Asteroid (16) Psyche: Visiting a Metal World

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The Psyche mission has been selected as the 14th in the NASA Discovery program. This mission will investigate what is likely an exposed planetary metallic core, the asteroid (16) Psyche. Estimates of density range widely but cluster between 6,500 and 7,500 kg m^3 [1, 2, 3, 4]. Any density higher than 3,500 kg m^{-3} likely indicates metal: rocky main belt asteroids have average densities roughly one-third to one-half their parent rock density [5]. Orbiting in the outer main belt at ~3 AU, the asteroid (16) Psyche has an effective diameter of ~235 km [7], and is thought to be made almost entirely of Fe-Ni metal [8, 9].

Models show that among the accretionary collisions early in the solar system, some destructive “hit and run” impacts strip the silicate mantle from differentiated bodies [6]. This is the leading hypothesis for Psyche’s formation: it is a bare planetesimal core. If our observations indicate that it is not a core, Psyche may instead be highly reduced, primordial metal-rich materials that accreted closer to the Sun.

The mission has five objectives:
1) Determine whether Psyche is a core, or if it is unmelted material;
2) Determine the relative ages of regions of its surface;
3) Determine whether small metal bodies incorporate the same light elements as are expected in the Earth’s high-pressure core;
4) Determine whether Psyche was formed under conditions more oxidizing or more reducing than Earth’s core; and
5) Characterize Psyche’s topography and impact crater morphology.

We will meet these objectives by examining Psyche with three high heritage instruments and radio science:
(i) Two block-redundant multispectral imagers (MSL Mastcam heritage) with clear and seven color filters provide surface geology, composition, and topographic information. Lead: J.F. Bell, ASU, partnering with Malin Space Science Systems, Inc.;
(ii) A gamma-ray and neutron spectrometer (MESSENGER heritage) determines the elemental composition for key elements (e.g., Fe, Ni, Si, and K) as well as compositional heterogeneity across Psyche’s surface. Lead: D.J. Lawrence, APL;
(iii) Dual fluxgate magnetometers in a gradiometer configuration characterize the magnetic field. Investigation Lead: B.P. Weiss, MIT. Development Lead: C.T. Russell, UCLA; and
(iv) Radio science will map Psyche’s gravity field using the X-band telecomm system. Lead: M.T. Zuber, MIT.

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The solar-electric propulsion chassis will be built by Space Systems Loral in Palo Alto, California [10], the mission will be led by ASU and JPL will be responsible for mission management, operations, and navigation.

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