ASTEROID PHYSICAL PROPERTIES PROBE. H. Anita. Ai[1] and Thomas. J. Ahrens[2], [1]Caltech, 252-21, Pasadena, CA, 91125. ahr@gps.caltech.edu, [2]Caltech, 252-21, Pasadena, CA, 91125. tja@gps.caltech.edu.

Introduction: Physical properties of asteroidal and cometary nuclei are important to measure because they are critical to understanding the origin and evolution of these objects. Since direct measurement of the physical properties of asteroid surfaces is impractical to conduct, a set of experiments to measure in-situ physical properties, including density, strength, and seismic compressional velocity, of the ground of asteroidal and cometary nuclei were conducted. Such a package of instruments may be included on an asteroid or cometary lander/sampler to measure in-situ physical properties of asteroids in the solar system. Three unconsolidated materials: Portland cement, All purpose sand, and Bedford chips, with the average grain size increasing in order (Fig. 1), are chosen to simulate the asteroid ground surfaces.

Figure 1: Three test materials.

Set up and results:

(1) Density: The use of gamma rays is an attractive solution for the measurement of bulk density on planetary surfaces. This method has been described in detail by Ball et al [1]. For a ^{137}Cs source with photon energy of 662 keV, measurements of the attenuation or scattering of gamma rays by the Compton process are closedly related to the bulk density of the material. The experimental set up is shown in Fig. 2. The ^{137}Cs source, whose activity is ~ 0.09 mCi, is mounted on the tip of a hollow penetrator emplaced in the sand. The attenuation of gamma rays is detected by a G-M detector, Monitor 4, placed on the surface of the sand. With a known thickness of material between the source and a detector, measurement of the change in detected count rate of transmitted photons will allow determination of the mean bulk density along the source-detector path. Moving the ^{137}Cs source up and down within the penetrator, a profile of intensity vs. depth is obtained (Fig. 3). The bulk density is given by

$$\rho_{meas} = \frac{1}{\mu R} \ln\left(\frac{I_0 / R^2}{I_{att}}\right) \qquad (1)$$

where I_0 is intensity at zero distance from the source, while I_{att} is intensity once a material of thickness R has been added. μ is the mass attenuation coefficient at 662 keV, taken as 7.7x10^{-3} m^{2}kg^{-1} for sand (SiO_2) [1]. Density of sand measured by this method is shown in Table 1. Limited by the accuracy of the G-M detector, the result has an error up to ± 10%, and is lower than the bulk density. Cadmium zinc telluride(CZT) detector is going to be used in the future work to get a more accurate intensity measurement.

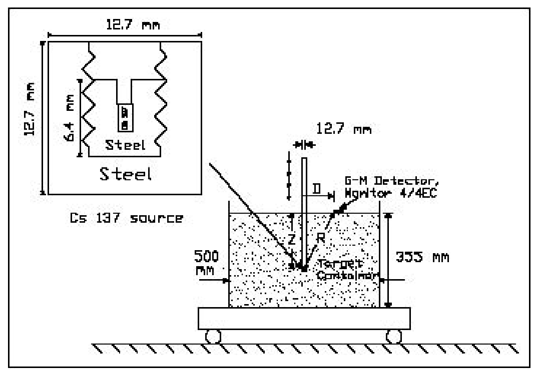

Figure 2: Geometry of test of ^{137}Cs density profiles.

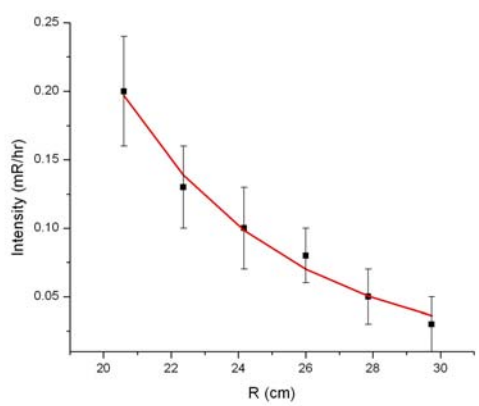

Figure 3: Profile of intensity vs. distance of tests in sand.

(2) Strength: In-situ strength measurements of cometary nucleus surfaces would be valuable in

Table 1: Physical properties of asteroid surface analog media.

Material	Density ($\times 10^3$ kg/m^3) a	b	Strength[c] (MPa)	Seismic V_p[d] (m/s)
Sand	1.36±0.16	1.64	0.23±0.012	260±10
Bedford basalt chips	No data	1.43	0.24±0.008	300±10
Cement	No data	1.06	0.06±0.020	No data

[a]: Measured by gamma ray attenuation;
[b]: Measured directly;
[c]: Measured by penetrating deceleration;
[d]: Detonation detected by geophones.

designing and operating instrument telemetering data to a carrier spacecraft. Previously, high velocity penetration into concrete has been conducted [2]. Low velocity penetration experiments is designed using the drop tube apparatus to measure the strengths of the three test materials (Fig. 4). A bar code reader with a white light source is used for recording the deceleration during the penetration. A typical deceleration record of Bedford basalt chips is shown in Fig. 5. Penetrating velocities are calculated from the peaks of the records and the bar code width, which is 5 mm in this case. The strengths of the test materials are obtained from the deceleration history. The strengths of the three materials are shown in Table 1.

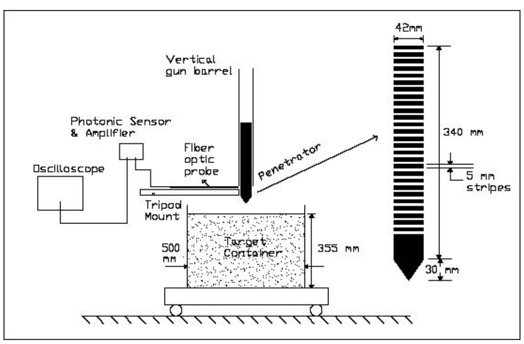

Figure 4: Geometry of penetrator displacement versus time measurement for granular media.

(3) Seismic compressional velocity: Seismic characteristics provide constraints on the grain cementation of asteroid surfaces. In this study, a "sand box" experiment is designed to measure the seismic compressional velocities of All-purpose sand and Bedford basalt chips. The test material is placed in a plastic box with dimension of 1.5x0.9x0.5 m. A 0.13 g, contained PETN detonator embedded in the deployment ribbon is used as the explosion source. One PZT transducer is placed near the source, other three 10 Hz geophones are placed in an array as receivers, with 0.3 m increment. The first arrival of each geophone is recorded by a separate channel of an oscilloscope. Seismic velocity of the material is calculated from the first arrivals. For sand, it is 260±10 m/s, and 300±10 m/s for basalt chips (Table 1). The result for sand is concordant with earlier data [3].

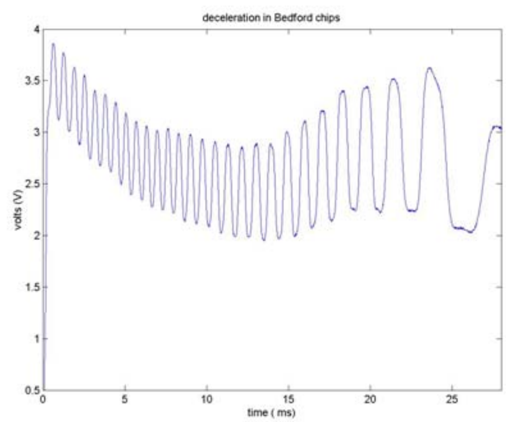

Figure 5: Deceleration record for impact into Bedford basalt at 14m/s.

References:

[1] Ball A. J. et al. (2001) *Planetary and Space Science, 49*, 961-976. [2] Liu C. and Ahrens T. J. (1999) in *Shock Compression of Condensed Matter*, edited by Furnish L. C. et al., 1,039-1,042. [3] Domenico S. N. (1977) *Geophys*. 42, 1,339-1,368.