novel materials are not predictable theoretically *(K. Rabe)*
  - beyond basic quantities such as Young's modulus
- Many materials formed in the Solar Nebula are likely to be unstable (K. Oberg)

Materials Science

- Proto-solar nebula, asteroid cooling, collisions
  - Novel conditions not reproducible in lab.
  - Esp. Long timescales for condensation, cooling
  - E.g. Widmanstätten pattern takes Myr to grow.
- Several dozen “meteorite minerals” not found on earth
  - Tetrataenite: high magnetic coercivity (resists changing B-field)
  - Panguite:
- Only naturally-occuring quasicrystal (in Khatyrka Meteorite)
- Most very poorly characterized properties
  - Samples too small
- Revolutionized by Asteroid Retrieval

ARM has appeal to a Wider Scientific Community

- Granular Physics
- Condensed Matter physics
- Materials Science → New Technology

Need to involve these communities, build case