The Japanese Hayabusa-2 mission is a sample-return mission currently on its way to the C-type asteroid Ryugu. Hayabusa-2 carries the small lander MASCOT (Mobile Asteroid Surface Scout), whose scientific payload includes the infrared radiometer MARA. The primary science goal of MARA is to determine Ryugu's surface brightness temperatures at the landing site for a full asteroid rotation, which will be measured using a long-pass filter, an 8 to 12 µm bandpass, as well as four narrow bandpasses centered at wavelengths between 5 and 15 µm. From these measurements, surface thermal inertia will be derived, but because MARA performs single pixel measurements, heterogeneity in the field of view cannot be resolved. Yet, the surface will likely exhibit different surface textures, and thermal inertia in the field of view could vary from 600 (small rocks) to 50 $Jm^{-2}s^{-0.5}K^{-1}$(fine regolith grains). Sub-pixel heterogeneity is a common problem when interpreting radiometer data, since the associated ambiguities cannot be resolved without additional information on surface texture. For MARA, this information will be provided by the MASCOT camera, and in the present paper we have investigated to what extent different thermal inertias can be retrieved from MARA data. To test the applied approach, we generated synthetic MARA data using a thermal model of Ryugu, assuming different thermal inertias for sections of the field of view. We find that sub-pixel heterogeneity systematically deforms the diurnal temperature curve so that it is not possible to fit the data using a single thermal inertia value. However, including the area fractions of the different surface sections enables us to reconstruct the different thermal inertias to within 10% assuming appropriate measurement noise. The presented approach will increase robustness of the Ryugu thermal inertia determination and results will serve as a ground truth for the global measurements performed by the thermal infrared mapper (TIR) on the Hayabusa-2 main spacecraft.

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325.11 – *NEAR* MSI Images of Asteroid Eros: New Data Products and Analysis

The *Near-Earth Asteroid Rendezvous* (*NEAR*) spacecraft orbited asteroid Eros for approximately one year in 2000–2001, returning thousands of images obtained with the MultiSpectral Imager (MSI) camera system. R. Gaskell used ~20,000 of these images to construct a high-resolution shape model of Eros that was archived in the NASA Planetary Data System (PDS) in 2008. We have produced backplanes for this set of images, and are in the process of preparing them for delivery to the PDS. The 16 backplanes contain information of interest for each pixel in an image: 1. Image pixel value. 2. *x* value of point, body centered coords. 3. *y* value of point. 4. *z* value of point. 5. Latitude. 6. Longitude. 7. Distance from center of asteroid. 8. Solar incidence angle. 9. Emergence angle. 10. Phase angle. 11. Horizontal pixel scale (km/pixel). 12. Vertical pixel scale. 13. Slope. 14. Elevation. 15. Gravitational acceleration. 16. Gravitational potential. This set of backplanes will be provided to the PDS Small Bodies Node, with PDS-4 labels.
The Gaskell shape model, produced with stereophotoclinometry, has more than 3.1 million plates. Hence this model has more than an order of magnitude better spatial resolution compared with the older shape model (200,700 plates). The high-resolution shape model permits substantial improvements in photometric normalization of images to be made, because the incidence, emergence, and phase angles can be determined at smaller scales. We plan to perform new photometric normalization of color image sets in order to search for mineralogical variations at higher resolution than was previously possible. In addition, we will carry out phase-ratio analysis to extract information on surface texture and scattering behavior for features of special interest.

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325.12 – Visible Wavelength Reflectance Spectra of Near-Earth Objects from Apache Point Observatory: Science Highlights

In January 2015 we began a program of near-Earth object (NEO) astrometric follow-up and physical characterization using a 17% share of time on the Astrophysical Research Consortium (ARC) 3.5-meter telescope at Apache Point Observatory (APO). Our roughly 500 hours of annual observing time are split into 2 hour runs usually in the middle of every other night (see poster by K. Nault *et al.*), and frequent half-night runs devoted to physical characterization (this poster). NEO surface compositions are investigated with 0.36-1.0 µm reflectance spectroscopy using the Dual Imaging Spectrograph instrument. As of June 22, 2016 we have obtained reflectance spectra of 129 unique NEOs, ranging in diameter from approximately 5 m to 6 km.
Highlights of this work presented here include 106 spectra of (357439) 2004 BL86 spanning 3 hours 4.5 minutes, more than a full rotation, and spectra of 18 objects with diameters comparable to historical Earth impactors (*e.g.*, Tunguska, Chelyabinsk and smaller bolides).
This work is based on observations obtained with the APO 3.5-meter telescope, which is owned and operated by ARC. We gratefully acknowledge support from NASA NEOO award NNX14AL17G, and thank the University of Chicago Department of Astronomy and Astrophysics for observing time in 2014.

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325.13 – The Four-Color Broadband Photometry for Physical Characterization of Fast Rotator NEOs

Fast rotator NEOs, having size in the range of several meters in diameter (H > 22), turn to be very faint. In order to study their physical characterization using photometry, it is required to use a system of filters that covers for each of them a large bandwidth of at least 0.8 micrometers. Traditional and inexpensive Johnson-Cousins broadband filters (B, V, R, I) work efficiently well.
11 NEOs were observed at the Vatican Advanced Technology Telescope (VATT) from 2014 to 2016. Their absolute magnitudes range from 21.9 to 28.2. We found that their spin rates vary from 0.172+/- 0.003 to 2.300 +/- 0.003 hours. 6 of them (2014 AY28, 2015 TB25, 2015 VM64, 2015 VT64, 2015 XZ1, and 2016 GW221) are clearly of C-type and dominate our sample, while one (2014 KS40) belongs to X-type. One NEO (2016 EW1) falls between C-type and S-type asteroids on the plot (B-V) versus (V-R) while on the plot (V-I) versus (V-R), it is among C-type asteroids. We rule it to be C-type asteroid. NEO 2014 WF201 stays between C-type and S-type on both plots.
NEO 2014 EC appears to us of very special interest as its V-R color index is close to zero. Its relative reflectance normalized to R-filter shows that it belongs to B-type asteroid. Would it be an indication of fresh interior material excavated by a recent impact?

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325.14 – Characterization of the high-albedo NEA 3691 Bede

Characterization of NEAs provides important inputs to models for atmospheric entry, risk assessment and mitigation. Diameter is a key parameter because diameter translates to kinetic energy in atmospheric entry. Diameters can be derived from the absolute magnitude, H(PA=0deg), and from thermal modeling of observed IR fluxes. For both methods, the albedo (pv) is important – high pv surfaces have cooler temperatures, larger diameters for a given Hmag, and shallower phase curves (larger slope parameter G). Thermal model parameters are coupled, however, so that a higher thermal inertia also results in a cooler surface temperature. Multiple parameters contribute to constraining the diameter.
Observations made at multiple observing geometries can contribute to understanding the relationships between and potentially breaking some of the degeneracies between parameters. We present data and analyses on NEA 3691 Bede with the aim of best constraining the diameter and pv from a combination of thermal modeling and light curve analyses. We employ our UKIRT+Michelle mid-IR photometric observations of 3691 Bede's thermal emission at 2 phase angles (27&43 deg 2015-03-19 & 04-13), in addition to WISE data (33deg 2010-05-27, Mainzer+2011).
Observing geometries differ by solar phase angles and by moderate changes in heliocentric distance (e.g., further distances produce somewhat cooler surface temperatures). With the NEATM model and for a constant IR beaming parameter (eta=constant), there is a family of solutions for (diameter, pv, G, eta) where G is the slope parameter from the H-G Relation. NEATM models employing Pravec+2012's choice of G=0.43, produce D=1.8 km and pv≈0.4, given that G=0.43 is assumed from studies of main belt asteroids (Warner+2009). We present an analysis of the light curve of 3691 Bede to constrain G from observations. We also investigate fitting thermophysical models (TPM, Rozitis+11) to constrain the coupled parameters of thermal inertia (Gamma) and surface roughness, which in turn affect diameter and pv. Surface composition can be related to pv. This study focuses on understanding and characterizing the dependency of parameters with the aim of constraining diameter, pv and thermal inertia for 3691 Bede.
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325.15 – Searching for Brazil Nuts on Q-type near-Earth Asteroids

Q-type asteroids, the best spectral analogs of ordinary chondrite meteorites have only been definitively detected in near-Earth space. S-type asteroids, the space weathered counterparts of Q-types, however, are common, indicating that surfaces exposed to the space environment are rapidly weathered. Nevertheless, the existence of Q-type asteroids is evidence that one or more processes act to freshen asteroid surfaces, overturning the regolith to expose the un-weathered material that lies beneath. Nearly all Q-type near-Earth asteroids have been shown to currently or recently exist in orbits that bring them within close proximity to at least one terrestrial planet (i.e. a few planetary radii away). This observation has been used to infer that tidal interactions during close planetary encounters cause regolith mobilization on these bodies. This mechanism may lead to particle size segregation on the surface and interior of these bodies, particularly the sorting of large boulders to the surface. Because a large number of boulders raises the average surface thermal inertia, we hypothesize that the thermal inertia of Q-type asteroids are systematically larger than the average near-Earth asteroid population.
To test this hypothesis, we determine the thermal inertia of approximately one dozen Q-type near-Earth asteroids from measurements of their thermal emission. The targets for this study are selected based on known rotation periods and observations that are made at pre- and post-opposition, with a large difference in solar phase angle. This observing geometry is crucial in constraining thermal inertia, which influences the surficial diurnal temperature variation and thus the thermal emission as a function of phase angle. We have been acquiring observations at 3.6 and 4.5 µm with the InfraRed Array Camera (IRAC) on the Spitzer Space Telescope. At these wavelengths, the measured flux is generally dominated by thermal flux, but may contain a component of reflected flux. A model that removes the reflected light component is therefore used to isolate the thermal flux. We will present the thermal flux measurements along with our thermal inertia estimates in the context of the “tidal freshening” hypothesis
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325.16 – Simulating regolith ejecta due to gas impingement

Space missions operating at or near the surface of a planet or small body must consider possible gas-regolith interactions, as they can cause hazardous effects or, conversely, be employed to accomplish mission goals. They are also directly related to a body’s surface properties; thus understanding these interactions could provide an additional tool to analyze mission data. The Python Regolith Interaction Calculator (PyRIC), built upon a computational technique developed in the Apollo era, was used to assess interactions between rocket exhaust and an asteroid’s surface. It focused specifically on threshold conditions for causing regolith ejecta. To improve this model, and learn more about the underlying physics, we have begun ground-based experiments studying the interaction between gas impingement and regolith simulant. Compressed air, initially standing in for rocket exhaust, is directed through a rocket nozzle at a bed of simulant. We assess the qualitative behavior of various simulants when subjected to a known maximum surface pressure, both in atmosphere and in a chamber initially at vacuum. These behaviors are compared to prior computational results, and possible flow patterns are inferred. Our future work will continue these experiments in microgravity through the use of a drop tower. These will use several simulant types and various pressure levels to observe the effects gas flow can have on target surfaces. Combining this with a characterization of the surface pressure distribution, tighter bounds can be set on the cohesive threshold necessary to maintain regolith integrity. This will aid the characterization of actual regolith distributions, as well as informing the surface operation phase of mission design.
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325.17 – M4AST - A Tool for Asteroid Modelling

M4AST (Modelling for asteroids) is an online tool devoted to the analysis and interpretation of reflection spectra of asteroids in the visible and near-infrared spectral intervals. It consists into a spectral database of individual objects and a set of routines for analysis which address scientific aspects such as: taxonomy, curve matching with laboratory spectra, space weathering models, and mineralogical diagnosis. Spectral data were obtained using groundbased facilities; part of these data are precompiled from the literature[1].
The database is composed by permanent and temporary files. Each