EPSC Abstracts
Vol. 11, EPSC2017-941, 2017
European Planetary Science Congress 2017

UV Spectroscopy of Metallic Asteroid (16) Psyche

N. J. Cunningham (1), T. M. Becker (2), K. D. Retherford (2), L. Roth (3), L. M. Feaga (4), J.-E. Wahlund (5) and L. T. Elkins-Tanton (6)
(1) Nebraska Wesleyan University, USA (ncunning@nebrwesleyan.edu), (2) Southwest Research Institute, Texas, USA, (3) Royal Institute of Technology, Stockholm, Sweden, (4) University of Maryland, USA, (5) Swedish Institute of Space Physics, Kiruna, Sweden, (6) Arizona State University, USA

Abstract

Asteroid (16) Psyche is the largest M-type asteroid, and the planned destination of the NASA Discovery mission Psyche [1] and the proposed ESA M5 mission Heavy Metal. Psyche is considered to be the exposed core of a differentiated asteroid, whose mantle has been stripped by collisions [2]; but other histories have been proposed. We observed Psyche with the Space Telescope Imaging Spectrograph (STIS) and Cosmic Origins Spectrograph (COS) aboard the Hubble Space Telescope, to obtain a full ultraviolet (UV) spectrum of both of Psyche's hemispheres. We seek to test three possible scenarios for Psyche's origin: Is Psyche the exposed core of a differentiated asteroid? Is it an asteroid with high olivine content that has been space-weathered? Or did Psyche accrete as-is in a highly-reducing environment early in the history of the solar system? We will present the UV spectra and their implications for Psyche's history.

1. Introduction

Like other M-type asteroids in the Tholen classification scheme [3], Psyche exhibits a relatively featureless, red-sloped spectrum in the visible and near-IR. Its high radar albedo [4], high density [5], and high thermal inertia [6] support the leading theory, that Psyche represents a dense, exposed metal core. An alternate proposal suggests that rather than being developed through collisional stripping, Psyche accreted from highly-reduced, metal rich material near the Sun early in the formation of the solar system [1]. A third possibility is that Psyche (and some other M-type asteroids) may have formed as differentiated bodies with metal cores; but their olivine-rich mantles, rather than being collisionally stripped, were processed by space weathering so that the 1 μm olivine absorption feature is weakened and spectrally shifted to shorter wavelengths [7]. Psyche and some other M-type asteroids show a weak absorption band near 0.9 μm.

Laboratory studies [8] find that the UV spectral region is more sensitive to different mineral properties than longer wavelengths, motivating our study.

2. UV Spectral Indicators

Specific features targeted by our study include: Fe3+–O and Fe2+–O absorption bands at 210–230 nm and 250–270 nm, respectively, shown to be intense and identifiable in lab spectra within many minerals common to planetary surfaces [8]; and "blueing" of spectral slope at short UV wavelengths. The presence of Fe–O bands in the absence of spectral blueing, for example, would give support to the theory of Psyche as a more recently-exposed metallic core. Conversely, the lack of Fe–O absorption features together with spectral evidence of space weathering would lend credence to the formation in a reducing environment closer to the Sun.

3. Preliminary Spectra

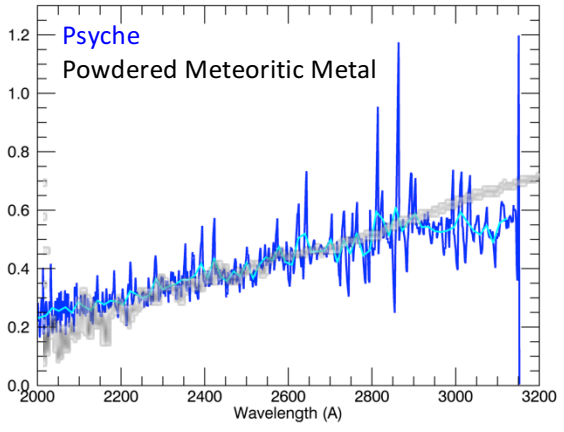

Figure 1: STIS spectrum of one hemisphere of Psyche (raw spectrum divided by solar spectrum); vertical axis is arbitrarily scaled. Graphed laboratory spectrum from [8] overlaid for comparison.

STIS spectra of both hemispheres, shown in figures 1 and 2, are similar, and exhibit a slope similar to that found in laboratory measurements of non-oxidized powdered meteoric metals [8].

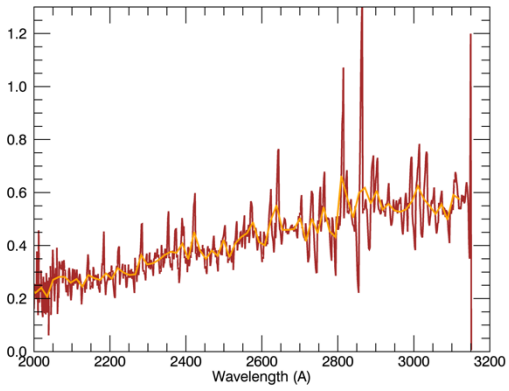

Figure 2: Preliminary STIS spectrum of Psyche, after dividing by solar spectrum; opposite hemisphere from Figure 1.

The slopes of laboratory-measured orthopyroxenes [8] are shallower than the slope observed in our spectra.

4. Summary and Conclusions

Full analysis of our UV spectra of Psyche are underway. Preliminary spectra appear to indicate large-scale homogeneity in Psyche's surface, with similar spectra for both observed hemispheres. We note no clear Fe–O band absorption features, and find a UV spectral slope similar to the laboratory measurements of meteoric metal powder. The lack of Fe-O bands is surprising for an iron body that has been exposed to space weathering, and could indicate (1) that the surface of Psyche has not long been exposed to space weathering (and is therefore young); (2) more work is needed to understand how space weathering affects M-type asteroids; or perhaps (3) the surface is protected from weathering by a magnetic field.

Acknowledgements

This work is based on observations made with the NASA/ESA Hubble Space Telescope, obtained through the Space Telescope Science Institute, which is operated by the Association of Universities for Research in Astronomy, Inc., under NASA contract NAS 5-26555. These observations are associated with program number HST-GO-14609.

References

[1] Elkins-Tanton, L.T. et al.: Asteroid (16) Psyche: the science of visiting a metal world, 47th Lunar & Planetary Science Conference, 1631, 21-25 March 2016, The Woodlands, Texas, USA, 2016.

[2] Asphaug, E., Agnor, C. B., and Williams, Q.: Hit-and-run planetary collisions, Nature, Vol. 439, pp. 155-160, 2006.

[3] Tholen, D.J.: Asteroid taxonomy from cluser analysis of photometry, thesis, Univ. of Arizona, Tucson, USA, 1984.

[4] Ostro, S. J., Campbell, D. B. and Shapiro, I. I.: Mainbelt asteroids: dual-polarization radar observations, Science, Vol. 229, pp. 442-446, 1985.

[5] Kuzmanoski, M. and Kovačević, A.: Motion of the asteroid (13206) 1997GC22 and the mass of (16) Psyche, Astronomy & Astrophysics, Vol. 395, pp. L17 -L19, 2002.

[6] Matter, A., Delbo, M., Carry, B., and Ligori, S.: Evidence of a metal-rich surface for the Astroid (16) Psyche from interferometric observations in the thermal infrared, Icarus, Vol. 226, pp. 419-427, 2013.

[7] Britt, D., Kohout, T., Schelling, P., and Consalmagno, G. J.: Space weathering in olivine and the mineralogy of (some) M-class asteroids, Division for Planetary Science Meeting #46, 506.01, 9-14 November 2014, Tucson, Arizona, USA, 2014.

[8] Cloutis, E.A. et al.: Ultraviolet spectral reflectance properties of common planetary minerals Icarus, Vol. 197, pp. 321- 347, 2008.